Becoming a Teacher: An Inquiry Into the Experiences of Novice Teachers of Mathematics in Cegep

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ABSTRACT

Becoming a teacher: an inquiry into the experiences of novice teachers of mathematics in cegep

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This dissertation presents an inquiry into the experiences of novice teachers (under five years of experience) of mathematics in cegep institutions, the first step of postsecondary education in Quebec, Canada. Using Dewey's theory of learning alongside narrative inquiry's conceptualization of life as lived narratively, our aim is to contribute to the understanding of the process of becoming a cegep mathematics teacher, the research puzzle of this study. For this purpose, I met five novice mathematics cegep teachers, individually except for one meeting with three of them, each seven times, to talk about mathematics, teaching, and learning and created field texts associated with these meetings. As we realized these novice teachers spoke of who they are and are becoming in terms of their past experiences as students, as teachers, and outside of school, we decided to attend to the ways novice teachers' stories, stories they live and tell as teachers, are shaped (justified, modified, or affirmed) by these past experiences. Based on the field texts and the notes I took during our meetings, I wrote a booklet of research texts that narrates justifications, modifications, and affirmations of stories. We then analyzed these research texts attending to the ways novice teachers' stories were shaped according to three emerging strands of analysis: *implicit training* experiences, *explicit training* experiences, and experiences in relation to *university mathematics*. Then, we explore what this analysis tells us about our research puzzle. We end by exploring resonant threads, particular plotlines, and patterns about the process of becoming a teacher of mathematics in cegep, which emerged from the analysis conducted, the booklet of stories and the field texts. We address: bumping stories and tensions that can prevent novice teachers from living stories, novice teachers' unique journey to teaching, novice teachers' inclination to strive towards quality teaching, the connection between the process of becoming a teacher and being a university student in mathematics, and a characterization of the valid behaviours novice cegep teachers engaged in as they entered the profession.

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INTRODUCTION

> "you are a story.
> do not become a word.
> one word.
> because you want to be loved.
> love does not ask you to be nothing
> for
> something.
> - name"
> Nayyirah Waheed, 2013

Narrative Beginnings

When I was in third grade, my teacher shared the story of how she chose to become an elementary school teacher. I remember her saying that her father had not pushed her into it, but supported her decision. That is my first memory of thinking about becoming a teacher.

When I was in fifth grade, the teacher gave us something to do, some mathematics problems to solve. I remember it being different from anything I had ever done and I remember enjoying how much I had to think to do it. Months later, I remember walking into class one morning, the morning of our field trip to a local library, and my name was written on the board, saying that I had won. I was the best in the province for a national mathematics contest I did not even know I had entered in the first place. I was then known as the "math person," and that never really left me.

When I was in my fourth year of high school, I had to take a physics class. Our teacher was a former student of our school. One day, our class was held in a different room, and she told us the story of how it was in that very classroom that she asked herself for the first time: "Why not become a science teacher?" That was the second time I thought about becoming a teacher, of mathematics specifically.

When I was in my first semester as a cegep[1] student, my linear algebra teacher had this way of teaching, a way that just worked so well for me. I remember telling my grandfather about her at a

[1] Cegep institutions will be addressed in the next chapter in detail. For now, let us just say that it is the first step of postsecondary education in the province of Quebec, Canada. To refer to those institutions, we will use words such as cegep, cegeps, and collegial in English and cégep, cégeps and collégial in French.

Christmas Eve dinner, how, if one day I become a cegep teacher, I would be like her. That is the third time I thought about becoming a teacher, and that never really left me. When I had to apply to university, I remember sitting down at a table near my locker looking at a description of every program available at the university close to where I lived. I remember getting excited only by the programs that offered a heavy mathematics course load, concluding that a degree in mathematics was really the only viable option if I wanted to love it. I applied, thinking I would graduate three years later and become a cegep teacher.

When I was in the last semester of my undergraduate degree, I accepted a contract as a teaching assistant for cegep-level courses at my university. I was so excited to see how I would do. I was extremely nervous the first time, but I ended up enjoying it. I thought I was doing a pretty good job. I remember students asking me simple questions, such as to remind them which technique lowered the power of x: differentiating or integrating? I would confidently remind them that it was differentiating.

One day, a student came in and asked me about a problem involving a parabola. It had something to do with finding the zeros, so I reminded him of the quadratic formula, which is part of the high school curricula. When he expressed his feeling of being lost again, I tried to figure out what he needed from me. I finally understood that he knew the formula but was wondering where it came from. The fact that he would need to know where a formula came from, even know the proof, in order to use it came as a shock to me. It was absolutely mind-blowing. I had never felt the need for such proof at that level and it seemed unnecessary for solving such simple problems. But it got me thinking. What else did I not know about how other people do mathematics? What they need to do mathematics? To learn mathematics? How they would like to be taught mathematics? And then I thought: I am certainly not ready to get a job as a cegep teacher if I did not see that one coming. I needed to know more. I decided I needed to do a master's in mathematics education, thinking it was a good place to learn more about how others deal with mathematics.

When I was a master student, I learned about teaching and learning, research and methodologies, theories and mathematics. This whole new world opened up to me, a world to which I was completely new. I was asked to be a teaching assistant in classes for preservice teachers, and to be a research assistant for multiple research projects. I liked it enough to decide to pursue a doctoral degree.

When I was in my first semester as a doctoral student, I was a teaching assistant in the Math Help Centre—a drop in service for students doing cegep and first-year mathematics courses. I was nervous because it was the first time I would be doing mathematics in English, let alone trying to explain it to others in English. I remember students asking me which technique lowered the power of x: differentiating or integrating? Without thinking about it, I asked them what it meant to differentiate and what it meant to integrate, working on a simple linear function. My hope was to get them to find the answer by themselves, thinking that they could later, in a test for example, do it again if needed.

I then realized how different my answer was compared to when I was a teaching assistant for the first time. It made me realize how different of a "teacher" I was two years later. What was it that I learned in my training in mathematics education or during my research or teaching assistantships that made me answer differently? How did these experiences change my vision of mathematics, teaching, and learning? Looking back, I could somehow track how the "teacher" in me changed in the years that followed my studies in pure mathematics. Something changed and I felt I could never go back. And I wondered how I would have been, as a teacher, if I had jumped right into it after my bachelor's degree. Or if I had decided to do a certificate in cegep teaching or a master's degree in mathematics teaching. Had I taken any one of these different paths, how and who would I be?

And I wondered: how do cegep teachers walk through those first few years as a teacher?

This Dissertation

This dissertation explores *the process of becoming a mathematics teacher in cegep*. This process is our *research puzzle*—narrative inquiry's version of a research question (Clandinin, 2013, p. 42). For the purpose of this exploration, we[2] present a narrative inquiry (NI) into the experience of beginner teachers of mathematics in cegeps, in Quebec, Canada, turning our attention to the

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[2] This thesis is based on work done by Claudia Corriveau, Nadia Hardy, and me. It is a summary of the individual research done by the author while working within this team framework. Narrative inquiry is a relational methodology, which is why the pronoun "we" is used throughout this dissertation. The pronoun "I" is used in regard to work that was performed by the author only, such as interviews, or the authors' personal story.

experiences of novice cegep teachers transitioning from being a mathematics student in university (bachelor, master, or doctorate) to becoming a mathematics teacher in cegep.

Underlying the choice of doing a NI is a commitment to understand the unique and complex lives of the actors in the research puzzle. This led us away from a linear inquiry that would be guided by set research questions and a list of categories that would determine the conduct of the study. Indeed, Clandinin and Connelly (2000, p. 125) warn us that life always gets in the way and to try to anticipate exactly what one wants to study is like picturing life at a standstill. Life will happen and a seemingly static life will shift and move in complex ways. As such, we were dedicated early on in this project to the research puzzle mentioned above, knowing that the goal may shift and get more precise as we read about similar topics, get to know novice teachers and reflect alongside each other. We were committed to "focus on experience and to follow where it leads" (Clandinin & Connelly, 2000, p. 188). We briefly narrate here how our journey into NI unfolded.

From that early commitment, we began reading about postsecondary teaching and becoming a teacher at all levels. We wondered about what we started calling novice teachers' *relationship with mathematics, teaching, and learning*, a vague concept which helped us think about their opinions, perceptions, and beliefs about mathematics, teaching, and learning. I went into the field with that relationship in mind, with the aim of understanding novice teachers' experiences in the process of becoming a cegep teacher. I conducted a pilot study in the winter of 2017 with three novice teachers. I then conducted the main study in the fall of 2017 and the winter of 2018 with five novice teachers. We were open to hearing any stories they wanted to share about our research puzzle and about themselves. That exploration was meant to be as open as possible, in the hope of understanding the participants' unique lives as novice mathematics cegep teachers.

Eventually, the time came to look back at the stories that were shared with us and write research texts. It became clear that our participants talked about who they were and were becoming in terms of how their past experiences (as a students, teachers, or persons outside the school) changed or justified their relationship with mathematics, teaching, and learning. They shared how each experience played a role in their life. With that in mind, we came back to our starting point. We added onto our corpus of literature and went back to the conceptual and theoretical foundations of narrative inquiry to seek more tools, such as the concept of *stories to live by* (Section 2.2.3), to help us understand the experiences that were shared with us. We rephrased our interest to the following: the nature of the experiences that shape (justify, modify, or affirm) novice cegep teachers' stories to live by (in relation to mathematics, teaching, and learning) and the ways in which teachers' stories to live by are shaped (justified, modified, or affirmed).

In a narrative inquiry, research texts are co-composed between the researcher(s) and the participant(s) and the meaning given to them is negotiated. In this work, negotiations of meaning and co-construction of field texts happened during my time in the field, during 7 meetings over 15 weeks. Between each meeting, I would compose field texts and at the following meeting, there would be a space to negotiate meaning. However, we did not go back into the field, go back to the participants, following the writing of research texts, namely the booklet of stories (Appendix D) and both chapters of analysis (Chapters 4 and 5), as it is usually done in a narrative inquiry. This fact stems from how this research developed and from our own story as we engaged with narrative inquiry as a theory and as a method. In particular, our ethics certificate only encompassed the protocol for the 7 meetings. The writing of the research texts happened long after those meetings were over and the time to both obtain a new ethics certificate and go back to the participants to co-compose and negotiate meaning of the research texts would have seriously jeopardize reasonable time completion of a doctoral thesis. Because of that, we chose to write this dissertation about *fictional characters*, inspired by the novice teachers we met. This decision did not alter our desire to root our work in the experiences that they shared with us and in the field texts we created and were able to negotiate with them. For more on this, see Section 3.1.6 on ethics considerations.

This dissertation is the research text associated with our inquiry into the process of becoming a teacher of mathematics in cegep. It is presented in a linear way, though the process to get there was nothing like that. We start in Chapter 1 with a literature review where different aspects of our research puzzle are explored. We then explain the theoretical and conceptual foundations of this dissertation in Chapter 2 and then detail the research method in Chapter 3. Chapters 4 and 5 are the research texts, meaning the analysis and results of our study. We end this dissertation with a concluding chapter, Chapter 6, where we reflect on our work, its results, limitations, and implications.

CHAPTER 1: POSITIONING THE RESEARCH PUZZLE

This chapter serves as an exploration of the research puzzle that is the focus of this dissertation, namely, the process of becoming a cegep mathematics teacher. It positions our work in a practical way as we explore cegep institutions, the training of its teachers (Section 1.1), and the training of postsecondary (Section 1.2) and K-12 teachers (Section 1.3). It also positions our topic of research in the existing literature on becoming teachers (Section 1.4), especially at the postsecondary (Section 1.5) and K-12 levels (Section 1.6). We conclude this chapter with a section about research on the influence of past experiences on teaching (Section 1.7), which we added at a later stage in light of our meetings with novice teachers.

1.1 What is a *Cegep*?

In the province of Quebec, Canada, postsecondary education is separated into two institutions: cegep and university. Normally, a Quebecer goes through 6 years of elementary school and 5 years of high school. Then, at around 17 years of age, cegep is the next step. Cegep is an acronym[3] for "**c**ollège d'**e**nseignement **g**énéral **e**t **p**rofessionnel," that is, college for general and professional learning. Cegeps offer two types of programs: a pre-university program for students who wish to pursue a bachelor's degree and potentially graduate studies, and a career program for students who wish to enter the workforce upon completion of their cegep degree. The pre-university programs are 2 years long and the career programs (e.g. nursing), typically 3 years long. Most mathematics courses taught in cegep entail material similar to what is covered at the end of high school and at the beginning of university elsewhere in Canada and in college freshman year in the United States. Cegep graduates are welcomed by Quebec universities into a three- or four-year bachelor program. A brief overview of what typical cegep programs look like follows.

Pre-university programs are four semesters long. Students usually take 6 or 7 courses each semester and do not generally follow the same group of colleagues from course to course. There are two main pre-university streams that include mathematics: the science and the social science.

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[3] Because it became an acronym that was used so often, it is now accepted to use as a common word, with low case letters, that can be pluralized. Nowadays, the recommended spelling is a "cegep" or multiple "cegeps" (Office québécois de la langue française, April 2019).

In the science stream, students have to take mathematics, physics, chemistry, and biology. It is meant for students who wish to pursue a bachelor's degree in health sciences or pure and applied sciences (e.g. chemistry, engineering). There are three mandatory mathematics courses in the science stream: Calculus I (differential calculus), Calculus II (integral calculus), and Linear Algebra (matrices and vectors). Some cegeps offer more advanced mathematics courses as electives—for instance, multi-variable calculus, probability and statistics, differential equations, or discrete mathematics. The three courses that are mandatory in the science stream are offered as electives (in sometimes different formats) in the social science stream, where students can choose to specialize in education, law, international business, psychology, or a variety of other domains. Additionally, social science students have to take a quantitative methods course which touches on some elementary statistics concepts and methods.

There is a great variety of career programs and each cegep offers its own selection. To give a few examples, there are programs in animal health technology, architectural technology, computer science technology, nursing, industrial electronics, and professional music and song techniques. Some programs include mathematics courses and some do not. They are 6-semester long, and students in a given cohort mostly stick together in all their classes.

Every student in cegep, no matter the program, has to take French, physical education, English, and humanities courses. Most cegeps also offer remedial mathematics courses that cover high school-level mathematics, usually from secondary 4 and secondary 5. These are courses that students must take to obtain admission into a science program if their high school grades are lower than those required. These courses may also be taken as electives by students in some non-science programs.

Some institutions offer mathematics courses in continuing education. The continuing education system allows students who want or need to study part-time to take night classes. The population in those courses usually consists of students who come back to school after a period away from studying and students whose high school grades are too low to be admitted into a pre-university or career program.

1.1.1 Cegep Teachers' Training: First Considerations

The history of cegep institutions is filled with questions about the training of its educators. Indeed, the 1964 Rapport Parent (Gouvernement du Québec, 1963-1965), a publication that triggered the creation of cegeps, recommended a mandatory education for cegep teachers similar to that required for teaching at elementary and high school (a 4-year university program that leads to a teaching licence). However, the rapidity with which the institution was created did not allow any time for the training of new teachers (Conseil Supérieur de l'Éducation [CSÉ], 2000, p. 12). When the first cegeps opened their doors in September 1967, there was an immediate need for teaching power that was filled by senior high school teachers, university professors, and other professionals knowledgeable in relevant disciplines (for example, engineers were hired for their knowledge in mathematics).

In 1978, 1993, 1996, and 1997 (CSÉ, 2000, pp. 12–13), similar concerns about the training of cegep teachers arose for different reasons. Then, and still today, most cegep institutions do not require mathematics teachers to undergo any training in the areas of teaching, pedagogy, or didactic. A majority of them have a strictly mathematical background. More precisely, cegep mathematics teachers are required to have a bachelor's degree in mathematics (CSÉ, 1997, p. 57). However, institutions can scale up the requirements and it is actually recommended by the CSÉ to favour candidates who have earned more than a bachelor's degree (2000, p. 56). Some institutions require a master's or doctoral degree in mathematics (CSÉ, 2000, p. 13). Some see different levels of training in education as an asset—for example, a minor in education or a graduate specialization in didactics or in cegep teaching, programs which are offered by a few universities in the province.

In this study, we take the position that mathematics university programs aim at training students to become mathematicians, i.e. researchers in or practitioners of mathematics, in an undefined sense but within a certain (academic) culture that does not include "mathematics teacher" as a descriptor of a mathematician. We are not saying that upon graduation, students of university mathematics programs are actually prepared to be researchers in or practitioners of mathematics. Rather, we are saying that this is, nevertheless, the ultimate goal of the training they receive. This training does not (explicitly) attend to training mathematics teachers. In particular, students' capacity to teach is not tied to their success in their university program in mathematics (Beisiegel, 2009, pp. 282–283).

As cegep institutions reached thirty years of existence and pioneer teachers approached retirement age, the question of how to pass on the expertise to new teachers became more present (and pressing). Around the year 2000, the workforce started to be significantly renewed as the teachers who were there since the beginning started to retire. Many new teachers have been entering and still are entering the profession in recent years, making this an excellent time to rethink the requirements and the available training for becoming a cegep teacher (CSÉ, 2000, p. 22). While the 1997 CSÉ report did not question the current cegep teachers' abilities, it did call attention to new teachers' training and preparedness for the classroom (CSÉ, 1997, p. 58). On this topic, the CSÉ (1997, 2000) suggests that further reflection is required regarding the mandatory education for cegep mathematics teachers.

According to the CSÉ (1997, p. 13), the work of the cegep teacher is now more interdisciplinary than it used to be. Indeed, the role of the cegep teacher of today is to present the knowledge as situated in a context in order for the students to draw connections between the material and broader questions. This is to be done as part of a multidisciplinary world and multidisciplinary curricula, so that the knowledge can become alive and relevant in the eyes of the students. This reality increasingly requires the ability to connect different disciplines and to take an epistemological stance. The CSÉ emphasizes that the disciplinary degree most teachers have is not always adequate to engage in such work. Nevertheless, teachers should be able to understand and situate the contribution of the various related disciplines within cegep education. Indeed, it is in contact with other disciplines that the subject matter that is taught will make sense (1997, p. 63).

Further, the CSÉ argues that the context in which teachers are working is increasingly complex. There is growing pressure for student success, an increased diversity of students, particularly in terms of their background and needs, and an increased use of technology in the world and in the classroom (2000, pp. 8–10). The changes to the programs in the 1990s, which gave much more independence to the institution in terms of curriculum development, increased the complexity of teachers' work (CSÉ, 2000, p. 7).

On a similar note, the CSÉ argues that teachers are more than carriers and transmitters of the subject knowledge (2000, p. 53). Teachers have a responsibility towards their institution as participants in the institutional life, and, most importantly, a major pedagogical and didactic responsibility towards students. However, requiring only disciplinary studies from teachers may suggest that to teach at cegep level means *only* transmitting disciplinary knowledge. In saying this, the CSÉ is not trying to undermine the importance of subject knowledge. Rather, the CSÉ is questioning its general monopoly over other types of knowledge required for teaching. There are knowledge and skills ("savoirs et savoir-faire") necessary for teaching at the cegep level, other than content knowledge, that need to be identified and addressed (CSÉ, 1997, p. 58).

In short, multiple reasons were underlined by the CSÉ to justify that the minimal mandatory education to teach in cegep needs to be reconsidered in light of the actual demands of the profession. In other words, what is actually expected of the teachers is further and further away from what they are minimally required to have as preparation. The CSÉ argues that if teachers were better prepared for the particularities of their profession, they might feel more effective (2000, p. 11). Naturally, we ask: what would such preparation look like?

1.1.2 Cegep Teachers' Training: Second Considerations

This section touches upon what this new and more adequate training could be. The CSÉ tells us that "*[t]ant que les enseignantes et les enseignants du collégial n'auront pas d'identité professionnelle clairement définie, tant qu'ils ne pourront se reconnaître à travers un minimum d'éléments de socialisation communs, ils sauront difficilement assumer le devenir de leur pratique. Pour parvenir à consolider cette identité, la qualification professionnelle représente un instrument majeur*[4]" (CSÉ, 1997, p. 57). From this perspective, investigating and understanding the *profession* is key for the design of useful and meaningful pre-service education and professional development opportunities for cegep teachers. In particular, there is an explicit call for an empirical investigation of the skills and competencies put into play in cegep teachers' everyday tasks (CSÉ, 1997, p. 58) to inform, at least in part, new training programs. The CSÉ believes an initial and continuous training rooted mainly in the particularities of cegep is necessary for cegep-level teachers: "*[c]'est d'abord dans les particularités du collégial que se trouvent les fondements de*

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[4] as long as cegep teachers do not have a clearly defined professional identity, as long as they cannot recognize themselves through a minimum of common elements of socialization, they will have trouble undertaking the future of their practice. In order to consolidate this identity, professional qualification represents a major instrument. [my translation]

cette réflexion sur la formation du personnel enseignant[5]" (2000, p. 7). The CSÉ emphasizes the relation between professional development specifically designed for cegep teachers and the improvement of teaching in those institutions (1997, p. 57).

Hence, to revamp those programs, the CSÉ (2000) wishes to reach not only into the research and theories of education, but also to in-service teachers. Empirical research that involves those educators can give access to some of the elements needed to understand the specificity of the profession and the expertise those teachers have: "*Perrenaud décrit bien l'importance, voire la nécessité, de théoriser les savoirs issus de l'expérience, pour ensuite les faire circuler, les confronter et les proposer en soutient à la pratique. Il voit d'ailleurs dans cette contribution à la théorisation des savoirs d'expérience une condition de professionnalisation de la pratique de l'enseignement au sens où c'est à ce prix que l'on parviendra à une réelle professionnalisation de l'enseignement*[6]" (CSÉ, 2000, p. 47). Fifty years after the creation of the cegep model, these institutions have their own unique history and its teachers carry their own unique expertise. This uniqueness calls for targeted research (CSÉ, 2000, p. 24).

A brief overview of existing training for postsecondary teachers and for K-12 teachers follows in the next two sections. The purpose of this overview is to get an idea of existing training and see if, how, and to what extent it connects to the cegep level, an institution where little research has been conducted.

1.2 Training for Postsecondary Teachers

We recognize that as students pass through their university programs, they are exposed, engaged, and subject to "explicit" training and "implicit" training. In this section, we address "explicit" training—training that is explicitly stated in or can be inferred from learning outcomes, course syllabi, program goals, etc. We address "implicit" training in Sections 1.5, 1.6, and 1.7—a sort of

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[5] it is first and foremost in the peculiarities of cegep that the foundations of this reflection on the training of teachers are found. [my translation]

[6] Perrenaud describes well the importance, even the necessity, of theorizing the knowledge that results from experience, and to circulate, confront, and propose it in support of practice. He also sees this theorization of experiential knowledge as a condition for the professionalization of the practice of teaching, in the sense that it is required for achieving a real professionalization of teaching. [my translation]

apprenticeship training by imitation which is not in the intended goals of the instructor or the course, nor often in the learning goals of the student.

There seems to be a growing recent interest in researching the training of postsecondary educators (Deshler, Hauk, & Speer, 2015). Nowadays, many universities offer some program in postsecondary teaching; more often than not, this training is not discipline-specific (Barton, Oates, Paterson, & Thomas, 2014, p. 149). Further, the importance of training postsecondary educators is increasingly acknowledged. For example, Deshler et al. (2015), in a summary of the available training for graduate-student teaching assistants (GTAs) and associated research, emphasize the importance of the GTA population. Not only do they teach current undergraduate students who need to take mathematics courses, as these are increasingly assigned to GTAs, but some of them are also future faculty. The Mathematical Association of America's National Study of College Calculus affirms that successful calculus programs in university include professional development for GTAs (Bressoud, 2015, cited in Deshler et al., 2015). We address below what we know of the available training for cegep teachers, university faculty, and GTAs.

There are university certificates that do not lead to a teaching licence but which in-service or prospective teachers can take to further their professional development; these programs are open to in-service cegep teachers and students interested in cegep teaching. However, few programs are offered specifically to cegep teachers: most are directed mainly to elementary and high school-level teachers. According to teachers who have completed those university programs that train future cegep teachers, whether specifically for cegep or not, the curriculum offered does not align with the reality of the classrooms (CSÉ, 2000, p. 16). There have also been reports of some of those programs having a negative impact on the teachers' vision of pedagogy as a discipline (CSÉ, 2000, p. 16).

There are university programs created for postsecondary teaching (i.e. cegep and university) and programs in cegeps specifically designed to integrate new teachers (CSÉ, 2000, pp. 18–19). We have not found any report or study that describes those programs or the experience of teachers who have attended them.

As far as professional development for university faculty, there are few examples in the literature. One example is the DATUM project, which started at the University of Auckland. DATUM stands for Development and Analysis of Teaching in Undergraduate Mathematics (Barton et al., 2014; Oates, & Maciejewski, 2016). It brings together mathematics and mathematics education faculty to discuss and co-learn from video-recordings of their lectures (p. 150) and their pre-lecture and post-lecture ROG's (**r**esources, **o**rientations, and **g**oals from Schoenfeld's framework employed to describe in-the-moment decisions in the classroom). The project was evaluated by external researchers to have had an overall positive impact on the participants' quality of teaching; the researchers examined two videotaped teachings from lecturers, one from the beginning of the project and one from its end. The project created a professional development culture within the mathematics department—something that could be sought in cegep departments. Another example is Project NExT (Gallian et al., 2000; Mathematical Association of America, 2019), a professional development program for new or recent doctoral graduates. Project NExT, or **N**ew **Ex**periences in **T**eaching, is for people who wish to better the teaching and learning of undergraduate students. Establishing a research program, grant writing, involving undergraduates in research, and balancing teaching and research are among the topics that are covered, but the main focus is on teaching. Participants of the project emphasized positive outcomes of their involvement, such as becoming part of a community with whom to interact about teaching and learning as well as feeling more confident about their role in their department, from teaching to grant writing. All in all, though, the training of faculty for university teaching is rarely researched.

Regarding the preparation of graduate-student teaching assistants (GTAs) for teaching, the number of programs is increasing and the corresponding field of research is growing fast. The programs are of varied form and length, from a 3-hour summer course to ongoing seminars throughout their stay in the institution. Varied goals are pursued: for instance, to move away from only lecturing or to get a better understanding of the departmental culture. More can be found about such programs in Beisiegel (2017), Deshler et al. (2015), and Harris, Froman, and Surles (2009). Programs for training GTAs are relevant when thinking about training cegep teachers. Indeed, their education is similar: both groups are students of mathematics (trained/being trained to be mathematicians; see Section 1.1.1) and normally have no prior training in the areas of pedagogy, teaching, or didactic. Both groups teach similar courses as GTAs are often assigned introductory mathematics courses, similar to what is taught in cegep. That said, there are important differences between cegep and university institutions (e.g. class sizes, general science program in cegep as opposed to disciplinary programs in university).

As we attended to the existing programs and studies on the training of GTAs and university faculty, we were left thinking about the many questions raised by those projects. We concluded that there still seems to be much work to do to understand what kind of training would be best for postsecondary teachers, whether GTAs or faculty. Questions were raised about how GTAs learn to teach (Deshler et al., 2015), how GTAs' actions influence students' learning (Speer, Murphy, & Gutmann, 2009), how to implement training in departments where some faculty or students may find training to teach useless or a waste of time (Harris et al., 2009; Keynes & Olson, 2001), and how to redefine what effective teaching is (DeFranco & McGivney-Burrelle, 2001). Studies also ask how to make teachers value research results as a basis for improvement (DeFranco & McGivney-Burrelle, 2001), how to train GTAs to learn from their own experiences and practices throughout their career (Kung & Speer, 2009), what GTAs *know* about teaching and learning when they enter graduate school (Kung & Speer, 2009), how to evaluate the effectiveness of training programs for GTAs other than the popular and controversial student evaluation (Speer, Deshler, & Ellis, 2017), and how to assess change from one semester to the next in GTAs' ability to enhance the learning outcomes of their students, in a context when grading systems are not uniform (Harris et al., 2009).

Researchers encourage gaining a deeper understanding of the beliefs and values of instructors hold (e.g. Keynes & Olson, 2001), as well as of their life and experiences. This would allow for the creation of a teacher education program that would integrate into their day-to-day life and possibility creating real change (Beisiegel, 2009). Combined with the questions raised by the CSÉ about the skills and knowledge specifically needed to teach in cegep, we get the sense that there is (still) more to becoming a teacher at postsecondary level than what we already know. This led us to delve into an exploratory empirical study on the process of becoming a cegep mathematics teacher.

1.3 Training for K-12 Teachers

As we reflect on cegep teachers' training, if we consider cegep education chronologically placed between compulsory education (elementary and high school) and university, we may naturally look at both current trends in the training of postsecondary teachers (as in the previous section) and in the training of elementary and secondary teachers.

There is a large amount of research on teacher training for elementary and secondary teachers and its impact. However, we will argue in this section that more research into teaching at the postsecondary levels is needed before engaging in adapting or transferring the results of those studies to address the training of postsecondary teachers—or arguing that such adaptation or transfer is not possible or desirable. Indeed, not only is the experience of novice teachers at postsecondary level fundamentally different from the experience depicted in those studies, but the institutional differences are too important. To make our point, we give examples of three categories of research about teachers: in pre-service education, during their first years of teaching, and in professional development.

Research about Pre-Service Education

Ambrose (2004) presents a study on prospective elementary teachers who agreed to take an experimental course named Children's Mathematical Thinking Experience (CMTE) at the same time as a mathematics course. This study gives examples of changes in beliefs of prospective teachers, during the CMTE course, about teaching mathematics (e.g. that it is more than just presenting information), about multiple solution strategies (knowing more than one way to help more than one child), and about the importance of understanding mathematics (e.g. conceptual understanding is required even for teaching young children). The author also discusses how the CMTE course gave the opportunity for such changes. Another example is the study presented by Feinman-Nemser et al. (1989) who looked into first-year pre-service teachers enrolled in an introductory course called "Exploring teaching" that was created for them to be confronted with their preconceptions of teaching. The study focuses on the eventual changes in first-year pre-service teachers' conceptions and how their conceptions changed and why. There were four strands of analysis: (a) traditions of teaching, (b) the relationship between teaching and learning, (c) the contexts of teaching, and (d) teacher knowledge (i.e. the knowledge teachers require to teach). The results suggest there were changes in the conceptions under study and these were attributed to the form of the course.

Research about Teachers in their First Few Years of Teaching

Ensor (2001) recalls a 2-year longitudinal study where 7 students were followed during a mathematics method course set in their first year of teaching at a high school in South Africa. The purpose of the study is to examine the re-contextualization of pedagogical practices from the method course to the new teachers' classroom. First, the mathematics method course was studied: the classes were observed, students and teachers interviewed, and work collected. During their first year of teaching, the seven participants were each interviewed four times and some of their lessons video recorded. The main conclusion of the author is that "[a]n apparent disjuncture was identified between the practices privileged from the mathematics method course and the ways in which this teacher (and others in the sample of seven) practiced in her classroom. [...] It was found that the mathematics method course influenced her professional argot rather than her classroom practice" (p. 316).

Research about Teachers' Professional Development

We consider the following example: Franke et al. (1998) report on a study in which they followed three elementary teachers during a professional development opportunity, Cognitive Guided Instruction (CGI), over four years. The professional development opportunity, through workshops with the researchers, interactions between participants, and with a mentor experienced in CGI, focused on children's mathematical thinking. The researchers analyze how changes occurred in the teachers' beliefs, knowledge, and classroom practices through CGI. They conclude "that professional development focused on children's mathematical thinking provides a basis for teachers to engage in ongoing practical inquiry directed at understanding their own students' thinking and thus, provides a basis for teachers to engage in self-sustaining, generative growth" (p. 79).

In all the examples above, the training that was developed and the evidence that it had (or not) an impact on the beliefs, conceptions, practice, or growth of the (prospective) teachers is interesting and could be useful when thinking about developing training for postsecondary teachers. However, we argue below that there are important (institutional and personal) differences between postsecondary and elementary/high school education that may need to be understood before developing appropriate training for cegep mathematics teachers (as opposed to attempting to transfer the existing training for elementary and high school teachers to the postsecondary setting without exploring and attending to the fundamental differences of these contexts).

Indeed, one of the triggers and fundamental assumptions of the present research is that postsecondary mathematics teachers are trained to become mathematicians (in the sense referred to above, in Section 1.1.1) and this makes their training before arriving to the teaching profession fundamentally different from that of K-12 (pre-service) teachers who have enrolled, or are enrolled, in pre-service teaching programs aimed at training elementary or secondary teachers. One essential difference is that being enrolled in a pre-service teaching program allows the students to put themselves in the position of a teacher; they have opportunities to think and act as a teacher (Lee & Shallert, 2016). On the other hand, university mathematics students' success in their program is independent of their ability, capacity, or interest in teaching (Beisiegel, 2009, pp. 282–283).

There are also institutional differences such as the small amount of time that postsecondary teachers spend with their students compared to the time elementary and high school teachers do—which may make trying new things harder (Speer, Smith, & Horvath, 2010, pp. 100–101); and the size of classrooms which tend to be considerably bigger at postsecondary levels. There are also differences of didactic nature. For example, mathematics learning difficulties are often specific to the content being taught, which is, of course, different between levels (Speer, Gutmann, & Murphy, 2005, p. 77).

More empirical research on teaching at postsecondary levels would certainly increase our understanding of its uniqueness and inform the design of training for postsecondary teachers (Speer et al., 2010, p. 100). Further, such research may illuminate how to adapt or transfer some of the findings in research about elementary and secondary teaching into the field of postsecondary education (Speer & Hald, 2008, p. 313).

1.4 What Do We Mean by "Becoming a Teacher"?

The sections above are aimed at justifying our interest in exploring questions of postsecondary teacher training, specifically for cegep teachers, through an empirical study. The inadequacy of existing training, the scarcity of research into the training and professional development of pre-service and in-service postsecondary teachers, and the fundamental differences between K-12 and postsecondary levels point to the need for a better understanding of the realities of postsecondary teachers. In particular, understanding the skills and competencies put into play in cegep teachers' everyday tasks and the challenges they face will hopefully inform discussions about their training and professional development.

It is in this context that we decided to study the **process of becoming a cegep mathematics teacher in the first few years of teaching**. We take a perspective, as Beisiegel does (2009, p. 26), that only by (at least partially) understanding the life and experience of novice teachers will we be able to truthfully and meaningfully weigh in on the issue of preparing novice teachers for what is to come in their professional life. Also, by understanding (at least fragments of) the process, of what happens in the beginning, we will understand (some of) the needs, if any, of cegep teachers when they start their new profession. It makes sense for us to focus on the beginning of their journey, to understand their "first" challenges and the skills and competencies they seem to require right away at the start of their participation in the profession. Our expectation is that this study will help enlighten the process of becoming a postsecondary teacher, give insight on new teachers' experiences, and contribute to the ongoing discussion on teacher preparation.

In the context of this research, we consider the process of becoming a teacher in the first teaching experiences in cegep, where the new teacher is *entering* the profession. We do not claim that this process has a definite start and end; on the contrary, it is an ongoing process (Beisiegel, 2007). Bilodeau (2013), who inquires about the process of becoming a cegep teacher from the point of view of experienced teachers (with 10 to 30 years of experience), mentions that the participants showed in multiple ways how they never stopped *becoming a teacher* (p. 261)[7]. We take the stance that there is not one moment when one starts to become a teacher, or finally is a teacher. We will then use this expression, *becoming a teacher*, in the sense of an ongoing process, happening over, at least, the first few years of teaching, if not for as long as the person is teaching. Moreover, it is

[7] Bilodeau asked experienced cegep teachers, independently of the discipline, to revisit their entry into the profession, specifically from the perspective they have today as mentors for novice teachers. The author had teachers write stories of significant events that happened during their first years as teachers. The analysis of the stories reveals that mentors who revisit their entry into the profession are likely to discover elements that could be useful in their role of mentor to novice teachers.

not a progression towards one goal, or one way of being; and becoming a teacher is not just in the practice, it is in the ways of thinking and of seeing things. Becoming a teacher is about learning "what works and what does not," for oneself and for the students. It is about defining what becoming and being a teacher is and means to a person in the profession. Below are two examples of the (very few) studies that address the process of becoming a teacher at postsecondary level. The following examples show fragments of this process of *becoming*.

Epp (2003, cited in Speer et al., 2010, p. 103) writes about the change she decided to make in her classroom when teaching logic. She explains how she came to teach a course similar to a transition-to-proof course. She expected that it would solve the problems of struggling students in advanced courses and that she would have the opportunity to address the basic material other teachers did not have time to touch upon, such as sets, functions, and relations. At first, she went over logic concepts and rules quickly so as to move on to sets, functions, and relations. Her observations of students' difficulties recognizing equivalent logical statements, negating statements, and grasping quantification, led her to believe that students would benefit from spending quite a bit of time at the beginning of the course on basic notions and language related to elementary logic. She then changed her teaching to reflect this. Epp's self-reporting shows an example of a teacher in the process of *becoming a teacher* not necessarily at the beginning of their teaching career. It also gives an example of how lived experiences can impact a teacher's decisions. In this case, the teacher's experience of observing students' difficulties led her to change her ways of teaching. This example also shows us that teachers can give a rationale for the changes in what they do and think as teachers.

Beisiegel (2017) reports on a study where she looked at the journey GTAs take as they become mathematicians and teachers of mathematics. She did so through the lens provided by the four developmental stages that school teachers go through according to Katz (1972): survival, consolidation, renewal, and maturity. Beisiegel interviewed GTAs in first through fourth year of their graduate studies and found that they go through similar stages. However, the way Beisiegel went about this work, with a lens that led her to look for the four stages of Katz, counters our commitment required in a narrative inquiry (Clandinin & Connelly, 2000). In our study, we are committed *not* to enter a linear inquiry guided, for example, by a list of stages to look for, but to listen and learn from the stories that novice teachers tell about their lives while becoming a teacher.

This is one aspect of narrative inquiry: to let the lives we meet tell us what they are about. In this sense, the main goal of this study is to let the teachers tell us about their journey into becoming teachers. We want to know their perspective on the experiences that made them who they are and are becoming.

Now that we've established our position of what it means to be in the process of becoming a teacher of mathematics at cegep level, we next address studies on the process of becoming a teacher at the postsecondary level. This next section also addresses elements which may influence that process. Afterward, Section 1.6 addresses the process of becoming a teacher at elementary and high school levels.

1.5 Becoming a Teacher at the Postsecondary Level

"He who can, does. He who cannot, teaches."
George Bernard Shaw, 1903

"A mathematician is great or he is nothing."
Philip J. Davis and Reuben Hersh, 1981

A distinguishing feature of becoming a postsecondary teacher is, as already mentioned in Section 1.1.1, that the teachers had been trained with goals other than teaching[8]. Further to this, among the generally scarce research in this area, a considerable amount of research points to an implicit training that may hinder the trainees' interest in teaching.

In her dissertation, Beisiegel (2009) explores what it means for GTAs to become mathematicians and teachers of mathematics. She concludes that there was a tremendous influence from the department and its culture hinting to the GTAs that their attention and efforts should be on becoming a mathematician, rather than, or in opposition to, becoming a teacher of mathematics. She shows how certain behaviours were valued in order to become part of the "group": for instance, to avoid giving a bad evaluation to mediocre professors and to replicate the conventional lecturing-style teaching they received. On the contrary, behaviours that suggest an interest in

[8] We take the stance that they were trained as mathematicians, i.e. researchers in mathematics, or practitioners of mathematics, where the culture does not qualify "teaching mathematics" as a defining practice of mathematicians.

improving or giving time and attention to teaching were forbidden or discouraged in the journey to becoming part of the group. It seems that everything in the lives of the GTAs, from teaching assistantships to research and even coursework, hindered a focus on and possible improvement of teaching (Beisiegel, 2009, p. 179).

Beisiegel's study opens our eyes to the notion that the process of becoming a teacher starts far before a first teaching contract is signed. The study reveals *implicit training* (see beginning of Section 1.2) that greatly influences the process of becoming a teacher—e.g. the "hints" that departments (teachers and supervisors) provide. We found that other researchers comment on similar issues. For example, DeFranco and McGivney-Burelle (2001, p. 687) observe how the institution, and in particular the department, shaped the GTAs' vision of teaching and learning and underscored the primary importance of research through students' day-to-day interactions with faculty. Herzig (2002) also remarks that GTAs would adhere to teaching styles enacted by the professors they would live alongside the most.

Research that suggests mathematics faculties influence GTAs in their vision and practice of teaching cannot be discussed without mention of the critiques of mathematicians' teaching in general. Indeed, teaching methods used in university mathematics education are cited as a significant reason why students choose to leave the discipline of mathematics (Martin, 2001; Seymour, 2000, both cited in Beisiegel, 2009). Kline (1977) even maintains that "[t]he greatest threat to the life of mathematics is posed by the mathematicians themselves, and their most important weapon is their poor pedagogy" (p. 5, cited in Beisiegel, 2009, p. 37).

Aside from the teaching practices, visions of teaching and of mathematics are another aspect that seems to be passed on to students in mathematics departments. Beisiegel (2009, p. 29) writes about a change in postsecondary education that is reported by Kline (1977), Boyer (1990), and Kronman (2007). Before the mid-nineteenth century, the goals of universities were to educate, rather than research, and therefore teachers were asked to refrain from research as it would take away time from what their main focus should be: teaching. However, by the early twentieth century, the focus shifted towards research and it was recognized that the quality of teaching suffered. This, in part, led to a belief in the community that mathematics faculty with a focus on teaching are poor mathematicians and that it is a sign that they are not good enough to participate in the mathematical community (Kline, 1977, cited in Beisiegel, 2009, p. 47). As a result, good teaching is synonym for a failed career in mathematics, an impression that is passed on to graduate students through the culture of university mathematics. Further, there seems to be a generally negative judgment in mathematics departments towards lower-level university mathematics courses (Beisiegel, 2009, p. 48), which are similar to cegep-level courses in Quebec, in that the content of these courses is not really mathematics as it does not meet the mathematicians' standards of "real" mathematics.

Beisiegel's work reveals the influence university education in mathematics has on mathematics students and graduates as they become postsecondary teachers, and in particular, cegep teachers. The goal of her study, to explore how mathematics graduate students develop a sense of themselves as future mathematicians and as postsecondary teachers of mathematics, is similar to that of this dissertation: to explore the process of becoming a teacher at cegep level after completing a university degree in mathematics. However, the approach, hermeneutics versus narrative inquiry, and participants, graduate students versus novice cegep teachers, are different. It will be interesting to connect the conclusions of our exploration of working teachers with the conclusions she drew from her exploration of GTAs.

This past section outlined some of the factors that influence the process of becoming a teacher at the postsecondary level—in particular, living in university mathematics departments for some time, an experience shared by GTAs and cegep teachers. In the next section, we explore the topic of becoming a teacher at the elementary and secondary levels.

1.6 Becoming a Teacher at the Elementary and Secondary Levels

There is an important amount of research that addresses the process of becoming a teacher at the elementary and secondary levels. In this section, we report on a sample of these studies; our review is split along five themes. While some studies may fit into more than one theme, we mention each as an example within only one theme. We return to the topics addressed by these studies in Chapters 2 and 3, where we contrast them in light of the tools chosen for our study.

As discussed above, studies addressing the process of becoming a teacher at elementary and high school levels bring much to our reflection. They remain, however, fundamentally different from the study that is the object of this dissertation. The studies focus on a reality where in-service and pre-service teachers are exposed to a long explicit teaching training program—which is far from the reality of in-service and pre-service postsecondary teachers.

1.6.1 Examples of Research that Use Stories

The use of stories in the exploration of becoming a teacher fits the goals of our study. The sample below shows us how such an approach can humanize the data and bring a rich understanding of the teachers' lives as well as put a face on the struggles often hidden when other tools of research are used.

Renard (2003) shows, through the story of a new teacher[9] who left the field after one year, the challenges novice teachers face in connection with the school's expectations. One expectation was that new teachers would do the same job as experienced teachers, and in the same amount of time. The study points out this unrealistic expectation and provides arguments as to why novices take more time to do teaching-related activities (such as preparing classes and tests or grading) than experienced teachers. The author concludes that new teachers need to be given the time and space to become a teacher. She suggests lightening the load outside the classroom, to keep a novice teacher in the same grade for more than a year and to increase support by putting in place observations and mentorship from more experienced colleagues. This use of a story succeeds in giving a face to a struggling novice teacher and the phenomena of attrition.

Using portraiture, Mascio (2018) explores, through classroom observations, interviews, and document analysis, the complexities of learning, teaching, and learning to teach. He follows a pre-service teacher in a one-year student teaching internship in fifth grade to assess her growth as she combines the theoretical knowledge gained during her training with the reality of the classroom. Portraiture was chosen as a way to capture humanity in the process of learning to teach and to bring a deep understanding to the process. Mascio holds that looking at teachers both as learners and teachers is how they can be best supported.

Orland-Barak and Maskit (2011) report on a narrative analysis of stories written by teachers about their experience in their first year of teaching. The authors analyzed the stories using multiple

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[9] The article does not say what year the teacher was assigned to teach. However, the teachers in this study were asked to work on the 9th year curriculum so we could hypothesize it was that year.

interpretative readings. The stories were read for form and content. Analytic tools from the literature were used to look into the use of headings, names, plots, and metaphors, as well as the dimensions of teachers' professional lives: people involved, roles, functions and accountabilities, didactic and pedagogical agendas, etc. The process included two major cycles, the first one a holistic reading looking for general themes in relation to content and form, followed by a second round of readings around the emergent common themes from cycle one. This allowed the authors to shed light on three themes, which they characterized as part of the "shady corners of teaching," that help better understand the life of novice teachers: (1) realizing the limitation of teachers' capacity; (2) coping with the realization that vision is incompatible with reality; and (3) struggling with the multiple voices that operate in the educational system.

We address in Section 3.1.5.1 why we chose to use stories.

1.6.2 Examples of Research Referring to Stages

Below is a sample of studies that invoke steps or stages through which teachers go in their process of becoming.

Katz (1972), as mentioned in Section 1.4 in relation to another study, presents a list of stages school teachers go through. The first is survival, where teachers doubt whether they can go through the day in one piece and with all their students still alive. The second is consolidation, where the teachers know they can survive and now need to consolidate what was learned previously and what are the next skills to master. The third stage is renewal, where teachers begin to open up to new approaches and innovative practices happening in their domain. Finally, the last stage is maturity, where the teacher builds the foundation of who they are as a teacher by exploring the underlying beliefs of their teaching practices.

Harrington and Sacks (1984) list stages they have identified in previous work (Sacks & Harrington, 1982) about the transition from student to teacher: anticipation, entry, orientation, trial and error, integration/consolidation, and mastery (p. 155). They come up with ways to help teachers at all stages in a semester-long seminar where student-teachers teach for the first time.

While these studies are revealing when it comes to stages teachers might go through in their journey of becoming, the research approach itself is essentially different from ours. We go about our goal of exploring teachers' process of becoming through a narrative inquiry, listening and learning from the stories teachers tell us about who they are becoming and why, focusing on their experiences as they speak of, and reflect on, them—as opposed to observing the experiences (through a list of predetermined list of categories, stages, or phases).

1.6.3 Example of a Research that Encourages Deeper Studies that Promote Understanding Experience

Below we report on a study that advocates for research that focuses on getting a deeper understanding of teachers' experience.

Veenman (1984) reviews 83 studies on the problems new teachers encounter, both at elementary and high school levels, which have appeared from 1960 to the publication of the paper. The data of the studies reviewed was gathered mostly from written questionnaires where teachers were asked to assess on a scale how much a given problem affects them. Veenman presents a list of 24 most frequently reported problems of beginner teachers (pp. 154–155). Most of these problems were similar, independently of the contexts in which the teachers were situated. The author argues that while the studies are informative on the problems beginner teachers may have, they do not situate the problems with respect to a person in context. Veenman urges future studies to go more in-depth and look at true experience, taking into account the person and the situation (institutional, social, and cultural) that form the context in which the problems arise. On a similar note, more should be said about certain topics to really understand the phenomena they engender. For example, papers report "classroom discipline" as one of the main problems identified by novice teachers; but, as Veenman argues, this may mean a lot of different things for different authors and teachers.

We align with the call for research that aims at gaining a deeper understanding experience and elaborate on our perspective in Section 2.2.2.

1.6.4 Examples of Research on Tensions, Challenges, Problems, and Concerns

Below we present a sample of studies that are interested in how tensions, challenges, problems, and concerns play out in the process of becoming a teacher at elementary and secondary levels.

Pillen, Beijaard, and den Brok (2013) examine tensions experienced in identity making by beginning teachers, and the associated feelings and ways to cope, in order to understand what kind of support new teachers would need. The transition from student to teacher is often challenging for novice teachers. The authors report on beginning teachers, which include last-year students in teacher training programs (who spend much time teaching in classrooms) and first-year in-practice teachers. They present a list of 13 tensions found both in the literature and from interviewing 24 beginning teachers. Some of the tensions listed are the following: wanting to care for students while being expected to be tough, experiencing conflicts between one's own and others' perspective on how one should learn to teach, and the contrast between the expectations about one's expertise in the knowledge to be taught and the feeling of having an incompetent grasp of this knowledge. The list was then used to create a questionnaire where 182 beginning teachers from elementary schools, high schools, and vocational schools had to qualify their experience of each tension using a scale from 1 to 4. The authors recognize their methodology does not allow them to claim that these tensions are exclusive to beginning teachers since they did not consider more experienced teachers. They also suggest in-depth interviewing rather than only a questionnaire as a way to gain deeper understanding of what led to the tensions experienced as well as the impact of these tensions on how and who they became as teachers. The authors analyzed the results of a questionnaire with a quantitative method.

He and Cooper (2011) address the professional development of secondary teachers by working with five secondary pre-service teachers (of English, social studies, and history) in the last year of their teacher education program and their first year of teaching. Their goal was to describe concerns the participants had and how they dealt with them. Three topics came up frequently during the teacher training, each participant relating to it at different levels: classroom management, student motivation, and parental involvement. After the first year of teaching, classroom management became less of an issue, but they were still working on motivating their students. Standardized testing and how it limits teachers in the topics they would like to use to interest their students, lack of administrative support, lack of modern resources such as smart boards, lack of parental involvement, and the difficulty of balancing professional and personal lives came up as factors that influence students' motivation. The teachers dealt with these issues using the following strategies (He & Cooper, 2011, p. 108): (1) learning from their students in order to better motivate them in content area learning; (2) using assignments, observations, and class discussions to better get to know students and their families; (3) sustaining their passion for teaching by focusing on positive experiences such as student accomplishments and statements of appreciation from parents; and (4) adopting individual ways to manage stress and frustration. The authors also emphasize that teachers faced challenges due to the varied and specific contexts in which they had to teach. The authors reflect on the success of their participants as new teachers and the potential benefits they got from participating in the study, which acted as a space to reflect on their practice (p. 112). They conclude with a list of things to do to improve training of secondary teachers.

While it is reasonable to expect that novice cegep teachers will encounter tensions, challenges, and problems in their journey, some or most of these may be significantly different than those described by elementary or high school beginner teachers. For example, parental involvement (He & Cooper, 2011) may not be particularly present in cegep as students are expected to act as adults and parents to be much less involved. Additionally, the reported feeling of having an incompetent grasp of mathematical knowledge (Pillen et al., 2013) potentially takes on a different form in the case of cegep teachers who are trained as experts of mathematics. Looking into the tensions, challenges, problems, and concerns beginner teachers identify at the postsecondary level might shed light on what areas postsecondary teachers would benefit from being trained. In Section 2.2.4 we discuss our perspective on these notions and how they may play out in the context of postsecondary education.

1.6.5 Examples of Research Using the Concept of Identity

The concept of identity has often been used in research focused on teachers.

Lee and Shallert (2016) investigate how pre-service elementary (pre-K to fourth grade) teachers conceptualize teaching and develop their identities as teachers during a teaching preparation program of three months. The study brings understanding to pre-service teachers' developmental trajectories. It discusses how pre-service teachers adopt a double stance of both teacher and student in their teacher-training program. The authors suggest that an understanding of teachers' trajectories would be heightened by researching their experiences in their first year of teaching.

Jones, Brown, Hanley, and McNamara (2000) discuss the transition from being a "learner of mathematics" to being a "teacher of mathematics"; specifically, they address the transition in terms of the interactions between participants' present perceptions of mathematics and of themselves, their memories of mathematics and of their past selves, and how an image of themselves and their identity as teachers of mathematics is created in the transition. The study describes pre-service elementary teachers' journey from seeing mathematics in a negative light to seeing it in a more positive light, as they let go of their vision of mathematics "skills" being in the genes and of their past failures.

Beattie (2000) looks at prospective secondary school teachers during a year-long teacher education program in which reflection through written narratives was one of the requirements. The author, over the years, has read over 900 narratives of prospective teachers. Three themes emerge from the narratives: "creating a professional identity: connecting the personal and the professional"; "creating relationships and making new relations: learning from and with others"; and "creating new narratives: connecting self, school and society" (p. 5). A study of the narratives in each theme shows that "the creation of a professional identity is a unique process for each prospective teacher, and that the process involves the examination and transformation of existing knowledge and the adaptation of such knowledge, skills and attitudes to the professional situations at hand. For each individual, what has to be learned is intimately connected to what is already known" (p. 19).

Schaefer and Clandinin (2011) wonder about beginner physical education teachers' experiential knowledge and their effect on them staying or leaving the profession. After meeting with two novice teachers four times during their first year of teaching, the authors attempted to fit their stories into conceptualizations found in the literature, particularly into the trends and tendencies of early career teacher attrition found in the literature. They conclude that the participants "fitted" in the categories, but found that their unique lives, their unique experiences, were lost in the "fitting" process. In other words, they were reduced to research trends while their lives as new teachers were much more than that. While the teachers did share a similar experience as novice teachers on the surface, the authors knew they both grew up, went to school, and taught in different landscapes. They also came to teaching for different reasons and had different goals. These key aspects of their lives as novice teachers were lost in the trends they represented. Schaefer and Clandinin then attended to the shifts in novice teachers' identity in the beginning of their lives as teachers through narrative inquiry, where they attended to elements such as why they came to teaching and their teaching goals. By thinking narratively about the teachers' stories, the authors were able to grasp the complexity of participants' lives as novice teachers, of who they are and are becoming.

According to the authors, attending to teachers' stories in such details is key to start the discussion on how to keep teachers in the profession.

This work gave us a concrete example of what we can learn by engaging in a narrative inquiry which attends to identity and to the elements that are lost when using solely existing categories to structure a research. As our study aims at contributing to a discussion on postsecondary teacher preparation, we hope that our narrative inquiry attends to the nuances that may be hidden in a study where one aims at making participants fit into categories.

In like manner, Driedger-Enns (2014) use a narrative inquiry approach to inquire into beginning elementary teachers' experiences. She met with them weekly over two years, at which occasion teachers shared stories of their experiences in school. The author shows how the experiences in their personal landscape shaped who the teachers were in school contexts, how their professional identities were created both on personal and professional landscapes, and how their personal experiences helped make sense of difficult situations in school.

We address our own conceptualization of identity in Section 2.2.3.

1.6.6 In Conclusion

The studies mentioned above inform us on the types of studies that are concerned with the process of becoming a teacher at K-12 level. To some extent, all (or most) of these studies connect or support their results to the pre-service education received by the participants under study. The fact that postsecondary teachers do not receive a comparable pre-service education, suggests to us that results and conclusions from such studies may not be easily transferrable (or not transferrable at all) to the context of postsecondary teaching.

However, certain aspects of those studies do inform our research. First, as done in, for example, Beattie (2000), Lee & Shallert (2016), Mascio (2018), Pillen et al. (2013), and Veenman (1984), we are drawn to see the process of becoming a teacher as a learning process. This seems particularly fitting in our project as postsecondary teachers do not receive training to teach. Therefore, most of their learning of what it means to be a teacher, and definitely what does and does not work for them (see Section 1.4), happens *on the job*. Studies on becoming a teacher at secondary or presecondary levels show different ways in which the transition from being a student to being a teacher brings challenges and tensions. Based on these studies, we expected that the participants in our study would also encounter challenges and tensions as they become teachers.

Identity is a key feature of many studies when the focus is on individuals—as it is in the case of our study. Our readings of such studies brought us to think of the process of becoming a teacher as the creation/modification of a (professional) identity. We choose an approach that conceptualizes identity in a way consistent with narrative inquiry, as is done in Schaefer and Clandinin (2011) and Driedger-Enns (2014). In particular, the use of stories is some of these studies illustrate the power stories have to express data in a humanized and nuanced way—we attempt to do so in this dissertation.

In light of the above considerations, we understand *becoming a teacher* as a process that happens over time and without a definite beginning or end. It is a learning process where a teacher's identity is modified as new experiences occur, sometimes challenging and sometimes creating tensions. This process is influenced by many factors, such as, for instance, novice teachers' experiences in university mathematics settings.

1.7 Research about Past Experiences that Influence Teaching

As explained in the introduction of this dissertation, we have entered our inquiry with an open mind about the process of becoming a teacher and went on to meet novice teachers. As we read and reread the stories the teachers shared with us, we asked ourselves questions about how teachers become/are becoming who and how they are as teachers. We asked what made them into the teachers they are today and are becoming. It became clear that, at the centre of how novice teachers talk about themselves as part of the profession, are the ways in which they justify their decisions and choices as teachers: using their past experiences. We therefore became interested in how past experiences influence new teachers' day-to-day actions as teachers.

In this section, we explore how the literature speaks about teachers' past experiences as students, as teachers, or in other contexts—that is, past experiences which play a role in teachers' lives, in *whom* and *how* they are as teachers. We argue that while it is widely accepted that past experiences influence who and how teachers are, the nature and influence of such experiences are not clear.

1.7.1 Past Experiences as Students and as Teachers

It is widely accepted that the past experiences of teachers as former students influence their teaching practice and who they are as teachers (e.g. Court, Merav, & Ornan, 2010). Multiple authors mention how teachers' experiences as students in school act as "implicit" training in teaching. In the case of postsecondary teachers, it might be the only teaching training they receive. While authors mention the case of teachers teaching as they have been taught (e.g. Schifter, 1998, p. 58), one could also imagine that teachers teach as they have *not* been taught, or as how they wish they were taught.

The Conseil Supérieur de l'Éducation mentions how cegep teachers have had the opportunity, as students, to socialize with the practice of cegep teaching but that it is not enough to sustain and promote the development of a true professional identity (CSÉ, 1997, p. 57). According to Beisiegel (2009), mathematics graduate students' sense of themselves as teachers is influenced by the education they received in university and by the implicit teacher training they received during their time as students (p. 42). Added to this implicit training is the fact that, as university students, they are often entrusted with teaching assistant duties; that students are assigned these positions while studying only mathematics reinforces the idea that sitting in mathematics classes is (also) a preparation for teaching mathematics (Beisiegel, 2009, p. 286).

Monaghan (1989) shows that teaching assistants rely mostly on ways of teaching they have been submitted to as students (cited in DeFranco & McGivney-Burelle, 2001, p. 682). DeFranco and McGivney-Burelle (2001) observe that before entering a mathematics pedagogy course, mathematics teaching assistants already have a belief system on mathematics, teaching, and learning similar to novice school teachers. Such system relies "primarily on models of teaching they had experienced as students" (p. 685). Furthermore, even after the pedagogy course and after the students adopted a new set of beliefs on mathematics, teaching, and learning, they did not change their practices (p. 687). This work emphasizes the power of the experiences as students of the discipline (as opposed to the experiences as students of pedagogy) on teaching practices.

In the case of secondary and pre-secondary teachers, studies have shown that past experiences as students shape how teachers enter their pre-service training as well as how and what they become as teachers. Clark (1988, cited in Weinstein, 1989, p. 1) says that "[s]tudents begin teacher education programs with their own ideas and beliefs about what it takes to be a successful teacher.

These preconceptions are formed from thousands of hours of observation of teachers, good and bad, over the previous fifteen or so years" (p. 7). The author also illustrates that these ideas are not representative of the real teaching work. Indeed, it comes from the perspective of students who only witness what happens in the classroom and not, for example, the administrative side of the profession and the preparation each teacher does before setting foot into the classroom. Hodgson (2001, cited in Beisiegel, 2009) connects the quality of mathematics teaching received by school educators in their education at all levels and the quality of the teaching they later dispense in schools.

Rust (2017) notes that "[t]here seems to be a collective amnesia among teacher educators about the fact that our students whether at the undergraduate or graduate level arrive in our pre-service teacher education programs with a wealth of experience of schooling and a lot of time watching teachers at work" (p. 383). Ignoring those experiences seems like a lost opportunity to root teachers' training in robust, long-term experiences. Further, it seems shortsighted to deny the potential effect of those experiences on whom the students in teacher training programs are and want to become.

Altan and Lane (2018) use narrative inquiry to study the potential impact of significant life experiences on teachers' dispositions, seen as "clusters of mindful and thoughtful habits that can evolve through constructive experiences" (p. 238). To categorize habits, the authors used a list of 16 habits of mind from Costa and Kallick (2000). They write that "[s]ignificant life experiences are the ones that 'personally affect the individual and are subjectively valued by the individual' and the significant experience results in 'expansion of skills and abilities, sense of self, or life perspective, or it precipitates a transformation that involves the whole person' (Merriam & Clark, 1993, p. 182)" (p. 239). Results show that significant experiences can be separated into two categories. The first is that of Learning Environments, which include school, though the ones related to family are the most important. The second category is of Personal Attributes: for instance, participants identified travelling and having hobbies as important in their development. Thus, there is a variety of experiences that teachers find significant to their development as teachers. In that sense, the study suggests that there are experiences not directly related to the teaching practice, learning, or subject matter that nevertheless have a significant impact on teachers' development.

Regarding the experience of teachers *as* teachers, we have already mentioned, in Section 1.4, an example of a teacher's experience influencing their beliefs and their practice: Epp's (2003) transformation as an example of a teacher changing their practice and beliefs about teaching and learning mathematics while being a teacher.

1.7.2 Experience Outside of School

Many authors emphasize that experiences outside school influence how one is and becomes a teacher. For example, Calderhead (1991, cited in Beattie, 2000) says that pre-service teachers' views about teaching are determined by knowledge from school and personal experiences. Crow (1987, cited in Weinstein, 1989, p. 53) observes that individuals have a "teacher role identity" (TRI) based on events from their childhood, past teaching experiences, or past teachers, even before they enter a teacher education program. During the teacher education program, their TRI filtered new experiences lived as part of the program and determined whether these were consistent with their identity, thus judged as valid, and then assimilated, or inconsistent with their identity, thus judged as invalid, and then rejected.

Kay Klauswith (2005) learns about the influence of life experiences on how one learns to teach, especially in the case of mature students in a teacher-training program for elementary school. The author concludes that experiences lived in other contexts, such as other employment, trips, or readings, were a basis on which teachers formed their decisions. Some experiences were helpful while some prevented teachers from developing new or effective teaching practices.

1.7.3 Nature and Influence of Past Experiences

While the studies I refer to above point to an important relation (often express as "influence") between past experiences and who and how the teachers are/become, they do not elaborate on the nature of the relation; past experiences influence the process of becoming a teacher—but how so, and what is the nature of such influence?

Grossman (1989) presents a fine-grained study of what kinds of knowledge secondary-school novice teachers use as they learn to teach. The particularity is that they received a university education in the discipline—literature, in this case—and not as teachers. Two of his participants held a bachelor's degree and one a doctoral degree. The study shows that learning to teach from experience alone was difficult for all three teachers. Indeed, they relied strongly on what they remembered of their experiences as students, both in high school and in college, and on their newly acquired classroom experiences as a teacher to shape whom they became as teachers. Experience shaped what they thought was appropriate curriculum, teaching methods, and grading strategies. It also shaped their expectations of students, how students learn, what they know, and what they would find difficult. One teacher acknowledged the need to adapt the teaching techniques used by her instructors in college, but did not address how she would attempt to do so. Another recognized that the methods he used, which were inspired by a college professor, were frustrating for students; but this teacher found it difficult to teach differently.

The author further observes that new teachers are rarely assigned the most performance-oriented classroom, which increases the gap between their image of ideal students and the students they actually have in their classroom. Because the teachers' experiences in the classroom were so dissonant with their expectations of what it would be to teach secondary students, their classroom experiences became their only source of knowledge about secondary students' interests, knowledge, and behaviour. The author states that the experiential knowledge they acquire in the classroom may take a while to become part of their everyday decision-making. Therefore, novice teachers may still feel the push towards teaching as they were taught in college, despite experiences in the secondary school classroom showing them the approach is unsuitable. The author establishes that the "disciplinary knowledge and interests [in literature] seem to overwhelm [the teachers'] pedagogical instincts" (p. 203). This study brings much understanding to novice teachers' first experiences as teachers and is close to the parameters of this study, as our participants are trained in their discipline first before their later transition to teaching.

We conclude that it is recognized that one's experiences as students, teachers, and outside of school play a role in the process of becoming a teacher. What is missing from the studies above is more fine-grained information on the experiences that turned out to be significant in the process of becoming in the case of individuals, and on how these experiences are significant. We believe such an analysis would be key in a well-informed reflection on appropriate training for cegep mathematics teachers.

1.8 A Brief Conclusion

We are interested in exploring the process of becoming a cegep mathematics teacher, with a focus on understanding their experiences. We thus hope to contribute a response to questions about pre-service training and professional development for cegep mathematics teachers, in particular, and postsecondary mathematics teachers, in general.

The above review of the literature on existing training for pre-service and in-service teachers of all levels as well as on the process of becoming teachers at various levels leads us to look empirically into the unique experiences of novice cegep teachers in the first few years of their practice. Topics such as identity, challenges, and tensions, as well as seeing *becoming a teacher* as a learning process seemed to fit our endeavour. The use of stories was also inspiring to us.

This chapter suggests that learning about the experiences of novice postsecondary teachers and the role these experiences play in individuals' process of becoming teachers would help us weigh in on the issue of pre-service and professional training. In the next chapter, we present our theoretical framework: it conceptualizes the ideas of learning, experience, and identity in connection with narrative inquiry.

CHAPTER 2: THEORETICAL FOUNDATION AND CONCEPTUAL FRAMEWORK

In this chapter, we outline the theoretical foundation and conceptual framework of this dissertation. We begin by reflecting on Dewey's theory of experience, which underlies our interest in novice teachers' experiences. We continue by addressing concepts associated with narrative inquiry that will help us refine, theoretically, our understanding of the process of becoming a mathematics teacher at cegep level. We conclude this chapter by stating the goals of our study, goals which stemmed from the theoretical foundation and conceptual framework detailed below, as well as from our time in the field[10].

2.1 Dewey: We Learn from Experience

This section details how we conceive learning and experience, two concepts at the heart of our research. Dewey's philosophy of education is our basis when it comes to thinking about those concepts. In a nutshell, learning happens through (educative) experience (Dewey, 1938, p. 25). Dewey holds that education and individual experiences are deeply and naturally connected. In this sense, Dewey's position enforces and supports the focus on experience that we chose for this project. In the next sections, we develop Dewey's ideas on the process of learning through experiences.

2.1.1 Experiences are Individual and Social

Dewey argues that all experiences are individual and social (1938, p. 39). Indeed, an experience is the result of the interaction between a person's *internal conditions* (such as one's needs, desires, or purposes; determinants of what kind of experience is had) and the *objective conditions* in which a person is engaged (the environment, physical or social; how a topic in brought up, someone's tone of voice, the weather) (1938, pp. 39–42). In other words, "[a]n experience is always what it is because of a transaction taking place between an individual and what, at the time, constitutes his environment" (1938, p. 43). The feedback of the environment in response to one's actions defines

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[10] As a reminder, it is following our data collection (see Chapter 3) that we added onto our theoretical foundations certain concepts, such as the concept of *stories to live by* (see Section 2.2.3), to help us understand the experiences that were shared with us in the field.

the experience lived. Specifically, Dewey points out that the general context of an institution (cultural, political, etc.) influences the experiences had within its walls (1938, p. 40).

In this sense, experiences cannot be considered as only internal to someone since everything around us is shaped by others' experiences and our own experiences help shape the world around us in return (1938, p. 37).

2.1.2 The Experiential Continuum

Dewey explains that having experiences changes the one who lives them in a way that will then modify how future experiences are had. Indeed, every experience is in some way characterized by the ones that were had before and then influences future ones in a continuing state of growth and change. This is what Dewey calls the "experiential continuum" (1938, p. 28). Indeed, "[w]hat [one] has learned in the way of knowledge and skill in one situation becomes an instrument of understanding and dealing effectively with the situations which follow" (1938, p. 44). Each experience is a result of a previous one, and guides to a future one: "every experience both takes up something from those which have gone before and modifies in some way the quality of those which come after" (Dewey, 1938, p. 35). Therefore, being aware of a person's past experiences can help understand how they deal with new experiences in their life.

2.1.3 Learning from an Experience

Dewey establishes that learning from an experience means "extracting" the full meaning of a given experience available for that particular person at that particular time: "it means that a person, young or old, gets out of his present experience all there is in it *for him* at the *time* in which he has it" (1938, p. 49; my emphasis). Learning occurs through a "quest for information and for production of new ideas" (Dewey, 1938, p. 79). This is done through the exercises of reflection, observation, interpretation, judgment, and use of common sense.

For learning to take place, an experience needs to be close enough to one's existing capacity of observation and judgment (Dewey, 1938, p. 68), as developed from past learning experiences. In other words, if a given experience cannot be put into continuity with an individual's past experiences, there may be no learning from this experience. Indeed, no subject matter, no discipline, is educational in and of itself (1938, p. 48) and is always subject to the principle of continuity. Also, because of the concept of interaction, the learning is influenced not only by the needs and capacities of the individual, but also by their (cultural and institutional) environment. In this sense, “[t]he principle of interaction makes it clear that failure of adaptation of material to needs and capacities of individuals may cause an experience to be non-educative quite as much as failure of an individual to adapt himself to the material” (Dewey, 1938, pp. 46–47).

In other words, a person’s existing knowledge and past experiences play a big role in their readiness to learn from an experience and be able to reinvest this new knowledge in response to future experiences. In the case of our project, this means that every new teacher does not necessarily learn the same thing, if anything at all, from a given experience; their unique personal knowledge and past experiences, their personal experiential continuum, make every journey of becoming a teacher unique.

2.1.4 (Mis-)Educative Experiences

Our perspective is that one learns through experience, that “all genuine education comes about through experience” (Dewey, 1938, p. 25). However, not all experiences are equal. Indeed, Dewey asserts that experiences can be given a value. They can be either educative or mis-educative (Dewey, 1938, p. 25). The quality of an experience is always determined by the experiential continuum, by what it can lead to in one’s personal experiential continuum. It is about the capacity to be connected with further experiences: “[the experience’s] value can be judged only on the ground of what it moves towards and into” (Dewey, 1938, p. 38).

An experience that has the effect of opening up to new experiences is educative, for example by sparking an interest or giving skills. An experience is educative when new notions and images arise from it and can be invested thereafter when one is confronted with new or similar situations. For this reason, experiences shape how one goes about the world and about new experiences, “[f]or it is somewhat a different person who enters into them” (Dewey, 1938, p. 35). In this sense, the principle of interaction cannot be discarded when judging the value of an experience, as the internal (existing capacities) and objective (environmental) conditions determine what kind of experience is had. It influences what the experiences can “move towards and into.”

An experience that has the effect of stopping or distorting the growth of an individual in the future, in that it prevents them from learning what they could from certain experiences or closes them off to certain types of experience, is considered mis-educative (Dewey, 1938, p. 25).

Consequently, the experiential continuum is implicated in every endeavour to differentiate between educative and mis-educative experiences (Dewey, 1938, p. 33). While there is continuity in all experience, it is the *type* of continuity that determines whether an experience is educative or not (Dewey, 1938, pp. 35–36).

2.1.5 Unfamiliar Experiences

Dewey indicates that being faced with challenging situations is a key aspect of life, growth, and change: "growth depends upon the presence of difficulty to be overcome by the exercise of intelligence" (1938, p. 79). Indeed, faced with a familiar situation, one can have an idea of how to act and what the consequences of those actions might be, based on knowledge acquired through past experiences. However, in an unfamiliar context, more reflection is needed. A person has to understand the significance of what they see. In other words, it is not enough to observe the situation; one has to understand the "significance" of it to figure out what will happen under a given action (Dewey, 1938, p. 68). To do this, one might have to connect different and apparently unrelated past experiences in order to decide how to act (Dewey, 1938, p. 68). Upon reflection, this process can result in new knowledge to be applied to future experiences.

Because of the importance of new and challenging situations in life, growth and change, such situations are at the heart of this study since our interest is in novice teachers' lives through the learning experience that is to become a teacher. And because an experience that is educative for some might not be so for others, it is important to focus on experiences lived by new teachers that, for *them*, are challenging and educational, and not on all experiences which are lived or which might be assumed by others to be significant. A person's internal conditions are shaped by the experiences they have lived and in turn, these conditions determine whether one is ready to learn from a new experience.

To conclude, the key feature of Dewey's theory in our study about becoming a teacher, seen as a learning process (see section 1.6.6), is that learning happens through the extraction of meaning from a given experience available to a given person at a given time, which then turns into tools that can be used in future experiences. We also keep in mind that unfamiliar situations are key in growth and change.

2.2 Narrative Inquiry: Phenomena and Methodology

We continue to develop our theoretical and conceptual perspective in this section by addressing concepts borrowed from narrative inquiry. Clandinin (2013) tells us that the word “narrative” in “narrative inquiry” refers to both the phenomena under study and the method of study (p. 214). In this sense, narrative inquiry [NI] is as much a part of our conceptual framework as it is of our methodology.

Therefore, in this section, we connect Dewey’s theory with NI and expose the tools we use in this study to shed light on our chosen research puzzle, namely to understand the process of becoming a cegep teacher of mathematics.

2.2.1 Experience and Narratives

Given the common emphasis on experience, Dewey’s theory plays an unsurprisingly important role in the theoretical background of NI. Clandinin and Connelly (2000) do not claim to interpret Dewey’s ideas rigorously or accurately, but use them to justify their general interest in studying experience.

The goal of NI is to understand people’s lives. Through the foundation brought by Dewey’s philosophy of education to NI, we can equate life, education and (educative) experience. Indeed, “[l]ife, to borrow John Dewey’s metaphor, *is* education” (Clandinin & Connelly, 2000, p. xxii, emphasis in the original) and education happens through (educative) experience (Dewey, 1938, p. 25). Therefore, NI approaches life through experience because experience is what people live (Clandinin & Connelly, 2000, p. xxvi) and because experience is an important source of knowledge for understanding people (Clandinin, 2013, p. 17). In the case of our project, this suggests NI has great potential to bring us to our main goal of understanding the experiences of novice teachers of mathematics in cegep.

In NI, experience is thought of via narratives. Narratives are also the way to study experiences and convey them to others (Clandinin, 2013, p. xxvi). Indeed, the essence of experience happens narratively, as “life […] is filled with narrative fragments, enacted in storied moments of time and space, and reflected upon and understood in terms of narrative unities and discontinuities” (Clandinin & Connelly, 2000, p. 17). Because people understand the world and people around them narratively, by stories they tell about themselves and others, it makes sense to study people’s experience narratively. Put simply, NI is the “stories lived and told” (Clandinin & Connelly, 2000, p. 20) by people.

2.2.2 Three-Dimensional Framework

To attend to experience, Clandinin and Connelly (2000, p. 50) put forward a framework that points out three interconnected dimensions that characterize any experience. This framework is strongly influenced by Dewey’s view of experience and the dimensions are key aspects in understanding experience in a narrative inquiry (Clandinin & Connelly, 2000, pp. 117–118). This framework constitutes our main tool to reach our main goal, as stated in Section 1.6.3, to gain a better and deeper understanding of novice teachers’ experience.

The first dimension Clandinin and Connelly identify is *temporality*; it is close to Dewey’s idea of experiential continuum. One aspect of temporality is that any place, person, thing, or event has a past and a future. In other words, in a NI, one does not examine something as happening at a certain moment but rather as an indication of something taking place over time (Clandinin & Connelly, 2000, p. 29). Hence, everyday experiences are “contextualized within a longer-term historical narrative” (Clandinin & Connelly, 2000, p. 19). For this reason, places, persons, things, or events should be thought of as located in time (Clandinin & Connelly, 2000, p. 29). In the case of this dissertation, this means that we see new teachers as *becoming*, as existing within their own life continuum with a past, a present, and a future, rather than as a static being. We hold a similar view of the places, colleagues, and students with which teachers interact.

The idea of temporality also plays a role in the fact that stories lived and told are the lenses through which people interpret the situations they go through in life; additionally, they are the lenses through which they relive and retell past experiences: “[p]eople shape their daily lives by stories of whom they and others are and as they **interpret their past in terms of these stories**. Story […] is a portal through which a person enters the world and by which their experience of the world is interpreted and made personally meaningful” (Connelly & Clandinin, 2006, p. 375, cited in Clandinin & Murphy, 2009, p. 598; my emphasis). In this sense, our stories are not only lenses through which we approach new experiences, but also shape how we think of past experiences. In that sense, a new experience may modify our account of a past experience.

Finally, the last implication of temporality is that an experience exists only in someone's account of it—and an account of a given experience exists at the moment in which it is recalled, so it exists in a different time than the experience itself.

The second dimension specified by Clandinin and Connelly is the matter of *interaction*, both personal and social. More precisely, humans need to be understood separately and simultaneously as individual and social beings in relation to a context.

The third dimension is that of *place*, that is, where a person or a group evolves. Place is defined physically: for instance, a particular room, in a particular building, in a particular neighbourhood, in a particular country. The last two dimensions bring our attention in this study to how novice teachers are situated physically in their past and present, surrounded by students, teachers, administration, and colleagues.

In short, NI is used to understand and inquire into experience, as it is in relation to people and where they are physically and socially over time, and with the awareness that humans lead storied lives (Clandinin, 2013, p. 13). Because NI's goal is to study human lives, NI as a methodology is interested in everything surrounding people's experiences, the "social, cultural, familial, linguistic, and institutional narratives within which individuals' experiences were, and are, constituted, shaped, expressed, and enacted" (Clandinin, 2013, p. 18).

Attending to all three dimensions in a NI helps us to show not only the complexity of people's lives (Clandinin, 2013, pp. 50–51) but also to highlight their uniqueness, as they are placed in their own three-dimensional experiences and are seen as embodiments of their own lived stories (Clandinin & Connelly, 2000, p. 43). The framework helps us see these stories are not static: they are lived and relived, told and retold. Our stories change as we retell and relive them throughout our life. This is equally true of a researcher throughout an inquiry: "[w]ithin the inquiry field, we lived out stories, told stories of these experiences, and modified them by retelling them and reliving them" (Clandinin & Connelly, 2000, p. 71). That means the same story could be told differently by the same person at two different times in their lives, as new experiences are encountered. Indeed, new experiences can lead to a new way of seeing or interpreting past experiences and people can develop a new sense of themselves by retelling a story (Clandinin & Connelly, 2000, p. 74).

By reliving and retelling stories with a new perspective, new meaning and interpretations may arise; these could lead to affirmation, modification, or creation of stories (Clandinin & Connelly, 2000, p. xxvi), which then modifies how one goes about the world. This is the essence of growth, as we "remake the past" (Clandinin & Connelly, 2000, p. 85) by reliving and retelling our stories. Indeed, experience is a "changing stream that is characterized by continuous interaction of human thought with our personal, social, and material environment" (Clandinin & Rosiek, 2007, p. 39, cited in Clandinin & Murphy, 2009, p. 599). We say more about how the reliving and retelling of stories play a key role in this dissertation in Section 3.1.

The previous two subsections addressed how we conceptualize individuals' living of experiences, as they learn from these and construct and make sense of their lives and of the world around them narratively. We develop in this next subsection the concept of *stories to live by* (STLB), created by Connelly and Clandinin (e.g. Connelly & Clandinin, 1999; Clandinin & Connelly, 1998), which allows us to attend to teachers' identities in a narrative way (Clandinin, 2013, p. 172). This will be a useful tool to understand novice teachers' experience through the journey under study.

2.2.3 Stories to Live By

"[…] the other side can do magic too."
-Cornelius Fudge
Harry Potter and the Half-Blood Prince
J. K. Rowling, 2005

Connelly and Clandinin, interested in teacher knowledge, inquired about teachers' experiences in schools. They came up with the expression *personal practical knowledge* to conceptualize the knowledge that comes from experience and knowledge of how to act in the present (Clandinin & Connelly, 1998, p. 150). This concept helped the researchers understand how knowledge is held and expressed in practice (Clandinin et al., 2006, p. 5).

The word "personal" is meant to indicate that this knowledge arose from the experience a person went through (Clandinin, 1985, p. 362). The word "practical" serves to underline that this knowledge can be visible in a person's action or discourse (Clandinin, 1985, p. 362). The word "knowledge" points to "that body of convictions, conscious or unconscious which have arisen from experience, intimate, social, and traditional" (Clandinin, 1985, p. 362). It includes personal theories, philosophies, or metaphors (Clandinin et al., 2006, p. 5). The knowledge is also provisional (Clandinin, 1985, p. 364) as "[t]eachers teach what each situation, each encounter, pulls out of their knowing" (Clandinin & Huber, 2005, p. 43), which can change as new experiences occur.

In sum, *personal practical knowledge* comes from, and can be understood by looking at, personal and professional narratives of experience (Clandinin, 1985, p. 362–363). In the case of teachers, this means that knowledge is shaped by personal experiences that happen outside school and by professional experiences that happen in school places.

This perspective on knowledge allows us to see teachers as knowledgeable beings: "as knowers of teaching, as knowers of children, as knowers of situations, as knowers of subject matter, as knowers of teaching, as knowers of learning" (Clandinin & Huber, 2005, p. 43). This perspective is important to us and is the reason for the opening quote of this section. Our vision is that we have a lot to learn from teachers—even novice ones that were not trained to be teachers. They are the ones who know best what it means to become a teacher in the early years. They are living it. Novice teachers of mathematics in cegep have their own expertise and their lives, knowledge, ideas, and opinions have value. We believe that as researchers in a narrative inquiry, we are meeting knowledgeable human beings with equally important, and equally magical, stories.

Because "knowledge was both formed and expressed in the contexts in which teachers live" (Clandinin & Connelly, 1998, p. 150), the concept of *professional knowledge landscape* was developed to grasp the complexity of those contexts. This landscape includes places both in and out of school. It is "composed of relationships among people, places, and things, [seen] both as an intellectual and a moral landscape" (Clandinin & Connelly, 1995, pp. 4–5, cited in Clandinin & Huber, 2005, p. 44). This concept allows us to talk about "how teachers' personal practical knowledge shaped, and was shaped by, their particular school contexts" (Clandinin et al., 2006, p. 10). Those two concepts together, *personal practical knowledge* and *professional knowledge landscape,* allow us to view teachers as "living storied lives on storied landscapes, landscapes both in and out of schools, landscapes both past and present" (Clandinin & Huber, 2005, p. 44).

As Clandinin and Connelly continued to attend to teachers' experience in schools over the years, they started to see that teachers would speak not only of their knowledge and their contexts, but also of how these are intimately knitted together when they reflect on their past, present, and future identity (Clandinin et al., 2006, p. 8). This realization pushed the researchers to put forward the narrative concept of *Stories To Live By* (STLB) to connect the concepts of knowledge, contexts, and identity, in the hope of understanding how they are connected and can be narratively understood (Connelly & Clandinin, 1999, p. 4).

More precisely, STLB are the stories people **live** and the stories people **tell** about themselves and who they are becoming (Clandinin et al., 2006, p. 10). It is what they use to make sense of the world around them and to act in the present. The identity of teachers "is understood as a unique embodiment of each teacher's stories to live by, stories shaped by knowledge composed on landscapes past and present in which a teacher lives and works" (Clandinin et al., 2006, p. 9). It is by narratively understanding knowledge and context that we can hope to understand one's STLB (Connelly & Clandinin, 1999, p. 4), which in turns allows us to grasp one's identity (Clandinin, 2013, p. 172).

Introducing the concept of STLB made us wonder about beginning teachers' identity. Who are they? Who are they becoming in the midst of becoming teachers? More precisely, what are the stories they tell about who they are and are becoming as novice mathematics teachers? This last formulation emphasizes our understanding of the STLB as the only aspect of teachers' identity that we can access. All we can do is ask teachers who they are, and all they can do is share their STLB. On any given day, they can only share their version of a story, telling it from the perspective they have on that day, even if it is a story from a long time ago. We cannot distinguish between the personal practical knowledge and the professional knowledge landscape as these are knit together with the identity of the teacher. Therefore, we are always looking at one's STLB as they are told on a given day. As Clandinin (2013) said, we "are always interpreting [our] pasts from [our] present vantage points" (p. 46).

In summary, this section outlines our perspective on the concept of identity. As seen in Section 1.6.5, many studies use the concept of identity to research the process of becoming a teacher. From our chosen stance, persons are the embodiment of their stories and therefore we, as researchers, need to study identity narratively. In this sense, we choose to use Connelly and Clandinin's conceptualization of identity.

2.2.4 Tensions and Contradictions

As we started to think about the novice teachers' experiences in schools in terms of their STLB, and of their storied identity as embodiment of their knowledge and context, we began to wonder how the stories teachers live and tell about who they are and are becoming can change as they experience becoming a teacher. We also wondered how their STLB might be modified or challenged by their new experiences as teachers. This section is dedicated to examining change in STLB.

Stories to live by (STLB) "are multiple, fluid, and shifting, continuously composed and recomposed in the moment-to-moment living" (Clandinin et al., 2006, p. 9). Therefore, STLB are not gathered into a smooth, coherent, stable unit. Indeed, while teachers are always looking for narrative coherence in the stories they live and tell about themselves, contradicting stories can co-exist in one's STLB. Teachers can then reflect on their stories and "begin to imagine themselves in new ways and to change their practices, the ways they live in the world. As they gain a deeper awareness of their stories to live by, they begin to shift those stories as they continue to go about their days" (Clandinin et al., 2006, p. 10). However, change in STLB does not happen in an all-changing, revolutionary way. Instead, it is an evolution, as each new experience occurs and slowly brings one to re-story themselves (Clandinin et al., 2006, p. 132). Unfamiliar experiences, such as the ones new teachers encounter, are great opportunities to reflect and grow (Dewey, 1938, p. 79).

Reflections that end up changing one's STLB can be triggered by new experiences, as one teaches new subject matter, meets new students and new colleagues, as institutional rules change, as teachers meet their life partners, have children, or as larger social changes take place (Clandinin & Huber, 2005, pp. 44–45). Changes in STLB can also be initiated by tensions. We understand tensions as *bumping* between stories. One's lived and told stories can bump against each other, against the lived and told stories of others or against dominant[11] cultural or institutional stories (Clandinin, Murphy, Huber, & Orr, 2010, p. 83). Tensions are created when things do not fit, when something does not seem right, "does not slide seamlessly into who we are" (Clandinin et al., 2006,

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[11] We talk about "dominant stories" to refer to the stories that are most lived or told in a certain context at a certain moment.

p. 132). As stories bump with one another, one's STLB can be challenged. This creates opportunities for possible change and opens up new possibilities (Clandinin & Huber, 2005, p. 57).

From a researcher's point of view, looking for tensions is a way to identify bumping stories and to understand the complexities of the many stories being lived and told. This focus on tensions and bumping stories helps us attend to how teachers construct and change their STLB (Clandinin et al., 2006, p. 11). Indeed, those bumping occurrences between stories are moments when the STLB become the most visible for an outsider (Huber & Clandinin, 2005, p. 315).

The idea that STLB are in constant evolution makes us see beginning teachers who enter their new landscape as embodying their STLB (Schaefer & Clandinin, 2011, p. 276), and as they go about their day, slowly changing and evolving their STLB. In other words, as individuals become teachers, they start to think about their stories to live by, stories of who they are, and who they are becoming as teachers, as they encounter new experiences (Clandinin et al., 2006, p. 41). Therefore, capturing how the STLB are being shaped (modify, justify, or affirm) as novice teachers engage in their new profession is a way to go about understanding the experience of novice teachers in their process of becoming teachers. We wonder about the nature of the experiences that shape (modify, justify, or affirm) one's STLB and the ways in which novice teachers' STLB are shaped (modified, justified, or affirmed).

As we have seen in Section 1.6.4, tensions and challenges are often used to locate areas in which novice teachers might need support as they become teachers. Rather than attend to tensions primarily as experiences to fix or for which to find a solution, we conceptualize tensions as moments that can help us, as researchers, see teachers' STLB, their identity, so as to understand them better.

Given the theoretical and conceptual framework of this project, we now have new words to express what we want to accomplish. With the main goal of bringing understanding to the process of becoming a (cegep) mathematics teacher, we aim to understand the experiences of novice teachers through narrative inquiry (NI). The theoretical foundation of NI prompted us to want to understand the that how novice teachers' STLB are shaped. Further, we wonder about the nature of the experiences that shape (modify, justify, or affirm) novice teachers' STLB and the ways in which teachers' STLB are shaped (modified, justified or affirmed).

2.3 Object of Study

"All mathematical pedagogy, even if scarcely coherent,
rests on a philosophy of maths."
René Thom, 1973

In this section, we narrow the focus of our study by specifying the types of stories to live by [STLB] to which we will attend.

As we situate this study in the field of mathematics education, we are interested in the teachers' STLB in relation to Mathematics, Teaching, and Learning [MTL]. Indeed, what makes the journey into becoming a mathematics cegep teacher unique is in their preservice education in mathematics, the mathematics they teach, the population to whom they teach these mathematics, and the institution in which they work. Consequently, we are interested in new cegep teachers' experiences as they relate mainly to mathematics, teaching, and (their students') learning, all the while taking into account the context in which these experiences occur.

STLB in relation to MTL includes new cegep teachers' STLB about mathematics and their STLB about mathematics education. In other words, teachers' STLB in relation to MTL entails their experiential knowledge, theories, philosophies, and metaphors (Clandinin et al., 2006, p. 5) about mathematics and its teaching and learning. It is a hypothesis of this thesis that novice cegep teachers possess such STLB, developed through years of doing, learning, and being taught mathematics. Many authors support such a claim and do so via their own tools for understanding the STLB of teachers. Indeed, there are many words in the literature used to describe what teachers know and think (e.g. "conceptions" and "beliefs"). There is, however, little consistency in the definitions and much ambiguity in their use (Brown & McNamara, 2011, p. 35). Nonetheless, studies that use these words suggest, in the same way we do, that people trained in mathematics have a way of seeing mathematics, teaching, and learning.

Some studies also argue that what teachers know and think about MTL plays a role in how they become a teacher. For example, Speer (2001) claims that teaching assistants' beliefs, especially about mathematics and undergraduate students, have a significant impact on how they teach and interact with students. Beisiegel (2009) affirms that graduate mathematics students' "views of the discipline and teaching are shaped" (p. 43) by their life experiences in a mathematics department, as are their views of how and what they should become. She also argues that the experiences those graduate students have can play a huge role in how they define their role as mathematics instructors (p. 43). Hence, the study of the STLB in relation to MTL rests on the hypothesis that such STLB and their relation to MTL play a role in how one becomes a teacher.

Those studies emphasize that mathematics students and new mathematics teachers do have STLB about mathematics and mathematics education, and that new teachers' relation to MTL does play a role in how they act in their new profession and how they deal with, interpret, and react to what happens to them. Other studies suggest that what one thinks, in particular about mathematics, teaching, and learning, influences how one acts as a teacher. For example, Thompson (1984) emphasizes that teachers' conceptions about mathematics and mathematics teaching play a huge role in how they act. Schoenfeld (2010, cited in Barton et al., 2014) says that dispositions, beliefs, values, tastes, and preferences have great influence on how people perceive, interpret, and prioritize what they encounter.

That said, we are not interested in STLB only in relation to MTL. Indeed, in the elaboration of our theoretical and conceptual framework, we have made clear that what each person learns from their experience is different. In this sense, an experience that may not be related to MTL may take part in how novice teachers' STLB in relation to MTL are shaped. Therefore, as we attend to our main goal of understanding the process of becoming a teacher, we have to stay open to experiences novice teachers share that may not be connected in an explicit way to MTL.

2.4 Our Goals

This dissertation is meant to be an exploratory study to understand the experiences of novice cegep teachers in the process of becoming teachers of mathematics, our research puzzle. We present our goals below, phrased in the words afforded by our theoretical foundation and conceptual framework, insisting on the caveat, mentioned above (see the beginning of this chapter), that these were only completed *after* my time in the field.

Based on our theorization and conceptualization of what it means to become a teacher, we came to focus on novice teachers' changing stories to live by in relation to mathematics, teaching, and learning.

We therefore chose to explore our research puzzle by aiming for the following goals:

(Goal 1) to reflect on the nature of the experiences that shape (modify, justify, or affirm) novice cegep teachers' stories to live by in relation to mathematics, teaching, and learning; and

(Goal 2) to explore the ways in which teachers' stories to live by are shaped (justified, modified, or affirmed).

CHAPTER 3: METHOD

"[…] there will be a time
when we must choose
between what is easy and what is right."
-Albus Dumbledore
Harry Potter and the Goblet of Fire
J. K. Rowling, 2000

As we explained in the introduction, we wanted to study our research puzzle[12] by exploring the nature of the experiences that shape novice cegep teachers' relationship with mathematics, teaching, and learning. To do so, we considered Dewey's theory of experience as our theoretical foundation (Dewey, 1938; see Section 2.1) and concepts developed in narrative inquiry (Clandinin & Connelly, 2000; see Section 2.2). However, as mentioned in Chapter 2 (see p. 36 and Section 2.6), after looking into the data, we realized we needed to review our theoretical and conceptual frameworks and add certain concepts[13] that would afford us the phrasing of our goals and inform how to go about addressing such goals. More precisely, our first goal is to reflect on the nature of the experiences that shape (justify, modify, or affirm) novice cegep teachers' STLB in relation to mathematics, teaching, and learning, and our second goal is to explore the ways in which teachers' STLB are shaped (justified, modified, or affirmed). These reformulated goals guided the first two chapters of this dissertation.

This third chapter unfolds as follows: it explains first how our narrative inquiry unfolded, from collecting the data to creating the data, and how we ended up with the goals we have now (Section 3.1). We then detail the process of analysis that unfolded after the data creation (Section 3.2), the results of which we present in Chapters 4 and 5.

3.1 Data Collection and Data Creation

In this section, we first justify our starting point of "telling stories" (Section 3.1.1) and then detail the path we followed in this research, according to the phases Clandinin and Connelly (2000) describe: entering the field of study (Section 3.1.2), going from field to field texts (Section 3.1.3), going from field texts to interim research texts (Section 3.1.4), and finally going from interim

[12] Our research puzzle, narrative inquiry's version of research question, is the process of becoming a teacher of mathematics at cegep level.
[13] We describe in Section 3.1.5 what was added to our frameworks following my time in the field.

research text to research texts (Section 3.1.5). We then address our choice of using stories (Section 3.1.6) followed by ethics considerations that emerged in our work (Section 3.1.7).

3.1.1 Before Entering the Field: Telling Stories as a Starting Point

> "I don't worry about the stuff I don't remember,
> I try to find the value in what does stand out.
> We all remember maybe ten good stories from our childhood
> and they all have meaning.
> We just have to value them enough to […] understand why did they stick with us."
> Michelle Obama, in an interview with John Green, 2019

We came into this inquiry wondering about the experiences that shape novice teachers' relationship with mathematics, teaching, and learning (MTL). In other words, we wondered about the stories of the experiences that make up their lives as teachers of mathematics in cegep (Clandinin & Connelly, 2000, p. 20). To do this, we chose to start with "telling stories" (Clandinin, 2013, p. 34) rather than with "living stories." This choice was made with an interest in accessing experiences teachers themselves found significant in their journey, as well as an interest in accessing the reflection, if any, behind the how STLB are being shaped (in the sense discussed in Section 2.2.4). We explain our choice in more details below.

Our choice emerged first from our theoretical and conceptual perspective. As we have touched upon in the last chapter (Section 2.2.2), experiences are lived and relived and told and retold throughout one's life. This can lead to a restorying of past experiences and therefore one can learn different things from past experience as this restorying process happens. In this sense, we do not seek to hear "true" experiences from participants as "there is no true version of events" (Clandinin & Connelly, 2000, p. 85). We believe that any story one shares about their life is a specific reconstruction; there could always be others (Clandinin & Connelly, 2000, p. 101). In this sense, stories people share may not be an accurate recollection of what *truly* happened, what was truly said to them, or what actions truly took place, as if there was, for example, a camera there to film the whole event. Rather, we seek to hear about their interpretation of their experiences and what they retained from the experiences, after potentially many retellings and relivings over the years. And it is what comes out of all that which is important to us. In the context of this research, it is precisely this interpretation of the novice teachers' own experiences that interests us. We are not trying to highlight what *really* happened. We are interested in how they interpret and tell stories of their experiences as novice teachers.

In the same line of thought, we care about experiences that stood out to the novice teachers, rather than what might stand out to an outside observer, as well as the ones that are triggered by the present conditions in which the retelling takes place. Indeed, if specific past experiences do not come up when novice teachers talk about who they are and are becoming as teachers, then we hypothesize they are not important (at this point in time) in their stories. This does not mean, however, that such stories were never or will never be significant for them; they are not significant at the time they are sharing stories with us. In other words, we are interested in the stories and experiences that come up as novice teachers are asked to talk about their lives and journeys as teachers, and about mathematics, teaching, and learning.

Our choice of starting with "telling stories" also came from the pilot study we conducted. On that occasion, we found it takes some time for teachers to be able to verbalize the effect that an experience had on their relationship with mathematics, teaching, and learning (for more about the pilot study, see Mathieu-Soucy, Corriveau, & Hardy, 2018). I interviewed three novice teachers for the duration of a semester. I met with them almost every week, wanting to hear about significant experiences from their previous week and how they dealt with them. However, we found that few experiences could be talked about in terms of how they played a role in the new teachers' relationship with mathematics, teaching, and learning. The experiences had only just been lived and we found that the reflections about them were, more often than not, incomplete; it was impossible to know whether they would transform into significant stories in the teachers' lives. This made us realize that we needed to focus on past experiences (further than the previous week) and allow the teachers to speak about experiences on which they had time to reflect.

As Dewey (1938) would say, the quality of an experience comes mostly from what it leads to, i.e. the resulting tools and how they help understand and act towards new experiences (p. 27). This takes time, since we think about our past experiences differently with time and reflection, and, probably, after other experiences take place. This means that if we want to hear about experiences that were significant in the teachers' lives, we need to ask about experiences on which reflections are well underway. We believe that some reflections may never be complete but that with time, reflections can become more precise and articulated. These are the kinds of stories we believe could inform us on the process of becoming a teacher.

We therefore decided to take an approach of "telling stories," where we would ask teachers about stories that relate to a specific area, context, or topic. That way, we hope they might recall shifts in their relationship with MTL, explain how their relationship was shaped, and allow us to hear about experiences *and* the reflection associated with that relationship.

From this starting point, we decided I would meet each participant, one-on-one, on seven different occasions. The participants would be informed of our interest in learning about the experiences they found significant as new teachers. Each meeting would be audio-recorded and guided by a protocol designed to have a guiding theme known by the participants. The first six meetings would alternately focus on mathematics, teaching, and learning, from their point of view and then from their students' point of view. For instance, the first meeting focused on their personal relationship with mathematics and the second on their students' relationship with mathematics. The third protocol targeted the theme of being a teacher and the participants' experience being taught, and the fourth the theme of teaching to students. The fifth meeting addressed their own learning and the last one the learning of their students. Since we aimed at conducting the meetings in the language, French or English, in which the novice teacher would feel more comfortable, protocols were developed in both languages. The protocols for each of the meetings can be found in Appendix C.

We came to this format following our pilot study where we learned that novice teachers struggle to talk distinctly about their personal experience and ideas versus those of their students. Therefore, having a space to focus on themselves, and then their students, would help us get a clearer image. Additionally, the series of meetings started with a focus on mathematics because we wanted to establish the culture that when we meet, in our inquiry space, we talk about mathematics. This was decided following our pilot study where we discovered that mathematics was a topic novice teachers struggled to talk about (Mathieu-Soucy et al., 2018). Jaworski and Matthews (2011) had, before us, made a similar conclusion regarding mathematics educators and mathematicians in the context of university teaching.

The seventh meeting was built around three mock-lesson preparations (see Appendix C) on which I asked the participants to comment as if they were a mentor for the new teacher who created these for their classroom.

3.1.2 Entering the Field

"It is the story that matters, not just the ending."
Paul Lockhart, 2009

"...all you can do, if you really want to be truthful, is to tell a story."
John Mason, 1998

In May 2017, I sent a recruitment email (Appendix A) to different cegep institutions through different contacts we had. Our contacts then distributed the recruitment material to teachers in their department who fit the criteria of having less than 3 years, or 6 semesters, of experience, as per our decision of a limit of 3 years of experience. As we shared this project at different stages of completion at different conferences over the years, we met a few cegep teachers who came and spoke with us. One thing that stood out from those conversations is that the very first semester of teaching is often focused on more technical aspects of being a teacher, such as figuring out institutional software and the photocopier. In this sense, they urged us to consider teachers who are not necessarily in their very first experience of teaching. On the other hand, we also wanted to make sure we were meeting *novice* teachers, not fully *set* in their practices. We felt that recruiting teachers who had between none and three years of experience would fit the profile that interested us.

Four teachers, Michèle[14], Vera, Sam, and Étienne, wrote back to express their interest. Michèle and Étienne were from the same institution, as were Vera and Sam. I replied to them in August 2017 to set up a first meeting and asked Sam if he would agree to meet with me during the winter semester, as we had decided 3 participants to be what I could handle in one semester (based on the pilot study). We want to stress that the meetings were conducted in the language, French or English, in which the participant felt the most comfortable.

I went to my very first meeting with Michèle. She asked me whether her office mate, Albert, could be in the room while we were talking and I agreed, as long as she was comfortable with it. Albert

[14] The name of all five participants are pseudonyms to keep their anonymity.

ended up participating in the discussion I had with Michèle, showing his interest and sharing his reflections on certain topics. Later that day, I asked him if he would like to be part of the research project and he agreed. Albert had five years of experience teaching but he had shown a great interest in our topics and a great insight into the topics of becoming a teacher; we thought that his participation could contribute to our goals in a meaningful way.

I met with Étienne later that week and he told me that he had spoken with Michèle and that he knew both Michèle and Albert were participating in the research. They even coordinated their schedule so I could meet with the three of them on the same day so I would not have to come to the institution three times a week. The three of them continued to speak with one another about our meetings and sometimes told me what they had talked about during the two weeks in which I did not see them[15]. We ended up doing the seventh meeting with the three of them together, joining in a new space of narrative inquiry.

I met with Vera and Sam during two different semesters, Fall 2017 and Winter 2018. They did not indicate to me in any way that they knew each other or of each other being part of the study.

The first meeting with each participant started with a short presentation of the goals and conduct of the study. Then I gave them a copy of the consent form (Appendix B), which I read out loud with them (Protocol 1, in Appendix C). They all signed giving their consent to participate in the study. We address some ethical considerations of this study in Section 3.1.6.

3.1.2.1 Participants

In this section, we describe each participant and say a few words about their education and teaching experience in cegep at the time of the meetings. We summarize the information in Table 1. We will dress a more detailed profile of each participant in Chapter 4.

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[15] I would like to point out that the teachers had been informed of the voluntary nature of their participation and that I, as a researcher, had to protect their anonymity (see Appendix B). Thus, although they felt comfortable communicating with each other about the research during the data collection process, I was not informed in detail of these exchanges, nor were they part of my data, unless it came up during our meetings.

Michèle

Michèle did a science program in cegep. She earned a bachelor's and master's in mathematics before she went on to teach in cegep. She later earned a certificate in postsecondary teaching from another university, part-time, while teaching. She taught at four institutions in the three years of her teaching career, sometimes at two institutions at the same time.

The certificate she completed in postsecondary teaching is a one-year graduate program. It aims at preparing its students to plan classes with appropriate pedagogical strategies, adapt their teaching according to the factors and characteristics that influence students' learning, assess learning through a competence approach, adjust their practice to concrete situations and elaborate a didactic approach using technologies. All was tailored specifically for postsecondary teaching.

Albert

Albert has five years of experience being a cegep teacher. He always worked full time in the same institution and holds a permanent position. Albert has a cegep degree in science and has a bachelor's and a master's in mathematics. He began a doctoral program in mathematics but eventually dropped out. He applied for jobs in the industry, which did not work out, and in different cegep institutions. He is still working at the institution that gave him his first teaching contract.

Étienne

Étienne, with one year of experience, is the participant with the least experience in this study. He completed a bachelor's degree in mathematics after finishing his cegep degree in science. When he failed to find a job right out of his bachelor's degree, he registered full-time in a one-year certificate in cegep teaching. He found a position the following August and has been a full-time teacher in the same institution ever since.

The certificate Étienne completed is a one-year graduate certificate that aims at preparing students to teach specifically in cegep and is based on the interrelation between the practical and theoretical dimensions of the profession. At the end of the program, the goal is for the students to be able to elaborate, implement, and evaluate pedagogical strategies for cegep teaching and show they can be critical of their own teaching to ensure its development. There is a mandatory internship for the students.

Vera

Vera has 3 years of experience as a full-time teacher in cegep, in the same institution. She earned a cegep diploma in science and a university degree in another discipline than mathematics. In the next few years, she worked in that field and tutored children, sometimes with special needs. She then went back to cegep to take a summer course in mathematics. She then decided to do a bachelor's in mathematics and a master's in mathematics education, which she did concurrently. Then, she found work as a cegep teacher.

Sam

Sam has been teaching for 3 years in the same institution. He has a cegep degree in social science and a B.A., majoring in two disciplines, one of which is mathematics. He then did a master's in mathematics education, same as the one completed by Vera. He found work in cegep a little after the end of his master's degree.

The master's program Vera and Sam attended is an academic program in mathematics education for anyone interested in teaching mathematics (mostly at secondary and cegep levels) and research in mathematics education. Students in the programs have to take advanced mathematics courses. They are informed on research in mathematics education, are led to have a critical stance on pedagogy of secondary and cegep teaching, and get trained in doing, presenting, and writing research. Vera chose the thesis option, where she had to conduct a substantial research project, while Sam took the course option.

Name	Undergraduate Education	Graduate Education	Years of experience teaching in cegep
Michèle	Mathematics	Master's in mathematics; Graduate program in postsecondary teaching	3
Albert	Mathematics	Master's in mathematics; Time in a doctoral program in mathematics	5
Étienne	Mathematics	Certificate in cegep teaching	1
Vera	Science; Mathematics	Master's in mathematics education	3
Sam	Two majors, one in mathematics	Master's in mathematics education	3

Table 3.1: Summary of each participant education and teaching experience

3.1.3 From Field to Field Texts

"I use the Pensieve.
One simply siphons the excess thoughts from one's mind,
pours them into the basin, and examines them at one's leisure.
It becomes easier to spot patterns and links,
you understand, when they are in this form."
-Albus Dumbledore
Harry Potter and the Goblet of Fire
J. K. Rowling, 2000

The data of narrative inquirers is field texts, which are "selective reconstructions of field experiences" (Clandinin & Connelly, 2000, p. 94). The term "field text," rather than "data," is used "to signal that the texts we compose in narrative inquiry are experiential, intersubjective texts rather than objective texts" (Clandinin, 2013, p. 46). Field texts are interpretative and contextualized (Clandinin & Connelly, 2000, p. 94) in the sense that they stem from a selective process of what was asked, and therefore not asked, and influenced by the researcher's (physical and verbal) response to what was said and not said. Field texts also stem from the relationship between the participant and the researcher (Clandinin & Connelly, 2000, pp. 94–95). In other words, who I am as a researcher, what my relationship with each participant is and how I am positioned within the three-dimensional framework (see Section 2.2.2) makes a difference in the field texts I compose at any given moment in this inquiry (Clandinin & Connelly, 2000, pp. 84–85). Interpretations that stem from whom and what one encounters are always born of one's own personal narratives (Clandinin & Connelly, 2000, p. 60). In this sense, we acknowledge that field texts are subjective and speak of the researcher in an implicit way.

In our case, we created accounts of each meeting with each participant, based on the audio-recordings. The accounts, written in the language the meetings were conducted in, tell the story of the meeting, the story of my own experience in the meeting. They are not transcripts but rather descriptive accounts of an experience. The accounts are constituted as much as possible of the words of the teacher, with only slight changes for clarity purposes in the grammar or vocabulary, as well as some photos or images of what was discussed, and specification on gestures or tone of voice.

As we seek to understand experience, our interpretation needs to be grounded in experience itself. In this sense, field texts act as a photograph of a certain moment that allows us to revisit this moment after it has ended. The creation of field notes and texts freezes a moment, takes a picture of it. Throughout this inquiry, I envisioned the field texts as my own personal pensieve, an idea taken from the Harry Potter series. As the quote opening this section suggests, I use the accounts as a pensieve. In this sense, the field texts helped me take a step back from the experience I had in the field and still remember what happened. The texts also allow me to get away from the intimate relationship I was building with the participant and take the stance of a researcher. Finally, it gave me the opportunity to bring others to live the experience with me. For those in the research team who did not conduct interviews or meet the interviewees, the accounts created through my eyes are all the participants are and will ever be.

Before each meeting, I would read the account from the previous meeting. I kept what I called a "follow-up" document for each participant where I kept track of any question I had about something that was said. I also kept track of ideas they raised that were connected to our research puzzle, the process of becoming a cegep teacher of mathematics, but not related to the topic of that particular meeting. This allowed me to remember to bring it up later and also to keep track of common knowledge that could be used as a trigger for further discussion and to go deeper into the topic at hand.

3.1.4 From Field Text to Interim Research Texts

"[…] people are never only
(nor even a close approximation to)
any particular set of isolated theoretical notions, categories, or terms.
They are people in all their complexity.
They are people living storied lives on storied landscapes."
D. Jean Clandinin and F. Michael Connelly, 2000

When our meetings were over with all 5 participants, it was time to dive into the accounts to create interim research texts. In our perspective, this dissertation represents the complete research text associated with this inquiry. In this section and the next one, we attend to how we went from the field texts in the form of accounts to the way we present the data in this dissertation. At this stage, we address interim research texts, the one or many iterations of transformation of the data (the field texts referred to in the previous section) into what we would end up presenting in this dissertation.

For those iterations, we were inspired by Chapters 5 and 6 of Clandinin's work (2013) where she describes an inquiry that started with "telling stories." We were also inspired by Polkinghorne's (1995) report of Dollard's (1935) work to create a story from data.

We decided to create an eighth account for each participant, from the seven already created, which was organized around the following analytical terms: *Present*, *Past*, *Relationship*, *Tensions*, and *Stories to live by* (STLB). In this last account, we did what is called "narratively coding" the data (Clandinin & Connelly, 2000, p. 131). All five analytical terms we attended to relate to the three dimensions of the three-dimensional framework (Section 2.2.2): temporality, interaction, and place. The *Present* section includes experiences or events participants were living at the time of the meetings. For example, the classes they were teaching at the time of the meeting, administrative positions they were holding, assessments they were currently trying, etc. The *Past* section included past experiences they shared with me, including their past academic experiences, previous teaching experiences, things they used to do, and so on. The *Relationship* section includes significant relationships in their lives in relation to mathematics, teaching, and learning. The *Tensions* section includes stories of tensions, challenges, or problems they encountered and talked about, in relation particularly to the transition from student to teacher and the process of becoming a teacher. As we heard teachers recall many tensions, it seemed appropriate that they be treated in their own section. Additionally, Clandinin et al. (2010, p. 83) mention that tensions are key moments through which to start and engage into inquiry. Finally, the section about *STLB* is, broadly put, where we come to know more about the identity of the participant, the knowledge they evoked, and what they know to be true.

Creating these eight accounts helped in starting to understand the stories, especially since they were gathered from seven different meetings and some were mentioned multiple times. Of course, the five analytical terms we used represent aspects of the novice teachers' lives that are deeply intertwined so the accounts could have been, as with any interpretation, otherwise (Clandinin & Connelly, 2000, p. 156).

I kept away from *traditional* coding of the transcripts, as coding field texts could lead the researcher to focus on the codes rather than focusing on the complexity and narrative nature of the experience being shared (Gergen, 2003, cited in Clandinin, 2013, p. 50). And, as mentioned at the beginning of this chapter, our goal was always to stay within the complexity and try to be as comfortable with it as possible. The analytical terms chosen to organize the eighth account were meant to act as a tool for understanding, for placing the stories somewhere along the three-dimensional framework, rather than to diminish the stories to words or categories. Also, "[q]ualitative data analysis aims to produce generalisations embedded in the contextual richness of individual experience. Coding and categorising techniques […] often results in texts sorted out into units of like meaning. Despite evident benefits of this, such as facilitating access to interpretation of the situation in question, this sorting out can strip contextual richness away" (Nardi, 2008, p. 18).

At this juncture of the research process, I began a personal journey where, for weeks, I lived alongside the stories that were shared with me by the participants. By reading and re-reading this 8th account, I saw themes (storylines) emerge. Things I had not seen before, or the extent of their importance to the stories the participants told about themselves, came into view. So I wrote a short story about each of those themes. The idea was not to write a story about themes we expected to observe or themes we had purposefully attended to in the meeting. The idea was to read the 8th account of each participant and see what stood out in relation to our research puzzle, what I learned from that person's experience, what I wanted to share about that person with others. As Clandinin and Connelly (2000, p. 188) would say, I focused on experience and followed it to wherever it led me. As such, the themes I chose for the interim research texts are not the only ones that were present in our meetings nor what another researcher might have chosen to write about. In the end, I wrote between 2 and 10 stories for each participant, 31 in total.

After I had written the 31 stories, we needed to decide what to focus on, what we thought we learned within the inquiry and wanted to share in this dissertation. In Polkinghorne's (1995) words, we needed to find the plot of the stories we wanted to write (p. 18), which would ultimately decide what this dissertation would be about.

3.1.5 From Interim Research Texts to Research Texts

"remember
you were a writer
before
you ever
put
word to paper
just because you were not writing
externally.
does not mean you were not writing
internally.
- stories"
Nayyirah Waheed, 2013

After months of spending my days alongside the participants' stories, I felt lost. So I asked for help in going from interim research text to research text. I followed Clandinin and Connelly's advice (2000, pp. 165–166; also Clandinin, 2013, p. 210) and brought stories to our research team for discussion. I chose one interim research text per participant. As we read the interim research texts I chose, we asked questions about the meaning and the significance of these texts and kept in mind our interest in the process of becoming a teacher (Clandinin & Connelly, 2000, p. 132). We were immediately drawn to discuss how the participants storied the ways in which past experiences played an active role in their day-to-day activities as teachers, in the decisions and actions they took as teachers. They spoke about how certain experiences changed what they did or thought as teachers. What we found interesting is the kind of experience they relied on and the way they storied the influence it had had on them. They also justified what they did or thought as teachers on the basis of past experiences. In other words, we found interesting what experiences they identified as key to the creation of the *knowledge* they used as teachers as well as their personal theories about mathematics, teaching, and learning.

We obviously expected that their past experiences would play a role in their decision-making process as teachers, per our conceptualization of temporality (see Section 2.2.2). What surprised us is how clearly they drew the causality between experiences and change. The aspect of *justification* was new for us. We wanted to know more and to bring understanding this new aspect.

As we started to use words such as "knowledge" and "personal theories" to talk about the stories teachers told about themselves, we were reminded of the concept of *stories to live by* (STLB) associated with narrative inquiry (see Section 2.2.3). We added this concept onto our conceptual framework and adopted it to phrase our goals: (goal 1) to reflect on the nature of the experiences that shape (justify, modify, or affirm) novice cegep teachers' STLB in relation to mathematics, teaching, and learning and (goal 2) to explore the ways in which teachers' STLB are shaped (justified, modified, or affirmed)[16].

How does these new goals fit into our inquiry and its research puzzle about the process of becoming a teacher? From the beginning, we sought to "focus on experience and to follow where it leads" (Clandinin & Connelly, 2000, p. 188), in the midst of being interested in the process of becoming a mathematics teacher in cegep and in novice teachers' experiences in relation to mathematics, teaching, and learning. Those interests led us to conduct meetings with novice teachers, during which we realized that stories of how past experiences shaped their STLB were prevalent in how they spoke about themselves and who they are becoming as teachers. We therefore believe that these stories are an important part of their process of becoming, and that understanding how novice teachers' STLB are shaped by past experiences will help us attend to our main goal of understanding the process of becoming a mathematics teacher in cegep.

I then took up the task of writing one story for each participant: this story would include all the experiences related to a justification for or an affirmation of STLB, or a modification in STLB,

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[16] As a reminder, we went into the field wanting to understand novice teachers' experiences, in relation to mathematics, teaching, and learning, in the process of becoming a cegep teacher. It is both our time in the field and our conceptual framework that have contributed in generating our new goals of reflecting on the nature of the experiences that shape STLB and exploring the ways in which these STLB are shaped.

knowing we are interested in STLB in relation to mathematics, teaching, and learning. As I came back to the original accounts, the original field texts of our inquiry, and started to write a tentative research text, it quickly became clear that one story would not do justice to the experiences and justifications I intended to capture. It was indeed a challenge to find a thread that would make all the topics flow from one to the other. We therefore decided to write multiple stories[17], in the most organic way possible, around events or themes. I wrote stories that felt right, that felt as if they did justice to the experiences that were originally shared with me. I used as much as possible the words of the participants, rearranging them around our chosen goals. In other words, I used part of accounts to create stories which stemmed from novice cegep teachers' STLB being modified, justified, or affirmed.

In this sense, it is the participants' voice that shapes the stories. My voice is present as I am the one who put together parts of the field texts to build intelligible stories as well as stories that would speak to our goal of understanding how novice teachers' STLB are shaped. We want to stress that this is the second time my voice is heard in the stories of the participants. As we have explained in Section 3.1.3, the narrative inquirer's voice is present in the composition of field texts, because of the inquirer's personal narratives and relationship with the participants. My voice is therefore implicitly present in both the field texts and the stories in Appendix D. In a similar line of thought, we want to acknowledge that our research texts could have turned out differently (Clandinin & Connelly, 2000, p. 156). Other researchers may have written other stories and offered different interpretations. Research texts take different forms according to the inquirer and their experience (Clandinin & Connelly, 2000, p. 133).

It became clear to me as I wrote these stories that this was the form that would allow me to help the reader get a glimpse into the teachers' lives. I was not caught anymore in an obligation to make each experience follow smoothly from one to the other, as a novel would. Indeed, writing only one story would have mashed together themes that did not relate. Having multiple stories allowed us to repeat ourselves when necessary and add nuances which will undoubtedly benefit our understanding in the end.

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[17] Stories are written in the language in which the meetings were conducted to avoid losing meaning through translation.

The stories we chose to write, and with which we created the booklet in Appendix D, are a pivotal part of our research text. We discuss how we chose the form of the research text below (Section 3.1.5.1). Another part of our research text is our analysis (in Chapters 4 and 5) of the stories we wrote; this analysis aligns towards our goal of reflecting on the nature of the experiences that shape novice cegep teachers' STLB and exploring the ways in which teachers' STLB are shaped. We hope that working towards this goal will allow us to bring understanding to our research puzzle, that is, to the process of becoming a cegep teacher of mathematics. We address our process of analysis in Section 3.2.

3.1.5.1 Research Texts: Stories of Research and Stories of People

"Because the one thing I have learnt all these years [of doing research]
is that all I can do is tell a story?"
Elena Nardi, 2008

In the end, the research text that is this dissertation is a story of the inquiry we conducted over many years. It is constituted of stories of research and stories of people. We chose to share our field texts as short stories of our participants' lives in a separate booklet (in Appendix D). We chose to do so with a deep belief that stories are a meaningful way to share data. Indeed, "as listeners, we make meanings [of others' narratives] by looking for similarities and differences between the stories in order to construct a meaningful story of our own" (Burton, 2004, p. 199). In this sense, we constantly, consciously or not, lay our experience (Clandinin, 2013) alongside the experiences expressed in stories we read. We not only make them meaningful for us, but each reader takes from them something different. It "engage[s] audiences to rethink and reimagine the way in which they practise and the ways in which they relate to each other" (Clandinin, 2013, p. 51). The perception is that "[s]tories lived and told educate the self and others […]" (Clandinin & Connelly, 2000, p. xxvi), that by learning about others' stories, as much as thinking about our own, we may be compelled to rethink our own lives, our own STLB. Using stories also allows us to stay within the complexity of human activities, to avoid diminishing the lives of humans to a set of static understandings (Mason, 2016, p. 105).

3.1.6 Ethics Considerations

As we worked towards our goal of bringing understanding to the process of becoming a mathematics teacher at the cegep level, ethics considerations arose. We address these and their impact on our study below.

3.1.6.1 Anonymity

Anonymity is a central challenge in our research endeavour. This became clear especially as we approached the end of writing this dissertation. Indeed, we realized that our goal of bringing deep understanding to the lives of novice teachers was in tension with our commitment to protect the participants' anonymity (see consent forms in Appendix B). Specific aspects of the participants' lives, education, and work, all of which were central, to different extents, to our endeavour of understanding them as becoming teachers, could jeopardize their anonymity. In light of the commitment we made to maintain their anonymity, we decided to omit or modify pieces of information that would make the identity of the participants, as well as their past or present institutions, recognizable to others.

For example, we systematically withheld information about dates and years, aside from each teacher's number of years of experience. We erased information that would identify the institutions in which the novice teachers studied, currently taught, or taught previously. Such information includes the names of courses or programs that are specific to certain institutions. When a participant's bachelor's specialization was not in mathematics, we withheld the name of the discipline. This was not done because the program was specific to a given institution but because it would jeopardize the anonymity of the teacher.

We erased such information at the end of our analysis process, when we could assess with clarity how each piece of personal information ended up playing a role, if any, in our understanding of the participants' processes of becoming a teacher. We removed from the stories and our analysis any information about the participants that we considered not to have played a significant role in our analysis. When we deemed a participant's potential identifying piece of information to have played a significant role in our analysis, we presented the information either in general terms or modified it, trying to preserve the contribution of such information to the analysis while protecting the identity of the participant.

For example, we will later mention that Michèle grew up around relatives who were cegep mathematics teachers. We have not disclosed the nature of the relationship with those relatives and the number of relatives, information which could have hinted at whom Michèle is. We will see later that living alongside cegep teachers in her personal life had an impact on her process of becoming but the nature of the relationship nor the number of relatives was significant to our analysis.

We wish to stress that by protecting the anonymity of our participants through the methods detailed above, we did not alter aspects of their lives. Indeed, we did not create a character by combining life stories of two participants or inventing new facets of their lives. In other words, when we refer to one character, we think of one participant, one set of stories, and the field texts composed from the time spent with one participant.

3.1.6.2 What Counts as Data in a Relational Inquiry

Another ethics consideration arose when we realized that the data of the study had become entangled with elements of the study that were not data. Indeed, I had not recorded every aspect of my relationship with the participants. As I met with them, there were moments when the recorder was off—before the official start or after the official end of the recorded meetings—and they would ask me about my life, the classes I taught, where I went to school, what it was like to pursue a doctoral degree. On these occasions, they would also share part of their life, as we slowly got to know each other better and attended to our relationship. These conversations are not part of the data of this dissertation; nevertheless, these moments are part of our relationship (Clandinin & Connelly, 2000, p. 173). Narrative inquiry is a relational inquiry (Clandinin, 2013, p. 20): the relationship we built determined what was asked and what was said (Clandinin & Connelly, 2000, p. 93) and therefore transpired in our meetings and appeared in the subsequent field texts (Clandinin & Connelly, 2000, p. 105). To honour and respect the agreement that the research was about what they said during the recorded meetings (and not what they may share before or after), we consciously reference in the analysis *only* what had been said during the recorded meetings and then transferred into the field texts.

3.1.6.3 Impact on our Study

In light of the two ethical dilemmas of anonymity and of what counts as data in a relational inquiry, we thought about Clandinin and Connelly's remark (2000, pp. 173–174) that we owe it to the participants to honour our promise to keep their anonymity and we owe it to our readers (and ourselves) to engage in what we set out to do to understand our research puzzle. With this in mind, we position our analysis in a world where all we "know" of our participants is that which was shared by them "on the record" and which protects their anonymity.

In this sense, given that our research puzzle is about the process of becoming a mathematics teacher in cegep, the novice teachers we write about in this dissertation are characters that were brought into being by that which was shared by them "on the record" and which protects their anonymity. They are five novice teachers whose portrayal is extensively inspired by the five novice teachers who agreed to participate in our study. These portrayals are set in a world in which our participants' anonymity is protected and are based on what was shared during the seven meetings with our participants. Michèle, Albert, Étienne, Vera, and Sam thus came to life as we presented them in Section 3.1.2.1. This approach allowed us to work towards understanding their process of becoming teachers while navigating ethical considerations.

We acknowledge that our participants' lives surpass what we know and what we could have dreamt of learning about them, even if we had taken into consideration *everything* that happened in our seven meetings. We acknowledge that what we reflect on to try to understand our associated characters' process of becoming teachers does not constitute their whole lives. However, as per our perspective (explained in Section 3.1.1), we consider the stories that came out in the seven meetings to be significant for them and relevant to who they are and are becoming as teachers. Those stories birthed our characters and form the basis on which we intend to imagine and understand their process of becoming teachers. Given the decisions made on the basis of ethics considerations, the stories presented in this dissertation (booklet in Appendix D) and the associated analyses and reflections reflect the characters we created rather than our participants themselves[18]. When we engage with the analyses and the composition of research texts, we continue to create

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[18] As mentioned in the introduction of this work, we did not go back into the field following the writing of research texts as it is usually done in a narrative inquiry. This fact stems from how this research developed and from our own story as we engaged with narrative inquiry as a theory and as a method. In particular, our ethics certificate only encompassed the protocol for the 7 meetings. The writing of the research texts happened long after those meetings were over and the time to both obtain a new ethics certificate and go back to the participants to co-compose and negotiate meaning of the research texts would have seriously jeopardize reasonable time completion of a doctoral thesis. Because of that, we chose to write this dissertation about *fictional characters*, inspired by the novice teachers we met.

characters on the basis of what emerges from the experiences the participants shared with us. We will refrain from using the word "participant" following this section to convey the sense that we are talking about the characters created in the stories we wrote.

While we acknowledge in this section that we are not able to address all the information gathered in the field, we pursue our work with the stated goal of honouring our participants to the best of our abilities. We maintain with utmost seriousness our commitment to understand the unique and complex experiences of novice teachers in the process of becoming teachers. We therefore root our work in the stories we wrote, stories which are based directly on our field texts (see Section 3.1.5 for more details) which are our only connection to true experience. The field texts inspired the stories we wrote and these stories inspired and gave rise to the characters. Therefore, by rooting our analysis in the stories we wrote, we root it in experience and take steps to honour the stories the participants chose to share with us. In the next section, we address how we conducted our analysis and came up with Chapters 4 and 5 of this dissertation.

3.2 Method of Analysis

In this section, we describe the process of analysis of this dissertation. It unfolded in two phases aimed at bringing different layers of understanding. As we worked towards the ultimate aspiration of this dissertation, understanding the process of becoming a cegep teacher of mathematics, our work on the field texts[19] guided us to our present goals: to attend to the nature of the experiences that shape novice cegep teachers' STLB (in relation to mathematics, teaching, and learning) and the ways in which teachers' STLB are shaped. To reach that goal, we first needed to attend to the stories we wrote that narrates STLB being shaped (see the booklet in Appendix D). In this sense, the first phase of the analysis, described in Section 3.2.1 and which resulted in Chapter 4, aimed at bringing meaning and understanding to the stories we wrote; we did this by attending to three different strands (more on this in the next section). In the second phase, which is described in Section 3.2.2 and which resulted in Chapter 5, we reflected on what attending to the experiences that shape (justify, modify, or affirm) novice cegep teachers' STLB taught us about the process of becoming a mathematics teacher in cegep. We describe both phases below.

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[19] Field texts are the data of narrative inquirers. I composed the field texts following my experience in the field (see Section 3.1.3).

3.2.1 Phase 1: Analysis of the Stories Along Three Strands

As stated in Section 3.1.5, our goal is twofold. First, we want to reflect on the nature of the experiences that shape (justify, modify, or affirm) novice cegep teachers' STLB in relation to mathematics, teaching, and learning (goal 1). Second, we want to explore the ways in which teachers' STLB are shaped (justified, modified, or affirmed) (goal 2). After writing the stories in the booklet (Appendix D), it was time to bring meaning and understanding to these stories.

By spending time with the stories we wrote and attending to the different experiences that shaped novice teachers' STLB, we were drawn to consider the nature of these experiences along three strands: implicit teacher training, explicit teacher training, and relation to university mathematics. The presence or absence of an intention behind teacher training that occurs in an experience makes it either implicit or explicit in nature. These first two strands, about experiences that led to implicit and explicit training, were in the back of our mind from the onset of my doctoral journey. The stories confirmed to us the relevance of both kinds of experiences in the lives of novice cegep teachers of mathematics. Attending to the process of becoming a teacher in terms of experiences that relate to different types of training is consistent with our perspective that becoming a teacher is a learning process. The third strand—the relation of an experience to university mathematics—was borne by a concern to attend to each teacher's unique university training.

We found that attending to these three strands, by organizing Chapter 4 around them, answered to our first goal (goal 1) of identifying the nature of the experiences that shape (justify, modify, or affirm) novice teachers' STLB. We give more details below.

3.2.1.1 Experiences that Lead to Implicit Training

In Section 1.2, we define implicit training as "a sort of apprenticeship training by imitation which is not in the intended goals of the instructor or the course, nor often in the learning goals of the student." Such training often comes up in studies that focus on postsecondary teachers and the lack of mandatory teacher training for them. For instance, Beisiegel (2009) talks about implicit training for university graduate students and how they learn to teach as they sit in university classrooms and live in a mathematics department. Students learn about teaching by being taught and by living alongside teachers.

In the stories we wrote in the booklet (Appendix D), which were based on stories that were shared with us by novice teachers, we encountered another kind of implicit training. Novice teachers would often recall experiences that happened in their classrooms while they were in the position of the teacher. This showed us that implicit training also occurred as they were teaching. This type of implicit training comes up in the literature. For example, Wagner, Speer, and Rossa (2007) address it when talking about mathematicians and the contextual nature of what they learn as they teach.

A third type of implicit training appeared in the stories: training that happened through experiences outside of the school context. This type of training was present in the stories shared by Vera and Michèle[20].

Various kinds of implicit teacher training, experienced by novice teachers when they were students, in the position of a teacher, or in situations outside of the school context, were present in the stories we wrote about how novice teachers' STLB are shaped. Our hypothesis is therefore that all types of implicit training, whether they occur in teachers' experiences as students, as teachers, and outside of school, are key in the process of becoming a teacher.

This perspective—that what teachers experience as students, as teachers, and outside of school forms an implicit training that is part of their process of becoming a teacher—is consistent with the theoretical and conceptual position we outlined previously. Indeed, in the theoretical perspective we hold and which is based on Dewey's, one can learn things other than what one is studying at a given time (1938, p. 48). This perspective is also consistent with our vision that the process of becoming a teacher has no definite beginning or end, and that it happens over time (Beisiegel, 2007; see Section 1.4).

3.2.1.2 Experiences that Lead to Explicit Training

We addressed teacher training opportunities that come in the form of explicit training[21] in the first chapter of this dissertation when we reflected on available training for elementary, high school,

[20] We are not saying that experiences outside of school did not play a role in the other teachers' lives. However, this did not come up in the stories we heard or the stories we wrote.

[21] We talk about "explicit training" to refer to experiences behind which there was an explicit intention for teacher training.

and postsecondary teachers, and specifically cegep teachers. This type of explicit training, in the form of structured program or education, was present in the stories of novice teachers.

We found, in the stories we wrote, another type of explicit training. Novice teachers often seek and receive help from others—from colleagues, for instance, and this also constitutes explicit training as assistance, in this case, is sought or provided intentionally.

We therefore witnessed structured and unstructured explicit training in novice teachers' stories of how their STLB were shaped. We consider both in our analysis. We split explicit training into two strands, according to whether the training happened when the novice teachers were in the position of a student, such as in a university program or a seminar that aims at training them to become teachers, or when they were in the position of a teacher, such as when they ask a colleague for help.

3.2.1.3 Experiences Related to University Mathematics

The third strand along which we conducted our first phase of analysis targets the experiences related to university mathematics. Rather than focusing on training of a specific nature, we focus on the teachers' experience studying mathematics in university and how it shaped their lives as teachers. We found in Section 1.5 that being involved in university mathematics may have a great impact on how one becomes a teacher and we hope to understand more about this impact by attending to how it shaped their STLB and, ultimately, how it shaped their process of becoming teachers.

Finally, as mentioned at the start of Chapter 1, one aim of this inquiry is to reflect on the necessary training for cegep teachers. Since a university degree in mathematics is the only mandatory education for becoming a cegep teacher of mathematics, it is relevant to attend to the experiences of novice teachers that relate to university mathematics.

3.2.1.4 How We Conducted the Analysis

We believe that attending to the experiences that shaped novice teachers' STLB in terms of those three strands—implicit training, explicit training, and experiences related to university mathematics—will help us understand how novice cegep teachers' STLB are shaped throughout the process of becoming a teacher as well as attending to our first goal[22].

In our analysis presented in Chapter 4, our aim is to attend to the second part of our goal: to explore the ways in which teachers' STLB are shaped (justified, modified, or affirmed) (goal 2). We started by diving into the stories in the booklet to seek out STLB that were justified, modified, or affirmed. Sometimes, the STLB, the stories novice teachers live and tell, were narrated explicitly. For example, they might explicitly say that their role as a teacher is to prepare students for university. Some STLB were narrated more implicitly. For example, they might tell us that even if they do everything right, a third of the class may fail. This tells us that a story to live by they hold is that the success of their students does not rely upon them entirely. On another note, we worked on STLB that were of general or specific natures. For example, a story to live by of a general nature is the story that learning occurs only in a pleasant atmosphere. A story to live by of a specific nature is the story that using visual representations as an introduction to a topic is helpful for students whose first language is not the language of instruction. We do not mean that there are two types of STLB, general or specific. We only mean that STLB may take on different forms; they are, nevertheless, stories novice teachers live and tell and are thus of interest to us.

Following this, we wondered how the STLB we found had been shaped and by which experience or experiences they had been shaped. To this end, we considered what we knew from the booklet of stories and the field texts. In other words, we considered what we learned of each novice teacher's life through the stories we wrote about them and the field texts we composed, and repeatedly asked the following questions (as per our goals stated in Section 3.1.5):

- What can be said about how these STLB were shaped?
- What are the experiences that may have had a part in shaping these STLB?

We asked these questions repeatedly in the hope of understanding the ways in which novice teachers' STLB are shaped. Sometimes, part of the answers was explicit in the stories or in the field texts. Indeed, some stories directly narrated how experiences helped shape a given story to

[22] Goal 1: To reflect on the nature of the experiences that shape (justify, modify, or affirm) novice cegep teachers' STLB in relation to mathematics, teaching, and learning.

live by. In other cases, to answer the questions above, we had to wonder and reflect on how the story to live by had been shaped. In such cases, we contemplated and hypothesized about the possible experiences that participated in the justification, modification, or affirmation of a given story to live by. In the following chapter, we discuss only the STLB about which we could adequately provide (or conjecture) an answer to the questions listed above. As such, not all STLB that can be found in the stories are addressed in the following chapter.

The outcomes of our reflection, following our repeated asking of the questions stated above, are grouped according to the nature of the experience that shaped STLB (Implicit Training—as a student, Implicit Training—as a teacher, Implicit Training—outside of school, Explicit Training—as a student, Explicit Training—as a teacher, and Experiences related to mathematics). We did this knowing that the three strands of our analysis are not mutually exclusive in the novice teachers' lives or STLB and that there may be more than one way of grouping our reflections.

As I have argued in Sections 3.1.3 and 3.1.5, the researcher's voice is present in both the field texts and the booklet of stories in an implicit way. The researcher's voice becomes explicit in the analysis chapter of this dissertation (Chapter 4). As explained above, we try to bring understanding to the stories and to the field texts while keeping our goal (of exploring the ways in which teachers' STLB are shaped) and research puzzle (the process of becoming a cegep mathematics teacher) in mind. To do that, we sometimes had to wonder and make assumptions about what shaped a given STLB, thus explicitly using our researcher's voice. In Chapter 4, to communicate that it is the researcher's voice that is being expressed at certain moments, we use the pronouns "I" and "we." Otherwise, it is the characters' ideas that are being expressed.

3.2.2 Phase 2: Reflections on and Insights into the Research Puzzle

In the second phase of analysis, we aimed to reflect on what attending to our goals of exploring the experiences that shape novice cegep teachers' STLB (in Chapter 4 and in the booklet) allowed us to understand about our research puzzle, the process of becoming a mathematics teacher in cegep. To do that, we looked through the booklet of stories and through Chapter 4 for resonant threads, particular plotlines, and recurring patterns (Clandinin, 2013, p. 132) that would help us reflect and get insight into the process of becoming a mathematics teacher in cegep. To do that, we laid novice teachers' stories metaphorically alongside one another, and looked for resonances or echoes that reverberated across their stories (Clandinin, 2013, p. 132). In other words, using the understanding that we formed of their stories in Chapter 4 and in the booklet, we put down their lives beside one another, not to see how they bump against each other but rather to strengthen our understanding of what a process of becoming a teacher can look like. We were inspired by Clandinin's reminder (2013, p. 143) to stay true to our commitment of honouring the lives and experiences of the novice teachers while we work towards finding threads, plotlines, and patterns. This is a reminder to steer clear of categorizations or generalizations and to keep our focus on the complexity of the lives shared through the stories that we wrote (Clandinin, 2013, p. 50).

We identified and addressed the following resonant threads in Chapter 5: implicit training, explicit training, university mathematics, bumping stories and tensions, the journey to teaching, the tendency to want to do a good job, the experiences as a university student, and the valid behaviour of novice cegep teachers.

3.2.3 Summary

For ease of reference, we provide the following table as a summary of key terms and steps of this inquiry.

Research Puzzle What guided this inquiry; narrative inquiry's version of research questions.	The process of becoming a cegep mathematics teacher.
Goals Stemmed from my time in the field and our conceptual framework; working towards these goals should help us bring understanding to our research puzzle, see Section 3.1.5.	(Goal 1) Reflect on the nature of the experiences that shape (justify, modify, or affirm) novice teachers' stories to live by; and (Goal 2) Explore the ways in which the stories to live by are shaped (justified, modified, or affirmed).
Field Texts Accounts, see Section 3.1.3.	What was gathered from my time in the field; an account of my experience during the meetings with novice teachers.
Booklet of stories Appendix D.	Stories about justifications, modifications, or affirmations of STLB for each character, written in a way that speaks to our **goals**.
Chapter 4: Analysis Aimed at attending to our **goals**.	Organized according to the nature of the experiences shaping STLB (Goal 1); we conduct the analysis to explore the ways in which the stories to live by are shaped (Goal 2) by asking the following questions: • What can be said about how these STLB were shaped? • What are the experiences that may have had a part in shaping these STLB?
Chapter 5: The Process of Becoming a Cegep Mathematics Teacher Aimed at bringing understanding to our **research puzzle.**	We first cover what our analysis in Chapter 4 has taught us about our **research puzzle** and then we explore the resonant threads, particular plotlines, and patterns we found in relation to our **research puzzle**.

Table 3.2: Summary of the key terms and steps of this dissertation

CHAPTER 4: ANALYSIS

"Lives are lived in parallel and perpendicular,
fathomed nonlinearly, figured not in the straight graphs of 'biography'
but in many-sided, many-splendored diagrams."
Maria Popova, 2019

"Nothing in life is to be feared, it is only to be understood.
Now is the time to understand more, so that we may fear less."
Marie Curie

The purpose of this chapter is to bring understanding to how novice teachers' *stories to live by* (STLB), in relation to mathematics, teaching, and learning, are being shaped amidst the process of becoming a cegep teacher of mathematics. As described in our method (Chapter 3), we have created a booklet of stories (Appendix D) that features novice cegep teachers' STLB (the stories teachers live and tell, in relation to mathematics, teaching, and learning) being justified, modified, or affirmed. In this chapter, we attend to the ways in which teachers' STLB are shaped (justified, modified, or affirmed) in those stories per respect to three strands, as detailed in Section 3.2.1, of experiences: implicit training[23], explicit training[24], and experiences related to university mathematics. We found that organizing Chapter 4 around them answered our first goal of identifying the nature of the experiences that shape (justify, modify, or affirm) novice teachers' STLB.

The chapter is structured as follows. For each novice teacher, we first write a profile, a biographical narrative (Clandinin & Connelly, 2000, p. 158), to factually dress a portrait of each individual. We address how they came to this profession as well as their most prominent ideas about mathematics, teaching, and learning. Then, as detailed in Section 3.2.1.4, we present our analysis which attends to our second goal: to explore the ways in which teachers' STLB are shaped (justified, modified, or affirmed). We place the outcomes of our analyses and reflections depending on the nature (Implicit Training—as a student, Implicit Training—as a teacher, Implicit Training—outside of school, Explicit Training—as a student, Explicit Training—as a teacher, and Experiences related

[23] We talk about "implicit training" to refer to experiences that result in implicit training to teach, training behind which there was no intention for teacher training.
[24] We talk about "explicit training" to refer to experiences behind which there was an explicit intention for teacher training.

to mathematics) of the experience that shaped novice teachers' STLB as is reported in the booklet of stories. These reflections stemmed from our repeated asking of the following questions:

- What can be said about how these STLB were shaped?
- What are the experiences that may have had a part in shaping these STLB?

We present our attempt at an answer below. We sort the outcomes of our reflection under different themes relating to the experiences

4.0.1 Precisions on the Format of this Chapter

We suggest the reader first look at the stories we wrote in the booklet for each novice teacher before engaging with the section about them. For example, we recommend you read Albert's stories (in the booklet in Appendix D, pp. 220–236) before reading Section 4.1 and read Vera's stories before reading Section 4.2. Throughout this chapter, we use brackets to cite the story we are referring to from the booklet. For example, if the ideas we are referring to are located in the booklet at p. 287 and is described between lines 12 and 17, we will write [p. 287, 12–17].

We also use footnotes to bring up new elements triggered by the reflection which did not make it into the stories shared in the booklet. In these cases, we cite accounts (see Section 3.1.3) of our meetings. In the texts, we will refer to the footnote between brackets (e.g. [[1]]).

Throughout this chapter, we use the verb "to story." Because our perspective is that people understand and go about their life narratively (see Section 2.2), we use the verb "to story" as a way of talking about how people interpret the world around them. It is our way of talking about stories novice teachers live and tell about themselves, who they are, and are becoming; the stories they tell about others and about the world around them, as well as the stories others tell about them. It is our way of talking about their stories to live by (STLB) and what they use to make sense of the world around them and to act in the present. To clarify, an example could be "They story the role of the teacher in cegep as helping students." In this sense, it means that their STLB about the role of the teacher in cegep is that they are there to help the students, which will influence, for example, how they act in the classroom. Another example could be: "Others story him/her as studious." In this sense, we talk about what others "know" about him/her, which will dictate, for example, how others act towards them. In other words, the knowledge one has about something, or someone, form how they story it/them. To use words that may not be directly connected to narrative inquiry, it encompasses one's visions, beliefs and interpretations.

Also, we use the expression "imagined stories," which are stories novice teachers imagined, about themselves as teachers, about the profession, about students, before they entered the profession. Schaefer and Clandinin (2011, p. 276) describe them as "forward-looking stories" of their imagined lives and identities as teachers.

4.1. Albert

4.1.1 Profile

In this subsection, we dress a portrait of Albert. We address his story in relation to his education and up to his entry into the profession of cegep teaching. We also address the most prominent stories to live by that he shared about mathematics, teaching, and learning[25].

Albert wanted to be a teacher when he attended elementary and high school. He used to put himself in his teachers' shoes and reflect on how he would do or say things differently if he were the teacher. Albert feels as if he lost sight of teaching in university.

He went through the science program in cegep. At that time, he was not really interested and focused on his studies. He does not consider himself to have been a great student; he just wanted to be above average. In cegep, he did not need to work hard to achieve that goal. He did not need to reach full understanding of the material or even to study every topic in a given course. He could not see how the material covered in his classes would be useful for him in the long run, so he was not motivated to do more.

Albert chose to do a bachelor's in mathematics because that is the discipline he liked the most in cegep. After completing his bachelor's, he did not know what to do next so he started a master's program in mathematics. Albert's master's thesis expanded on a research project he had conducted prior to entering the master's program. Because he did not have new research to do and his classes turned out to be repetitions of what he had learned before, he got bored and found other things to focus on. He was on multiple committees and played various sports. He did so much other than

[25] In the participants' stories to live by, we focus mostly on their "body of convictions" (Clandinin, 1985, p. 362) about mathematics, teaching, and learning (for more, see Section 2.2.3).

mathematics that he somehow stopped doing mathematics. At this point, he felt out of touch with mathematics.

After completing the master's, he still did not know what else to do, so he decided to enter a doctoral program in mathematics, instead of finding a job. After a while, Albert was unmotivated and felt isolated. He was not doing research anymore because he was uninterested by his project so he dropped out. He applied to find a job in the industry, to apply the problem-solving skills he learned in mathematics, and to a few cegeps to be a teacher. A former student colleague of his called him for an interview at a cegep. He was offered the job and took it "just to get a job." He has been teaching at the same institution ever since. He now holds a permanent position and is increasingly involved in the creation of courses and programs.

When Albert started to teach, he decided to attend seminars available at his institution for the professional development of teachers in all disciplines. He found the quality of the seminars to depend on who was leading it. Since each department has a different culture, some seminars did not resonate with him. Some departments leave their new teachers in a sink or swim situation, which is not how things are done in the mathematics department. Further, the types of assessments differ from one department to another—for instance, the assessments in arts or chemistry are different from those in mathematics.

Albert thinks his role as a teacher is to prepare students for their future. He believes that being a teacher means to take what he learned in mathematics and to transmit it to students. If he understands something, he can teach it. Albert will do everything in his power to motivate the students, but he believes it will be of no use if the students do not do the work themselves. His job is to give them the opportunities, but they have to take them and they have to do the work.

For Albert, to learn and to understand are different. To understand a concept is to be able to tell where it comes from, to play with it, and to explain it. Learning is to learn by heart. To understand the material and to be comfortable using it, one needs to use it. But, for students to learn new material, they must put aside their personal problems before he brings up new problems. For the students to understand something, Albert shares his personal understanding of it. For the students to learn, he makes them practise repetitively.

Albert teaches by slowly increasing the level of difficulty of the examples he shows in class. The brain can be trained, and it adapts to the work that it is asked to do. If you are used to doing advanced mathematics, learning or relearning lower-level mathematics will be easier, as if your body was trained to lift heavy weights and you suddenly lift light weights. Albert believes in an approach to teaching where he constructs knowledge *with* the students on top of what they already know. This forces him to understand what the students understand.

Good students have a good attitude towards the material and a will to learn. Albert believes that students learn better in an agreeable and relaxed environment; therefore, for him to have a positive attitude towards the material helps the students learn. Students are not motivated to learn material they will not use or need later on, just as he was not at their age. In general, students struggle with notation, in terms of understanding both what is written and the meaning of what they are writing.

According to Albert, there are multiple facets to mathematics. There is the applied side, where you start from something concrete, abstract it to be able to work with it, model it, analyze it, then draw conclusions that are concrete. There is also the abstract side, where definitions are a hundred percent unambiguous. In the general sense, mathematics is about solving problems, analyzing problems, analyzing situations, finding a path to a solution, and making rigorous steps towards finding a solution.

4.1.2 Implicit Training—As a Student

In this subsection, we reflect on Albert's experiences as a student, when the nature of the training he received on how to teach was implicit. For instance, we will encounter experiences in which Albert, as a student, observed his teachers and reflected on his, and his students-colleagues' needs.

Learning is dependent on the classroom environment and the classroom environment is (at least in part) dependent on the teacher

Albert lives a story in which his role in the classroom is one of great importance for the students' learning. Indeed, he stories[26] his attitude as possibly influencing not only how much students like his class, but also the learning they can achieve. Albert narrated experiences he lived as a student that shaped these stories. He shared experiences in which the teacher played a huge role in his love

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[26] From the verb "to story," defined in Section 4.0.1.

for the class, in cegep [p. 234, 6–8][27], in university [p. 234, 11–22; [28]], and even in the professional development seminars he attended [[29]]. In particular, he remembers a teacher in cegep who clearly did not like her job. He therefore saw firsthand how students can sense that kind of attitude and how such an environment can prevent them from learning [p. 234, 8–10]. Consequently, Albert lives a story in which he shows a great attitude in his classroom towards the material and the students [p. 234, 2–4, 8–10].

Each population needs a different teaching approach

As a teacher, Albert lives a general story about different populations of students as having different needs. Below we address and wonder about the story Albert lives with, and tells about, each population and how each story was shaped [p. 230].

Students in career programs only need to be able to apply mathematics

Albert tells a story about students in career programs only having to be able to apply mathematics [p. 230, 17–18]. As we wonder about how he shaped this story, we are drawn to think about an experience Albert lived in a statistics course he took with actuarial students [p. 223, 2–7]. In that particular course, proofs were mostly ignored. While Albert did not like it for himself, he justified the way it was taught by the fact that actuaries, in their profession, only need to apply formulas, not reflect about, justify, or understand them. We wonder whether Albert chooses to story students in career programs as needing a similar teaching approach from him. Our perspective is that when Albert is faced with the unfamiliar situation of teaching to an unfamiliar population, he has to rely on what he learned in lived experiences that had something in common with the unfamiliar situation (see Section 2.1.5 on Unfamiliar experiences). The statistics course we mentioned is the only example Albert spoke about that is related in some way to the teaching of future “applicants of mathematics” (which is how he stories students in career programs [p. 230, 17–18]). Since he

[27] We take this opportunity to remind the reader that throughout this chapter, we use brackets to cite the page and the line(s) to which we are referring in the booklet in Appendix D.

[28] À l’université, s’il aimait ses cours dépendait beaucoup des profs, de comment ils introduisaient la matière.

[29] À savoir s’il a aimé ça, ça dépendait beaucoup de qui le donnait. Pour avoir le droit de donner les séminaires, il faut avoir suivi les cours et avoir une accréditation, mais ça reste d’autres enseignants de cégep. Ils ne sont donc pas nécessairement du même domaine que toi et la dynamique de chaque département change beaucoup aussi.

was a science student in cegep, Albert most likely never sat in a mathematics class aimed for students in career programs.

Pre-university students need to understand the material

When it comes to pre-university programs, Albert tells a story in which science and social science students are future scientists who have to reach a complete understanding of the material [p. 230, 21–25]. This storying stood out to us considering this is not what he found important when he was a student in cegep [[30]]. Back then, his personal goal was to be above average. We wonder how Albert shaped the story he tells about students in pre-university programs. When he started to teach in cegep, he realized that putting in the time and effort to get a profound understanding of mathematics while he was in university left him with competencies which he now uses as a cegep teacher. He gathers these competencies under the umbrella of mathematical maturity [p. 225, 1]. He considers these skills as lifelong tools he could have applied in any profession he could have chosen [p. 225, 6–9]. Since his goal is to prepare students for their future [p. 225, 9–10], whatever their future may be, it follows that Albert would want his students to work towards those competencies, which he developed aiming for a profound understanding [p. 236, 7].

It is impossible to hold social science students to the same standards as science students

On a similar note, since Albert stories both science and social science students as future scientists, he would like to live out a story in which he holds them both to a high standard of rigour [p. 230, 3–4]. However, he lives out a story in which he holds social science students to lower standards[31]. Indeed, this change happened after some experiences he lived as a teacher showed him that social science students were not motivated enough to hold them to the same standard of mathematical rigour as science students. Albert does not mention specific experiences that shaped his story of social science students as being unmotivated. However, he does mention how he draws on his own experience of not being motivated as a student in cegep to give meaning to, and understand, social science students' lives. At the time Albert was in cegep, he did not know why he should be

[30] [Albert] était beaucoup moins assidu au cégep. Il faisait plus de parascolaire. Il n'était pas beaucoup axé sur ses études. Il n'avait pas tellement d'intérêt, il ne cherchait pas le 100 % et être en haut de la moyenne, c'est tout ce qui le satisfaisait, c'était ça son objectif et il l'avait.

[31] This story was shaped both by experiences Albert lived as a teacher and as a student. We decided to place this story in implicit training—as a student because it was in continuity with the stories above about how Albert stories teaching to different populations.

interested in mathematics [32] and getting good grades was just not enough motivation to want to reach understanding [p. 236, 15]. These memories shaped how he stories social science students: they do not know either why they should be interested, especially because they will not reuse their mathematics, contrary to science students who will use it in physics courses, for example. Because of that, Albert cannot hold them to the same standard of rigour.

4.1.3 Implicit Training—As a Teacher

In this subsection, we reflect on Albert's experiences as a teacher, when the nature of the training on how to teach was implicit. For instance, we encounter experiences Albert lived as he used the lesson plans of, or inspired by, other teachers and as he attended to the difficulties of his students.

Swiftly solving the problems in assessments

A key aspect in the stories of assessments Albert lives is that he does not fully solve the questions he asks students to solve [p. 228, 1]. In the beginning of his career, he did not solve them at all. This did not always work out well for him nor for his students [p. 228, 2–7]—which may refer to one or more experiences that encouraged him to change the story he lives. Now, Albert swiftly solves the problems in his mind before putting it into the exam. We wonder how this new story has been shaped. It may come from him learning that certain solutions can have an undesired and undesirable destabilizing effect on the students [p. 228, 5–7] and that, therefore, having an idea of the solution seems important to him. To accomplish that, he does the problems mentally.

Preparing for a class in a way to keep things interesting and to ensure students can trust him

Regarding how Albert prepares for a class, now that he is more experienced [p. 233, 11–12], he lives a story of preparation in which he does not write a lesson plan that is longer than a few words before getting to class [p. 223, 29–35]. We wondered how this story of preparation has been shaped[33].

First, we thought about how Albert wants to make his reasoning as explicit as possible to students when he solves problems in front of them in the hopes that they catch on to and try to replicate

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[32] Ce que [Albert] n'a pas compris quand il était au cégep, c'est parce qu'il n'avait pas l'intérêt de le faire ou que les profs n'ont pas su transmettre qu'il pourrait y avoir un intérêt pour ça. Ce n'était pas tout le temps clair à quoi sert ce qui est enseigné au cégep et à quel point quelque chose est important ou non.

[33] This story was shaped both by experiences Albert lived as a teacher and as a student. We decided to place this story in implicit training—as a teacher this is a story that was shaped mostly while Albert was in the posture of a teacher.

how he figures out how to solve problems [p. 225, 35–39]. We wonder if Albert is keeping his mathematical reflection more authentic by addressing in class problems he has never seen before. We also wonder if making his reasoning explicit may be easier when he tackles problems he has not yet solved, which would help him live out the story of showing students how he really thinks when solving a problem [p. 225, 35–39].

Another experience that could have shaped the story Albert lives as he plans his lessons happened as Albert started to teach. When he taught a course for the first time, he wrote detailed notes, just as his colleagues did. He found that he got lost in the pages of his class notes while he taught [p. 233, 28] because he was trying to follow them. Albert also mentioned that he felt bored when he used detailed class notes [p. 233, 10]. We wonder if Albert minimally prepares for his classes in order to keep things interesting for himself in the classroom.

Our reflection led us to ponder if inventing problems, or solving problems he has not seen before, was shaped by a desire to be kept on his toes and a desire to keep things interesting and challenging for himself [p. 233, 26]. Albert shared with us memories of being a talented mathematics student and enjoying solving challenging problems in university [[34]] and reflections about how his reality as a teacher in cegep is mathematically different than when he was a student in university [p. 226, 3–7]. This is especially true of his mathematical reality at the end of his university studies, when he was a doctoral student working on problems that might have no solution or a solution whose form no one could predict or know how to reach. Therefore, improvising brings a challenging aspect, which he loves, to the mathematics he is doing, mathematics that is not that hard after all he had gone through in university [p. 225, 25–31].

Still wondering about experiences that shaped Albert’s ways of preparing his lessons, we were drawn to reflect on an experience Albert shared about being taught by a lecturer in university whom he did not feel he could trust as a source of the knowledge he wanted to acquire as a student [p. 234, 21–23]. From that experience came a need for Albert to show his students they can trust him as a source of knowledge. This story no doubt shaped Albert’s story to live by about how

[34] Ce qui le rendait bon en mathématiques, c’était sa rapidité à s’adapter et à comprendre le concept. Ça rendait certains de ses collègues au bac frustrés. Ses collègues travaillaient en équipe sur un devoir depuis plusieurs heures et [Albert] arrive, il n’a pas encore commencé à travailler sur le devoir, et non seulement il les rattrape, mais il les aide à avancer.

prepared a teacher should be. As such, Albert would not prepare the way he does if he did not think he could pull it off and show enough mastery to convince the student they can trust him.

Teaching in a way that attends to the students' needs and difficulties

Albert shared stories of how he changed some stories he lives in his classroom, stories that could be seen as traditional, to live out stories that attend to the needs and difficulties his students had. We explore here how the new stories were shaped.

First, Albert went from living a story in which optimization and related rates assessments contained a minimal number of long questions to living a story in which the assessments were made of multiple smaller questions [p. 229]. Albert made that change after he saw students losing a lot of marks from making mistakes early on in a long question and he considered that the shorter questions would allow them to show better what they could do.

Albert also went from living the story prescribed by a textbook to one that was shaped by the difficulties he witnessed in his students. Indeed, Albert changed the notation used in Calculus I, based on the textbook, to avoid certain recurrent mistakes and help students succeed in their next class, Calculus II [pp. 231–232]. This change came about as he taught Calculus II for the first time. There were tensions between how Calculus I is usually taught and Albert's feeling that this approach is not the best for his students. All in all, Albert decided to live out a story that is outside the dominant[35] ones found in textbooks as he developed a sense of what his students needed to succeed.

Albert also tells a story of changes that occurred in the ways he stories the best way to find the level of difficulty of the questions he puts in assessments [p. 224]. He went from a trial and error method to a method that is informed by the day-to-day work of his students. He now takes the time students spend working on problems in class as a way to get information about the level the students are at. Also, Albert no longer bases his decisions about the level of difficulty in

[35] We talk about "dominant stories" to refer to the stories that are most lived or told in a certain context at a certain moment. In this case, the storying of mathematics present in the textbook used in Albert's department is considered the dominant story lived in this department, a story Albert decides to go against.

assessments on the questions students asked in class because such questions turned out to not always be representative of the whole group.

4.1.4 Explicit Training—As a Teacher

In this subsection, we reflect on the experiences Albert had involving explicit and intentional training on how to teach. We encounter experiences Albert lived in the professional development seminars he attended as a teacher [p. 235]. Indeed, these seminars have had quite an impact on the stories Albert lives and tells.

Involvement in the structuring of curriculum and programs

Albert lives a story in which he is involved in the structuring of curriculum and programs. In one seminar Albert attended, he was asked to create a timetable with teaching methods for a course [p. 235, 2–3]. He took this assignment seriously and continued to create material for the course he had originally picked. Those projects shaped the story Albert now lives of being involved in committees that discuss the structure of programs and courses in his cegep; this involvement is now a significant part of his day-to-day work life [p. 235, 5–9]. Albert tells a story about himself as someone who loves to think about teaching and pedagogy, knowledge and how programs are structured.

Still regarding what shaped the story of involvement he lives, Albert became aware of the freedom teachers have, as far as the sequence of teaching also through a seminar. He was told that the cegep curriculum is not strict as far as the order in which it can be taught. The seminars therefore gave him the confidence to use this freedom; this, in turn, gave him the power to make changes [p. 235, 22–25].

A teacher can teach in the way they are comfortable

Albert tells a story that each teacher can teach in the way they are comfortable, in the sense that there is no one *right* way of teaching. He justifies this story with an experience he lived in professional development seminars. He was told that teaching may (rightfully) take on many forms [p. 235, 18–22]. It freed him of some expectations he had for himself, such as that of teaching in the style of a lecture. Another experience that shaped his choice of teaching style is when he was exposed to different learning paradigms for the first time. He chose to distance himself from lecture-style teaching [p. 235, 10–22]. He learned he could make his own choice.

4.1.5 Experiences Related to University Mathematics

In this subsection, we reflect on Albert's experiences as they relate to university mathematics. As we attended to how Albert's stories to live by had been shaped, we were drawn to think that through his first few years of teaching, he had to modify his stories to live by in order to create continuity, to find narrative coherence, between his mathematical self, the person he had been for many years while studying mathematics in university, and his teaching self, this new identity he was taking on. Albert had to modify his old stories so they would work for him as a cegep teacher. We believe he did this in multiple ways. We explore here how some of his STLB have been shaped by his time in university, how these STLB were challenged by his new profession and how they were shaped into the stories he now lives and tell as a novice cegep teacher.

Cegep mathematics is important

For the duration of his time in university, Albert's identity was much defined by mathematics. Experiences he shares about his friends being frustrated by his abilities in mathematics [[36]], and about his grades increasing each semester [[37]], indicate that Albert was storied by others, and storied himself, as talented in university mathematics. It is during those times that Albert developed a storying of mathematics done in university, geared towards ideas, as the "true" mathematics, whereas the mathematics, geared towards techniques, done at lower levels, cegep and below, are not "true" mathematics. Therefore, when Albert started as a cegep teacher, he became involved with mathematics that he did not consider "true" mathematics [p. 221, 8–11]. This must have been quite a change for someone who was storied as talented in university mathematics to suddenly be working with "untrue," lower level mathematics.

At first, Albert expected not to love the mathematics he would be teaching in cegep, following the storying of mathematics he developed during his time in university. However, he realized, with surprise, that he enjoyed the mathematics taught in cegep much more than he expected [[38]]. Now

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[36] Ce qui le rendait bon en mathématiques, c'était sa rapidité à s'adapter et à comprendre le concept. Ça rendait certains de ses collègues au bac frustrés. Ses collègues travaillaient en équipe sur un devoir depuis plusieurs heures et [Albert] arrive, il n'a pas encore commencé à travailler sur le devoir, et non seulement il les rattrape, mais il les aide à avancer.
[37] Ses notes ont augmenté de manière stricte à chaque session, sa moyenne a augmenté de la première session à la sixième. Ce qui l'a aidé c'est qu'à chaque été il a fait des stages de recherche, il n'avait donc pas de pause de maths. Il avait vraiment progressé.
[38] En devenant enseignant, il a réappris à aimer les maths plus de base. Ça a été un choc, à sa première session d'enseignement, à quel point il aimait plus ça qu'il pensait.

that he considered concepts taught in cegep with his trained eye, he was able to relate the concepts to other areas of mathematics—including their applications.

As Albert started to teach, he modified his stories about mathematics and learning mathematics in order to justify his new love for the mathematics done in cegep, which was not "true" mathematics from the perspective he gained in university. To justify living and telling a story in which cegep-level mathematics, geared towards techniques, are important, Albert used a story of research. As an undergraduate student, he was involved in a research internship. On that occasion, he found that to do research, the "real" work of mathematicians, the technical side, is crucial [p. 221, 18–20]. His experience in research offered a justification for the technical side of mathematics—such as knowing how to differentiate efficiently—and a reason to subscribe to the emphasis on technique that characterizes cegep teaching and curriculum. This justified the attention given to techniques in the cegep curriculum, and the attention he has to give to techniques in the story he lives out as a teacher in his classroom.

Cegep teaching should value and support the practice of techniques

With this new take on the importance of technique, Albert also justified a story of teaching that valued, and supported, the practice of techniques and not only "ideas"; this was in contradiction with the teaching he often experienced in university [p. 221, 39–42; p. 222, 1–4]. Indeed, Albert experienced teaching in university which was guided by the vision that ideas are the essence of mathematics [p. 221, 39–42; p. 222, 1–4]. Albert justified his move away from this style of teaching by a story of another type of teaching, a type that is more detailed and rigorous [p. 234, 12–16]. Albert was drawn to this type of teaching because it was closer to his view of mathematics [p. 234, 15–16], and could better support the focus on techniques which is needed in cegep teaching.

Albert mentions two other reasons why he moved away from the teaching style he received in university. Firstly, he heard multiple negative comments from former mathematics students who had experienced such teaching [p. 222, 5–7]. Secondly, Albert believes that to understand material, one needs to use it; this is in contradiction with that way of teaching. We wondered where this story of learning, that one needs to use the material in order to understand it, comes from. This story drew us to a story Albert told about how rare it is for a person to understand a piece of material instantly. This can happen, but not for 15 weeks straight. Therefore, students usually need an opportunity to use the material [39] to understand it. Albert also tells the story of how he became highly effective in university at one point and could understand things quickly [40]. According to him, this came from uninterrupted work with mathematics [41]. These experiences encourage practice and continuous and constant work for success, which justify the story of teaching that Albert is living.

Students have to develop their mathematical maturity

As a teacher, Albert lives by the story that students should develop their mathematical maturity. This story was shaped as Albert started to teach and realized how different his approach to cegep mathematics was compared to when he was a cegep student [p. 225, 1–2, 6–8]. Upon reflection, he realized that this new approach was in part because of the special skills, which he calls "mathematical maturity" [p. 225, 3], he developed during his time studying mathematics in university. Since this mathematical maturity is what he says helped him when he decided to apply his knowledge in mathematics to teaching, he believes that skills that come with mathematical maturity would be helpful to anyone who will, one day, apply mathematics in their profession.

A teacher should provide students with opportunities to *start* to develop their mathematical maturity

Albert lives a story in his classroom in which he gives students opportunities to develop such maturity while not expecting them to develop all the same skills he did [p. 225, 16–18]. We wondered about what shaped the story that he is the one who should be providing the opportunities. We were first drawn to reflect on his proclaimed role to help the students develop their future [p. 225, 9–10]. Indeed, in the students' future profession, they will be needing some of the skills of mathematical maturity so he can at least help them start to develop these skills.

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[39] Pour s'approprier une matière, il faut l'utiliser. C'est très rare quelqu'un qui va juste voir un concept et le comprendre instantanément. Ça peut arriver parfois pour 1 ou 2 concepts, mais comprendre 15 semaines de cours comme ça, non. Il y a des dizaines d'heures là-dedans.

[40] Ce qui le rendait bon en mathématiques, c'était sa rapidité à s'adapter et à comprendre le concept. Ça rendait certains de ses collègues au bac frustrés. Ses collègues travaillaient en équipe sur un devoir depuis plusieurs heures et [Albert] arrive, il n'a pas encore commencé à travailler sur le devoir, et non seulement il les rattrape, mais il les aide à avancer.

[41] Ses notes ont augmenté de manière stricte à chaque session, sa moyenne a augmenté de la première session à la sixième. Ce qui l'a aidé c'est qu'à chaque été il a fait des stages de recherche, il n'avait donc pas de pause de maths. Il avait vraiment progressé.

Still wondering what shaped the story that Albert is the one who should provide opportunities, we remembered how he says that his approach to cegep mathematics was much different when he came back to it as a teacher [p. 225, 1–2]. We wonder if this means that mathematical maturity was not fostered for him in cegep and he therefore feels he has to be intentional about fostering it for his students. In other words, in cegep, mathematical maturity is not fostered unless it is intentionally being fostered, as it was not fostered for him.

Second, we wondered about what shaped the aspect of that story to live by that says that students should *start* to develop their skills. Albert's experience in the classroom shaped this aspect as he saw that students are not necessarily ready to develop the skills he aims for them to develop. For example, Albert recalls a time when he gave an exam question in cegep that was different from what he had shown in class, only to realize that students are not yet at that level. Students are focused on what was specifically taught for the purpose of this specific exam because, according to Albert, this is always how preparation for exams and evaluation work before university. However, Albert believes his intuition, part of his mathematical maturity, was especially developed in university because of the assessment culture in the program he completed. The questions in assignments were rarely the same or even similar to what the students had seen previously [p. 226, 22–27]. Nevertheless, he still lives out a story in which he gives them opportunities to get the skills of mathematical maturity [p. 226, 39–40].

4.1.6 Reflection on Albert's Stories

In this final subsection, we take a global approach and summarize what we learned about how Albert's STLB were shaped, per respect to the three chosen strands.

Albert's stories about how his STLB are shaped have a lot to do with his experiences in university mathematics. Indeed, these experiences are at the root of a lot of what he wants to live out as a teacher, such as teaching "true" mathematics and aiming to foster mathematical maturity in his students. His experiences related to university mathematics are very present in the stories he shares about himself as a teacher. Also, the ways in which Albert narrates having to create new stories to live and tell as a cegep teacher, because the stories he lived and told as a university students were not sustainable, were very informative about how the stories to live by of a novice teacher can be shaped during the transition from mathematics students to cegep mathematics teacher.

The explicit training Albert received in his institution gave him validation that he belongs as a teacher and that his ideas about teaching mathematics are relevant. This allowed him to branch out into being involved in administrative committees.

4.2 Vera

4.2.1 Profile

In this subsection, we dress a portrait of Vera. We address her story in relation to her education and up to her entry into the profession of cegep teaching. We also address the most prominent stories to live by she shared about mathematics, teaching, and learning[42].

Vera earned a pre-university cegep degree in health sciences and went on to do a bachelor's degree in science[43]. In the years that followed, she worked in that science field and tutored children, sometimes with special needs.

At one point, she was asked to tutor a young woman in a cegep-level course. Upon realizing she had never taken that course, she went back to cegep to do it. She settled on taking the course as a summer course at night. This meant attending class 4 nights a week, 3 hours a night. About halfway through the course, she discovered she was having an enormous amount of fun. She was truly enjoying the challenge, the work, the learning. She decided to apply for a bachelor's degree in pure and applied mathematics when the course would finish. It was a busy time but she had a great deal of fun. She enjoyed her degree and dedicated a lot of time to it. It was her choice to go back to school and she was committed to making it work.

During her bachelor's degree, she saw a poster for a master's program in mathematics education (details on the program are in Section 3.2.1). She was admitted to this program on the basis of the strength of her previous university degree in science and with the condition that she kept her grades up in the undergraduate courses she still had to take to complete her undergraduate degree. She then pursued the master's program concurrently with the bachelor's program. During this time,

[42] In the participants' stories to live by, we focus mostly on their "body of convictions" (Clandinin, 1985, p. 362) about mathematics, teaching, and learning (for more, see Section 2.2.3)
[43] We do not specify in what science field to maintain Vera's anonymity.

she got to teach a course in university and be a teaching assistant. She graduated from the master's program first, and from the bachelor's program later.

When she completed her bachelor's degree, she sent out applications to teach in cegep. She had an interview at a cegep where the selection committee offered the position to someone else. She had another interview a few weeks into a semester. This time, she was hired. She started that same week, on a Tuesday. She ended up teaching one day course and one evening course. This worked out incredibly well for her as it made for a bit less than a full teaching load; since she was jumping in mid-semester, this gave her more time to prepare. Vera has been teaching full-time in this same institution ever since. She has taught more than 10 different courses in the 3 years she has been a teacher.

Vera's view is that there is not one magical way of teaching something because everyone learns differently. She acknowledges that she has a natural tendency to teach concepts the way she understands them, so she prepares to have other options on hand for students who might need them. She is a facilitator in her classroom. She believes herself to be an asset in the classroom because she can help students achieve learning that would be harder for them to achieve on their own. It is her job to adjust to whoever is in front of her to the best of her ability. Teaching methods are not universal; some may be successful for one teacher but not for others.

Vera's role is to take students from high school to university. This means to give them more independence, while not putting them in a sink-or-swim situation. It is their responsibility to study, to do their homework, to determine how much homework they need to do, to manage their time. Her responsibility is to present the material and at least give them the opportunity to learn the material in a classroom. Vera wants her classroom to be a place in which her students learn, rather than a place in which to watch her do mathematics. She wants students to be able to use the concepts that they have been taught, but also to develop logical thinking. Her goal is to prepare students in case they want to go in mathematics, even if very few do.

Vera loves that there are rules in mathematics and that as long as you are in a given context, or working with a given problem, the rules apply. Doing mathematics, to her, is setting up a world where there are objects, like numbers, mathematical figures, and structures. There are rules and we define things, as well as we can, and once we lay out the rules, we play. It is a world of interesting things and well-defined rules and regulations. It can be a logical sequence of events, a logical program, but it is also creative. Part of doing mathematics is looking at a problem and starting off in one direction. The mathematical part is to recognize when you have hit a brick wall, be able to back up at least part of the way, and head into a different direction.

According to Vera, one could look at learning as getting to the understanding; that is, learning is the process and understanding the destination. Assessing understanding is incredibly difficult. Tests do not tell her if students understand mathematics; they tell her whether or not they can do her test under test conditions. There are people who are better than others at being assessed. Part of her job is to sort students and indicate to universities which students are in the top 10% of her class.

Understanding is a process; it does not happen overnight. Not everyone who gets through calculus understands calculus. Sometimes it takes a while for it to fit into the network of mathematical knowledge students have from before. For Vera, people like mathematics up until the moment when they feel they do not understand it. There are people who cannot get to cegep-level mathematics. Her goal is to prepare students in case they want to go in mathematics, even if very few ever do.

4.2.2 Implicit Training—As a Student

In this subsection, we reflect on Vera's experiences mainly as a student, when the nature of the teacher training she received was implicit. For instance, we encounter experiences in which Vera, as a student, observed her teachers and reflected on her success and on the ways in which she was assessed.

Teaching according to the students' knowledge

As a student, Vera hated when professors dismissed students' questions because they expected students to already know the answers [p. 240]. She remembers feeling distraught by the fact that this was preventing students from going forward. These experiences shaped Vera's story in which her teaching is sensitive to and maybe even dependent on the present knowledge of the students.

Understanding is useful, but not necessary, to succeed in cegep mathematics

In Vera's personal experience learning mathematics, understanding the material she was taught, in opposition to learning just a method to solve a range of problems, would help her pass her courses with ease [p. 256, 11–13]. These experiences shaped the story Vera tells her students: they should strive for understanding. However, Vera lives out a different story in her classroom. Indeed, Vera's story about success through understanding bumps with how she stories cegep students as lacking in maturity and in good-quality motivation, which prevents them from looking for understanding [p. 255, 22–23]. Therefore, the story changed and became one in which students are not put into a situation in which their success in the course relies on them understanding of the material. Indeed, Vera lives a story in which she teaches in a way that still provides support, a back-up plan, a road map, if students do not understand everything [p. 256, 10–20], while still promoting understanding.

4.2.3 Implicit Training—As a Teacher

In this subsection, we reflect on Vera's experiences as a teacher, when the nature of the training on how to teach was implicit. We encounter experiences Vera lived as a teacher that taught her many things about the students and their needs, level, and difficulties. In many ways, Vera said she did not know what to expect from students when she became a teacher [e.g. p. 255]. She narrates how some experiences modified the stories she lived and told as a teacher. Underlying how her stories to live by were shaped is Vera living a story in which her teaching needs to be tailored, at least to some extent, to the students (see previous section).

Multiple stories to live by about teaching and learning

We gathered here multiple specific stories to live by about teaching and learning, alongside the experience(s) that shaped them.

For instance, Vera became aware that the constants in a problem can cause confusion for students, so she should put some thoughts into her choice of them [p. 248]. She also tells a story of choosing the number of attempts permitted for an online assessment [p. 251] on the basis of students' input. And Vera strives to work more on word problems with her students after realizing how much they struggle with these [p. 256, 26–41; p. 257, 1–8]. She often has students whose first language is not the language in which she teaches [p. 242] and found value in using visual representations as a universal introduction. Vera continuously changes her lesson plans as she teaches and learns, among other things, how much time it takes students to grasp certain concepts [p. 245, 12–14].

Every group of students is different

Vera narrates how experiences she lived as a teacher taught her that every group of students is different. Indeed, since she was not sure of students' level in a typical Calculus I class, she took her first experience teaching this course as representative of the strength of every group [p. 249, 1–3]. Further teaching experiences, however, shaped the story she tells as she realized every group was different and that she would need more time if she hoped to figure out the strength of an average group.

She can teach any course

Vera lives out a story of confidence and comfort when teaching any course, in particular courses she has never taken as a student. She justifies being able to live out this story by her experiences teaching classes she was comfortable with at the beginning of her career [p. 253, 12–21]. Indeed, when she started to teach in cegep, Vera taught classes she had taken as a cegep student (e.g. Calculus I and Calculus II). At that time, she relied on knowing the material really well while she dealt with the anxiety of being a teacher for the first time. Since she knew the material so well, she could focus on becoming comfortable speaking in front of a group, dealing with mistakes she made on the board, and dealing with self-doubt [p. 245, 6–20]. Along the way, she started to teach classes she had never taken and never heard of, such as mathematics courses in career programs. Because of her experience in familiar courses, she was confident she could learn new material and teach it [p. 253, 12–21].

What works for some teachers may not work for others

Vera lives by a story that what works for other teachers might not work for her [p. 246]. This story was shaped by an experience in which she attempted to live out a story of assessment that her colleagues use and appreciate, without success. Indeed, as she sought help from her colleagues in figuring out how to assess students properly, she concluded that some things that other teachers claim work well for them, such as weekly assessments, do not work for her [p. 246, 6]. Vera narrates what story of assessment she decided to live out instead, exercises in class, justified by experiences she had as a student instructor [p. 246, 27–34] and research papers she read as a master student [p. 246, 25–27].

Students are focused on finding their grades

Before she started to teach in cegep, Vera imagined that students would be mature, motivated to learn, and excited by challenges [p. 255, 4–5]. This story immediately bumped with her reality as she started to teach; students were not as mature, motivated, and excited as she expected. Indeed, a few experiences as a teacher (see [p. 255]) shaped Vera's story of students. She now stories them as mostly focused on their grades and motivated by short-term goals such as to figure out what will be on the exam and how to pass it. They are not motivated by a desire to understand.

While this story was shaped by experience she had as a teacher, we found interesting to wonder where her expectations of students being mature, motivated, and excited had come from and one story came to mind. When Vera narrates how she went to cegep the first time, she says she was not mature enough to enjoy the gift of learning, whereas the second time, she was motivated to learn and enjoyed the challenges she was handed [p. 255, 1–4]. She was also motivated by the knowledge that what she was learning might be useful for purposes other than getting a good grade, such as being reinvested when she becomes a teacher. By her expressed expectations of her students being more mature, motivated, and excited by the challenges she brings to them, we wonder if she created imagined stories[44] of cegep students based on how she was as a returning student (the second time) rather than how she was as a young adult in cegep (the first time). Finally, while Vera may have arrived to teaching with the goal of giving students something similar to what she was looking for when she returned to school, she realized that cegep students are not quite there to enjoy the mathematics. This reminds us of Grossman's (1989, p. 205) study with teachers who were trained only in literature before starting to teach in school. Their conceptions of teaching all seem to presuppose students who are bright and motivated, students very much as they remember themselves being.

4.2.4 Experiences as a Tutor and Away From School

In this subsection, we reflect on Vera's experiences while she was away from school, particularly her experiences tutoring.

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[44] We use the expression "imagined stories," which are stories novice teachers imagined, about themselves as teachers, about the profession, about students, before they entered the profession. Schaefer and Clandinin (2011, p. 276) describe them as "forward-looking stories" of their imagined lives and identities as teachers.

Attending to others' learning can help one learn

Vera tells a story in which being a tutor is helpful in one's own learning. Indeed, Vera's own experience being a tutor increased her awareness of her, and others', learning processes [p. 239, 1–8] which later helped her learn new mathematics. Also, explaining things to people helped her understand such things more deeply [p. 244]. Those experiences shaped her story about how tutoring can be useful and she now tells this story to her students to encourage them to get involved in peer-tutoring programs to benefit from what they can learn by being a tutor.

Appreciating mathematics is beneficial

Vera lives a story in her classroom in which she aims to have her students develop an appreciation for mathematics—an appreciation that she had not had as a younger student [p. 243, 13–15]. Vera's time away from school gave her this appreciation. We wonder if this story was shaped by her idea that if one likes mathematics, they will do better at it [p. 238, 23–25] thus why students would benefit from developing an appreciation for mathematics.

Classrooms are a space for learning and learning occurs while doing mathematics

Vera is committed to living out a story in which the classroom is a space for students to (at least start) to learn, understand, and do mathematics, rather than a space for them to watch her do mathematics. We wondered about the experiences she shared that might have shaped this commitment.

On the one hand, we consider her stories about being on good terms with mathematics. Vera narrated how she has seen, in her time away from school, how useful it can be in life to be on good terms with mathematics [p. 238, 23–25] and how living alongside students who struggle with mathematics as a tutor for many years taught her that understanding is at least one approach to being on good terms with mathematics [p. 246, 27–34]. Vera also stories understanding as often key to success [p. 256, 11–13]. Therefore, giving her students time to understand, in part by doing instead of by looking at mathematics, and to attempt to learn while she is in the room to answer questions, is a way for her to get them to be on good terms with mathematics.

Vera also justifies the story she lives out in the classroom by wanting to create an atmosphere in which assessments are an opportunity for learning, as opposed to an experience in losing marks [p. 246, 6–7, 34–35]. We believe this is also connected to Vera wanting to foster in her students a good relationship with mathematics.

On the other hand, we consider her experience coming back to school. At that occasion, she saw learning as a gift [p. 255, 3–4]. Vera tells such positive stories about her journey in school as an adult that we are drawn to connect the story she wants to live in her classroom, a story of learning, with these later experiences she had in school. She wants her students to get something positive out of their time together, just as she was able to.

4.2.5 Explicit Training

In this subsection, we reflect on the experiences Vera had, first as a student (Section 4.2.5.1) in a master's program and then as a teacher (Section 4.2.5.2), involving explicit and intentional training on how to teach. We encounter experiences Vera lived in the master program she completed as well as experiences Vera lived as a novice teacher in her cegep institution.

4.2.5.1 Experiences as a Student

Mathematics as something for everybody

Vera completed a master's degree in mathematics education. The master program shaped Vera's story about mathematics [p. 238, 7–12]. Indeed, mathematics always used to be something she did and enjoyed, but during the master's program, she began to reflect on why she was enjoying it and why others could enjoy it. It broadened her vision of how mathematics can be addressed, popularized, and presented for a variety of populations.

Being taught is an opportunity to learn about being a teacher

Having been through the master's degree in mathematics education while still being a student in the bachelor's program in mathematics [p. 238, 1–6] has modified the story Vera lived as a student in mathematics classes [p. 238, 13–16]. Indeed, she narrates how being in the master's program changed the story she lived in her mathematics classes and she started to deliberately take a critical stance with respect to the teaching she received and gathered examples of problems and explanations in order to be able to use them later as a teacher. Lee and Shallert (2016, p. 77) talk about how preservice teachers envision their future as they sit in university classrooms and how they are more aware of the teaching they receive. This idea helps us understand the story Vera was living out. However, Vera does not make explicit in what ways did living out such a story in university mathematics classes shaped her stories to live by about teaching.

4.2.5.2 Experiences as a Teacher

As a teacher, Vera's experiences of explicit training occurred with resources, as she sought mentorship from colleagues and as she was asked to teach multiple different courses in the first few years.

Multiple stories to live by about teaching and learning

As a teacher in her institution, Vera has access to a folder [p. 253, 1–5] with many resources shared among teachers. She uses it to shape the stories she lives in her classroom, especially when she has to teach a course she has never taught before. For instance, she will look at the shared exams and review material. It seems she uses what other teachers do as a way to shape how she stories a certain course, to shape her idea of how she should address the material and assess the students.

Students' failures are sometimes out of the teacher's control

Vera lives by a story that even if she does everything right, a third of her class may still fail [p. 254, 7–9]. This story was affirmed by one of Vera's colleagues after the first exam she administered, and she now lives by it [p. 254, 7–10]. We, however, wonder what Vera means by "right," and are drawn to question and reflect on how she figures out what "right" looks like.

4.2.6 Experiences Related to University Mathematics

In this subsection, we reflect on Vera's experiences as they relate to university mathematics.

The mathematics training Vera received is sufficient for her teaching

The story Vera tells about her experience in university mathematics is that her training in mathematics was complete in that it allows her to teach any and every course in cegep. In this sense, Vera does not believe that taking more mathematics courses would have been impactful on her teaching [p. 252, 9–13]. We believe this story was shaped by experiences in which the deep knowledge of mathematics Vera's training provided her, helped her, for instance, to control her anxiety towards new teaching situations [p. 253, 19–21]. We also believe this story was shaped by experiences in which Vera consciously worked hard on her teaching methods rather than having to focus on grasping the mathematics she had to teach [p. 252, 14–19].

The role of the cegep teacher is to prepare students for university and to ask a few questions that require understanding

Vera lives a story in which she aims to prepare her students for university [p. 256, 1–3]. We believe this story was shaped by Vera's storying of cegep as a transitional institution [p. 256, 1–3]. And because she wishes to prepare students for university, Vera lives a story in which she gives her students a few questions to assess their understanding—questions for which the precise instructions she provided for what they should be doing are not sufficient but which the students can still approach [p. 256, 26]. This story was shaped by Vera's personal experiences in university where understanding was necessary to succeed. At that time, examinations required her to do more than what is explicitly taught to her, which required her understanding of the material [p. 256, 3].

4.2.7 Reflection on Vera's Experiences

In this final subsection, we take a global approach and summarize what we learned about how Vera's STLB were shaped, per respect to the three chosen strands.

Regarding her experiences as a teacher, Vera's stories give us a sense of the ongoing nature of her journey and the progressing formation of her identity as a teacher—as she tells us about the ways here STLB change as she becomes a teacher and about.

We feel Vera's stories did not do justice to how her experiences outside of school taint her identity as a teacher. In some ways, those experiences seem to have changed everything, from how she sat in her university mathematics classes to how aware she was of her own learning strategies. However, we do not feel we were able to grasp how her time away from school shaped her STLB. Something similar happened with Vera's stories of when she was a student. Indeed, Vera tells stories of learning from those experiences as a student and outside of school, but she did not give particular examples of what she learned from those experiences. For example, she mentioned collecting good explanations while she was a student in university, but she does not share precise examples of what she collected and how she uses them. She also claims that she's using, as a teacher, what she learned from her own learning experience as a university mathematics student when she came back to school but does not tell us more than one example. We wonder if we did not give her enough opportunities to share about those topics.

Regarding experiences in explicit training, these experiences seem to have shaped a story in which thinking about mathematics and teaching is something she does often and is comfortable with. Her experiences related to university mathematics did not come up often in how her STLB were being shaped, and when they did, the focus was exclusively on the mathematical knowledge she learned.

4.3 Michèle

4.3.1 Profile

In this subsection, we dress a portrait of Michèle. We address her story in relation to her education and up to her entry into the profession of cegep teaching. We also address the most prominent stories to live by she shared about mathematics, teaching, and learning[45].

Michèle was always very good in school, especially in mathematics. She loved this subject the most, loved how it called for exact answers and was an exact science: if you have the right answer, that is it, you are done. Her perception of mathematics changed with time but this is what originally brought her to mathematics.

Michèle has more than one relatives who were mathematics teachers in cegep. Growing up alongside multiple cegep teachers, she was always told that cegep is the best moment of one's life, so she was happy when she got there. She earned a cegep degree in science and went on to complete a bachelor's in mathematics. During this time, she started to be a teaching assistant. She always somehow knew she would study mathematics. She loved the communal aspect of mathematics, in that a group of students can sit down and do mathematics together. After her bachelor's degree, she still loved learning, so there was no question that she would apply for a master's in mathematics; and so she did.

Michèle soon realized research was not for her. It was too lonely. Gaps in her knowledge of mathematics were also starting to become apparent. She had to adjust her course load during her first semester; this had never happened to her. It was a huge failure for her. Her interests shifted towards teaching at this point and she took a graduate mathematics education course at.

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[45] In the participants' stories to live by, we focus mostly on their "body of convictions" (Clandinin, 1985, p. 362) about mathematics, teaching, and learning (for more, see Section 2.2.3)

At the very end of her master's, she heard about a cegep that was hiring. The cegep had reached out to a professor at her university and they referred Michèle. She applied and her name was put on a list to be called if they needed her. The school opened a summer course and because everyone before her on the list was not available, she got her first teaching contract. During that summer, she interviewed at a few other places; she got an offer from every one of them, including an institution where one of her relatives was working. She ended up choosing the larger institution in the bigger city (not the one where one of her relatives was) since she thought it would be a better place for her to learn to teach and become a great and better teacher.

She ended up teaching at four cegeps in three years. She sometimes taught at two institutions in the same semester in order to keep a good standing in both in case one could not offer her work the next semester. Now, she works at one institution. She decided to do so to have time for her hobbies.

After two years of teaching, Michèle thought she would struggle to find work, so she applied for a certificate in postsecondary teaching (details on the program in Section 3.2.1). In the few years that followed, it so turned out that she received contracts every semester so she ended up doing the certificate on a part-time basis.

Michèle got into mathematics because it was the subject in which she was strongest and the one she loved the most. For Michèle, genetics has nothing to do with being good at mathematics. Anyone can train their brain, even if some people may have to train longer and harder to get the same results. Being good at mathematics is about putting in the necessary time and practice. No one learns how to play piano by looking at a pianist.

In general, Michèle has given a lot more thought to teaching than to (her own or students') learning. She believes all teachers teach somewhat as they had been taught as students. Good teachers are good communicators, they are eloquent, and run their courses in varied ways. As a teacher, her role is to teach students not only the mathematics but also how to work. She is also a model in her classroom. She knows she can impact lives. However, she does not know what could have an impact. Is it when she shows what the material can be used for? Or the ways in which she cares about her students? So she tries to vary her ways. She also sees herself as a coach. In sports, a coach would never wait for the big game to check if what the athletes are doing is right.

Her role is also to introduce students to mathematical rigour in the writing and organization of their ideas. If she does not penalize them for their mathematical writing, they do not see why what they are writing is not what they want to say.

She uses a lot of games since everyone loves to play and if the class is more pleasant, students are more likely to enjoy the mathematics.

Understanding can be demonstrated when students can solve problems that are a bit different from what she has shown them. If students are able to generalize, they most likely understand.

4.3.2 Implicit Training—As a Student

In this subsection, we reflect on Michèle's experiences as a student, when the nature of the training she received on how to teach was implicit. For instance, we will encounter experiences where Michèle reflected on her needs when she was a student, on the teaching she received and on her experiences being assessed.

Reflecting on her experience arriving in university as a way to relate to her students

Michèle stories her students' arrival in cegep in a similar way to how she arrived in university [p. 260, 7–8]. Indeed, Michèle struggled to adapt to university, in terms of the level of difficulty of the mathematics as well as the amount of work required on her part. For the first time of her life, she had difficulties in mathematics and experienced failure [p. 260, 10–11]. Those experiences are similar to the ones her students' lives as they arrive in cegep. The struggle to adapt to the institution, with the increase in work load, the personal independence required, and the level of the mathematics [p. 260, 8–12]. This is much different from how Michèle stories her arrival to cegep as a student [p. 259, 4–10]. She was eager to start cegep, had been ready for a while, did not have any trouble adapting, and did not struggle with the mathematics. She therefore reflects on her experiences starting university to understand the experiences of her students.

Students should benefit from their teachers' insights in mathematics

Michèle lives out a teaching story in her classroom in which she is the mathematics expert of her own classroom and she wants her students to benefit from her experiences in mathematics. This story was shaped by experiences she lived in university where she felt professors could have shared their own insights on mathematics [p. 273, 7–10]. For example, she felt like it was assumed that because she was sitting in a mathematics classroom, she loved mathematics and therefore her professors didn't need to show the usefulness of mathematics or how it connects to other disciplines or other areas of mathematics [p. 262, 7–12]. She feels it would have helped her to see such connections and applications. She therefore knows it is wrong to assume that students will make all the connections themselves because she did not as a student. There are connections she only made as a teacher, through the work she did when preparing to teach, years after the material was first presented to her [p. 274, 1–4]. Michèle also discovered, when she first became a teaching assistant in university, that she had developed ways to help herself succeed in mathematics [p. 273, 1–4]. One of those ways was to start a problem with writing the definitions of the objects involved in the questions [p. 273, 5–7]. She wished to share these ways with her students to help them and she realized that none of her professors had shared such advice with her. She therefore aims to share with her students her insight on succeeding in mathematics [p. 273]. Because of experiences such as the two we mentioned, Michèle lives a story in which she shows applications, what the material could be useful for, connections with other topics or areas of mathematics [p. 262, 7–12], and ways of working that could be helpful [p. 273]. Experiences in which this was not done for her in university shape this story.

Teaching should be adapted to the students' level and interests

Adapting her teaching to her students is at the heart of Michèle's stories of teaching [p. 262, 23–32]. To her, adapting is about adjusting the level of difficulty as well as the context of the word problems (movies or hobbies students may be familiar with). As we wondered how this story had been shaped, we remembered that she shared stories of professors who were unable or unwilling to adapt to the students in front of them [p. 262, 21–23]. Michèle stories those professors as mediocre and we believe it could have shaped the story of adaptation she lives.

On another note, Michèle is continuously shaping this story to live by as she improves how to adapt to the students in an effective manner. Indeed, it has happened that the context she chose hindered the students' learning [p. 268, 4–14] so she is working towards better ways to adapt.

A teacher should have clear expectations and communicate these expectations to students

Michèle lives a story in her classroom in which she defines clear expectations when it comes to assessments and prepares her students accordingly. As we wondered how this story was shaped, we remembered when she mentioned that being transparent is extremely important to her [p. 271, 11–17] and when she narrated how she disliked surprise assessments as a student [p. 271, 17].

On another note, it took her some time to be able to live out this story. The first time she marked assessments, it was in university for a professor who hired her. She received no helpful guidance from the professor in charge of the course [p. 271, 4–5] and her marking was approximate for a while until she figured out her own expectations.

A teacher should be a model for, and reach out to, a variety of students

Michèle lives a story in which she aims to be a model for her students in several ways. This story was shaped by the tremendous impact her own teachers had on her [p. 263]. Indeed, different aspects of different teachers impacted her [p. 262; p. 263]. It was in the teachers' way of teaching, way of acting, and their way of being. For example, she always loved the classes in which she felt the most comfortable and loved the teacher the most. Michèle even describes her own teaching style in similar terms [[46]] to how she describes her favourite professor [p. 263, 7–9].

However, because she does not know exactly what will impact each student, as many different things impacted her from different teachers, she tries to be versatile so as to reach a large number of students, both personally and academically [p. 263, 12–23]. She tries to always be in a position to have a positive impact and to encourage students. To connect with them, she uses her experiences of struggle upon entering university [p. 260, 7–8] or her experiences juggling assignments and work while she taught and did her certificate simultaneously [p. 264, 14–17]. She also varies her teaching approaches to reach out to the highest number of students.

Assessments should be opportunities for students to show what they are capable of

Michèle tells the story of creating assessments in which students have longer timeframes to complete them [p. 269, 33–37]. She wants to give students an opportunity to show what they are truly capable of in less stressful situations. This story was shaped by experiences Michèle lived where she sometimes found the answer to a problem a few hours after the allotted time to complete the test. She narrated how frustrating it felt not to have shown her true potential in the given time

[46] [Michèle] est assez « maternante » et encadrante avec ses étudiants, mais les autres enseignants les laissent un peu à eux-mêmes.

slot [p. 269, 37–40]. Also, according to her, assessments in which students have longer timeframes to complete them is where the future of pedagogy is headed [p. 270, 2–4] and it is more representative of what students will face in real life, especially if they have access to external resources [p. 269, 35–37].

Nevertheless, Michèle struggles to actually live out this story of assessment as it bumps with the dominant story of the department and of her colleagues [p. 269, 33–41]. Indeed, the dominant story in Michèle's department is to give in-class exams; her colleagues' stories of teaching are tainted by a fear of plagiarism.

Students should learn for themselves rather than focus on the grades

Michèle tells a story in which students should learn for themselves rather than focus on their grades. This story was shaped as Michèle realized her own shift from focusing on finding out what would be tested in cegep and in university, to focusing on whether certain material may someday be useful [p. 269, 21–27], which is the perspective she holds today. Indeed, in thinking of her experiences attending classes again for the certificate in postsecondary teaching, she narrates how different her attitude was towards being a student which is why she changed her story assessment [p. 269, 20–32]. Also, looking back at her years in high school and cegep shaped her story to live by as she sometimes wished she would have focused more on what she could learn and could use today, such as learning to speak English, rather than focus on grades.

In light of this, Michèle now stopped giving the class average on assessments to support her story. She wants their focus to shift from the exam to something bigger [p. 269, 29–31].

Teamwork is beneficial for social interactions and success in mathematics

Throughout her university years, Michèle enjoyed working with others on hard problems. She found value in teamwork, both on a social level and as an asset to her success [p. 272, 3–4]. Therefore, her experiences in university shaped the story she lives in her classroom in which students have to work in teams. She lives that story even if her students do not like working in teams, as Michèle did not either as a cegep student, since she knows it could be useful for their future to learn how to work with others and that it can be helpful to help them learn the mathematics.

It is part of the teacher's role to help students overcome their difficulties

Michèle lives a story in which it is part of her role to develop ways to help her students overcome their difficulties [p. 274]. She shared that it sometimes took her time to understand exactly what it was she struggled with or did not understand about a particular concept or topic when she was a student [p. 274, 1–4], some of which she understood only as she became a teacher and prepared to teach them. Those experiences shaped the story she lives in which it is her role to help students with their difficulties since they may not be able to recognize them.

4.3.3 Implicit Training—As a Teacher

In this subsection, we reflect on Michèle's experiences as a teacher, when the nature of the training on how to teach was implicit. For instance, we encounter experiences Michèle lived as a novice teacher without job security, and experiences in which she reflected on marking and attended to her own transition from student to teacher.

Stories that were shaped by the lack of job security

As we spent time with Michèle, she shared some experiences that occurred because she did not have job security, and she shared how these experiences shaped the stories she lives as a teacher.

First, Michèle lives a story in which she adapts her teaching to each institution's rules and regulations. Indeed, as she worked at multiple institutions since the beginning of her career, she found out that each institution has their own rules and regulations, sometimes explicit, sometimes implicit, that she has to discover and follow [p. 276, 33–37].

Michèle also lives a story in which honesty and transparency towards her students are of the utmost importance. This story was shaped by experiences in which Michèle navigated teaching in multiple institutions at the same time and being asked to teach at the last minute [p. 276, 15–16]. On these occasions, she was not always as prepared to teach a course as she would have liked to be. She learned in these times that it is her obligation as a teacher to acknowledge when she makes a mistake or does not know an answer to a question.

In a similar line of thought, Michèle lives a story in which she will solve problems in class she did not prepare for [p. 276, 8–12]. Being asked to teach at a short notice, she sometimes had to invent problems and solve them in front of her students. She found that it worked well for her, especially in times when she is teaching more than a full load, so she is now comfortable living out that story.

Finally, Michèle tells stories of trials and errors being an integral part of a novice teacher's life [p. 276, 22–24]. This story was shaped by experiences in the beginning of her career where she tried things and saw whether they suited her and how they were received by the students.

Being a teacher requires a change of perspective

As she started to be a teacher, Michèle realized that being a teacher is much different than what she imagined. She started to live stories that were different than what she expected living, stories that were being shaped by her new experiences as a teacher.

Michèle had imagined she would live out a story, as a teacher, in which she still maintains the perspective of students, perspective she developed from her years in classrooms as a student. She did not want to be a teacher who is disconnected from the reality of her students. However, Michèle shares experiences that made her realize how easy it is for her to lose the students' perspective, even if she does not want to [p. 264], and losing this perspective prevents her from living out her imagined story.

For instance, her role has changed: she is now the one who leads the students where they need to go and she has the responsibility to cover the required material. Also, Michèle shares a tension that arose as she wants to remember that there is a student behind each exam she marks but at the same time, she wants to be efficient as opposed to someone who takes the process so much at heart that needs to take breaks from grading and pull themselves together before starting again [p. 264, 11–13]. These experiences shaped the story she now lives, in which being a teacher requires her to let go of the students' perspective and live stories of teachers.

4.3.4 Experiences Outside of School

In this subsection, we reflect on Michèle's experiences outside of school, especially experiences she had alongside her family. Indeed, Michèle's stories to live by about cegep mathematics education, as a student and as a teacher, were deeply influenced by her relatives who were cegep mathematics teachers.

Practice makes mathematics easy

Michèle tells the story that easiness in mathematics is about practice [p. 259, 16–18]. She shares experiences she lived alongside her relatives in which playing with mathematics was part of the environment; she says this helped her have ease in mathematics [p. 259, 11–15].

Stories that were shaped living alongside cegep mathematics teachers

Michèle shares how multiple stories she lives out as a teacher were shaped by her experiences living alongside her relatives who were teachers of mathematics in cegep. Indeed, she lives out stories of focusing on notation [p. 259, 19–25] and being inclined to innovate [pp. 269–270], all of which were shaped by her time with her relatives. Michèle also lives a story of passion and enthusiasm about teaching, an attitude that was shaped by times with a relative who always talked passionately about their profession [p. 266, 1–3]. She also says her life alongside her relatives shaped a story she lives of being open-minded about different ways of teaching [p. 266, 4–5], which allowed her to get more out of the certificate she completed than others she has met, and more than what the Conseil Supérieur de l'Éducation (1997; see Section 1.2) outlines because of her open-mindedness [p. 266, 4–5].

4.3.5 Explicit Training

In this subsection, we reflect on the experiences Michèle had, first as a student (Section 4.3.5.1) and then as a teacher (Section 4.3.5.2), involving explicit and intentional training on how to teach. We encounter experiences Michèle lived in the certificate in postsecondary teaching she completed as well as experiences Michèle lived as a novice teacher in her cegep institution.

4.3.5.1 Experiences as a Student

Explicit training as validation of existing stories to live by

The certificate in postsecondary teaching Michèle completed is significant in the stories she tells about herself and her teaching. It first played an important role of validation in the stories to live by she already had, as something that gave her formal words to talk about what she does or aims to do intuitively [p. 265, 4–6]. It also validated the relevance of certain pedagogical strategies she had already wanted to apply [p. 265, 6–10]. In this sense, the certificate she completed shaped multiple stories of teaching in validating them. Michèle, however, does not give more details on the stories the certificate shaped, while acknowledging explicitly that it did.

New stories that were shaped from explicit training

On a more practical note, during her certificate, Michèle developed pedagogical material, mostly for Calculus I, as part of the assignments of her courses. This material is an integral part of the story she lives on a daily basis [p. 265, 11–15].

Also during the certificate in postsecondary teaching, Michèle benefitted from a suggestion of a professor who advised they create their own student evaluation [p. 277], independent and on top of what the cegep may do for all classes. She decided to live that story in her classroom and it turned out to be a tremendous help for making informed decisions.

Further, during her master's in mathematics, Michèle took a course in mathematics education that focused on research regarding the teaching and learning of calculus [p. 265, 22–26]. She was introduced to the idea of non-routine tasks, presented in the research papers she read, and these are now a part of the story she lives in her classroom. This course also introduced her to a dynamic geometry software which is also part of her classroom narrative.

Classroom experience has more value than theoretical claims

Michèle told a story of how, before changing a practice that had so far been successful on the basis of what one of her professors in education said, she asked her students how they were experiencing her existing practice [p. 267, 6–13]. Because students answered that this practice worked well for them, she concluded it worked well for her as a teacher and kept doing it. Michèle lives by the story that directly experimenting in her classroom has more value than applying what she was told in theory, without another thought.

She seeks training in teaching instead of a training in mathematics

Michèle believes that professional development for teaching is relevant for her in her profession. Indeed, she sees a direct impact on her teaching as a result of such professional development [p. 265, 20–21]. However, she decreasingly appreciates the relevance of deepening her knowledge of advanced mathematics because it does not have an impact on her profession.

4.3.5.2 Experiences as a Teacher

Living alongside colleagues as shaping stories to live by and classroom experiences as shaping how to live out stories

Michèle narrated being inspired by her colleagues and how it shaped her stories of teaching. For example, she started to integrate contexts and stories into word problems in her exams and in examples she solves in class as some of her colleagues do [p. 268, 1–4]. Then, she narrated having to learn how to actually live out this story in her own classroom [p. 268, 6–14]. For example, she is learning to figure out when a context can hinder the students' learning and when it can help.

4.3.6 Experiences Related to University Mathematics

In this subsection, we reflect on Michèle's experiences as they relate to university mathematics.

Mathematics training is useful in teaching

Michèle lives stories where she's able to find new ways to explain some topics, providing additional insight to what appears in the textbook, and can understand rapidly topics she had never heard of before [p. 261, 9–13]. She tells us that these stories were shaped by her training in mathematics. In this sense, Michèle's training in university mathematics is useful as she teaches.

Doing mathematics improves one's capacity to deal with challenges

Michèle tells the story that learning mathematics has allowed her to train brain mechanisms that can be used anywhere [p. 261, 14–17]. Her experience going through pedagogy courses, which she found easy, shaped the story that her experience in mathematics classes had prepared her for any challenge. She credits the intensity of the program for preparing her.

4.3.7 Reflection on Michèle's Stories

In this final subsection, we take a global approach and summarize what we learned about how Michèle's STLB were shaped, per respect to the three chosen strands.

Upon reflecting on Michèle's experiences outside of school, which include her unique situation of growing up with relatives who are cegep mathematics teachers, we find that the context in which Michèle began to create her stories of teaching mathematics was key to what these stories eventually became. Michèle started creating stories of teaching as she was surrounded by passionate teachers who were open to new and innovative practices. It is not surprising that these teaching stories became, at least in part, the stories she wants to live out in her classroom, such as a story of innovative practices.

There is definitely a sense that Michèle justifies much of the stories she lives out as a teacher on the basis of what was fulfilling or missing during her time as a student. Answers to what was missing seem to come from a number of places; her certificate in postsecondary teaching is one of them. Regarding the certificate, it tremendously influenced Michèle's stories about teaching.

In her experiences as a teacher, we see Michèle attending to her students wants, needs, and personalities, and adjust her practice accordingly, without compromising what she believes is good for them, such as team work. Through Michèle's experiences at university, she found deep knowledge and confidence to tackle challenges. She also experienced struggles for the first time which helps her relate to her students.

4.4 Étienne

4.4.1 Profile

In this subsection, we dress a portrait of Étienne. We address his story in relation to his education and up to his entry into the profession of cegep teaching. We also address the most prominent stories to live by about mathematics, teaching, and learning that he shared[47].

Étienne remembers being interested in mathematics at a young age. He remembers his first interests in teaching at the beginning of his secondary 4 school year. At the time, he wanted to teach mathematics in high school. When he arrived to cegep, in the science program, he decided he wanted to become a cegep teacher of mathematics. Indeed, the material at this level was more advanced than high school, which he liked, and the students chose to be there which he believed is a great environment to teach at. When he got to university, he decided to stick to the idea of becoming a cegep teacher. The mathematics at university was abstract and proof-based, which he did not like as much as what he had experienced in cegep. Altogether, he found the mathematics he did in university to be more advanced than what he needs to know in order to teach in cegep.

Étienne earned a bachelor's degree in mathematics, after which he unsuccessfully applied to teach at multiple cegep institutions. Thus, he decided to complete a one-year certificate in cegep teaching, where he did a teaching internship (see details on the program in Section 3.2.1). He was offered a teaching contract the following semester; he is still teaching at the same cegep a year later.

For Étienne, mathematics is created, and then people discover properties of the objects they created. Mathematics is more of a tool for solving problems in other disciplines—physics, for example—and for understanding real life phenomena. Doing mathematics is mostly solving problems, applying theorems, or finding proofs.

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[47] In the participants' stories to live by, we focus mostly on their "body of convictions" (Clandinin, 1985, p. 362) about mathematics, teaching, and learning (for more, see Section 2.2.3)

Étienne believes some people have more ease than others in mathematics. For some, the mathematics just sticks in their head; everyone's brain works differently. It is not that some people are not "made for mathematics." The efforts a person puts in plays a huge role. One learns mathematics by practising it. Students do not always have the motivation nor the time needed for understanding mathematics.

As a teacher, Étienne does not feel comfortable telling students what to do, to impose his views, nor to be authoritarian or paternal because he is not much older than them. His role as a teacher is to help them learn and understand, popularize mathematics, give them time to do problems, prepare them for exams, and have them pass the course. To do all this, Étienne needs to be concise, have an idea of where he is going, and be prepared.

The goal of mathematics education in cegep is to prepare students for their professional future, whether they end up attending university or not. For students who will not have to use their mathematics explicitly in their profession, such as engineering, doing mathematics will help them develop their rigour, critical and logical reasoning and thinking, as well as their capacity to interpret results.

4.4.2 Implicit Training—As a Student

In this subsection, we reflect on Étienne's experiences as a student, when the nature of the training he received on how to teach was implicit. As we attended to Étienne's stories to live by, we were drawn to the ways in which Étienne relies on the stories he tells about his time as a student to form stories about his students. We explore those ways below, as well as how Étienne decides which of those stories to live out in his classroom.

Stories he tells about students

In general, the stories Étienne tells about his students are identical to the stories he tells about himself as a student. He stories his students as having the same habits he had as a student, learning in the same ways he did, loving and hating the same things he did, and experiencing school the same way he did. For example, students do not research the material they do not fully understand [p. 279, 6–10]. Students do not think and do not care about defining what mathematics is [p. 297, 22–27]. They are focused on what will be on the test [p. 295, 15–21]. For them, visualization is key for understanding and appreciating mathematics [p. 279, 22–29]. Students are motivated by the presentation of topics on which they will not be evaluated and that are not too abstract or theoretical [p. 282, 23–25]. They learn formulas at the last minute, apply them without understanding, and then forget them as soon as the exam is over [p. 289, 6–11; p. 293, 19–20]. Opportunities to solve problems that require thinking, drawing, and searching, rather than remembering, are motivating and allow students to develop logical thinking and perseverance [p. 282, 1–35].

While these are all stories Étienne *tells* about his students, he does not *live* out all of these stories in his classroom. In other words, he does not always live out stories of teaching that are aligned with the stories he tells about the students. We next expand more on a few of these stories, on which ones Étienne decides to live by, and try to make sense of why he chooses to do so. We will encounter experiences that prevent him from living out some of the stories he tells, some stories he chooses not to live out because they are in contradiction to the stories he finds are dominant in his department and some stories he decides to live out even if they contradict others' stories[48].

Problem-solving courses cannot work in cegep

Étienne would like to live stories of teaching that gives students opportunities to solve problems that require thinking, drawing, and searching, rather than remembering, that are motivating and allow students to develop logical thinking and perseverance [p. 282, 1–35]. He narrates how he wants to implement a problem-solving course in cegep, in the image of his favourite university course, to live out that story. However, he expresses that he does not see how to make this happen.

Indeed, in Étienne's storying of cegep, students are required to learn something new in their classes, some techniques—derivation, for example. However, Étienne does not recall learning new techniques in the problem-solving course he took [p. 282, 25–27]. The stories he tells about what he learned in the problem-solving course bump with his story of what cegep students should learn. This tension shapes the story he tells about implementing a problem-solving course in cegep being impossible.

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[48] Even if Étienne's decision to live out, or not, these stories occur while he is a teacher, we decided to place these reflections in the section *Implicit training – as a student* because the stories were originally shaped by experiences Étienne lived as a student.

We wonder if marking might also be something that shaped the story Étienne lives regarding the (impossible) implementation of a problem-solving course. His experience as a student was characterized by a marking based on students' reflection and work, not their final results[49]. However, he emphasizes that success in calculus is based on students' capacity to perform techniques [p. 282, 27–31]. Marking based on reflection and work certainly do not subscribe to the dominant stories of cegep mathematics teaching; this bumping of stories may be an uncomfortable experience to navigate for a novice teacher.

Living out others' stories, even if they contradict some of the stories he tells

Étienne lives out a general story in which he (sometimes) lives out the dominant stories of his department, the stories privileged by his colleagues, even if they are in contradiction with some of the stories he would like to live out. He justifies this general story by the fact that he is a novice teacher and we believe there is a need for him to conform to what is being done in the department. We explore below a few examples of stories Étienne lives even if they contradict the stories he tells.

For example, Étienne tells us he believes students learn formulas as he did as a student: learn at the last minute, apply them without understanding, and then forget them as soon as the exam is over [p. 293, 19–21]. As such, he prefers to provide the list of integration formulas during the exam instead of having students learn it. However, this story Étienne wants to live out bumps with the other teachers' stories. They would rather require the students to learn the formulas. Étienne chooses to privilege the dominant story of his department[50] because he is a novice teacher [p. 293, 21].

Étienne also follows the lead of his colleagues when it comes to proofs [p. 293, 30–41]. It is not written anywhere that they have to ask students to write proofs but every teacher does it. Étienne stories this as a norm created by the group of colleagues with whom he works. Even though Étienne tells a story of having hated proofs as a cegep student [p. 293, 39–40], of not even bothering to

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[49] Ils étaient en équipe et ils y réfléchissaient. Il n'avait jamais toutes les solutions, mais il avait toujours 10/10. Le prof y allait plus pour le raisonnement que pour la réponse. Si tu réfléchissais, ça allait.

[50] In Étienne's stories about this topic, he does not mention if he would be penalized in any way, by his colleagues, by the department or by the institution if he chose to give the list of formulas to students. He is only telling us that he is, above all, living a story where being a novice teacher means he does as his colleagues are doing.

listen when his teacher talked about proofs, he still lives the same story his colleagues are living. If they do it, so does he[51].

Étienne loves to give students opportunities to verify whether they understand the material with short assessments or practice assessments. However, for one semester, he chose not to do this because a colleague of his who taught the same course, and with whom Étienne was closely working in planning his teaching, did not want to do so [p. 293, 21–27].

There is a sense in Étienne's stories that when he agrees with his colleagues' decisions against his initial ideas, the agreement is temporary. Because he is new, he trusts his colleagues; he will do otherwise later if he sees fit [pp. 293–294]. Étienne therefore lives out a story in which for now he does as his colleagues do, and he justifies this by the fact that he is a novice teacher. This story dominates over a lot of his stories about teaching and learning as shown above. We explore next the stories he chooses to live even if they contradict his colleagues' stories or the institution's stories.

Living out his own stories even if they contradict the institution's or colleagues' stories

Étienne lives out a general story in which he (sometimes) lives out his own stories, even if they are in contradiction with the dominant stories of his institution or the stories privileged by his colleagues. We will first present examples of stories Étienne decides to live out despite them being in contradiction with the institution's or colleagues' stories. After, we will wonder how Étienne shaped this general story.

Étienne wants to live a story in which his students are given a time and a space to love mathematics, for instance by seeing interesting ideas on which they are not going to be evaluated [p. 282, 36–42; p. 283, 1–4]. An experienced colleague with whom Étienne works closely does not do this, but Étienne is convinced that it is relevant, so he lives his own story anyway.

Another of these contradicting stories rests in the fact that students are not allowed to miss more than three classes, and can be expelled from a course for doing so. This is a dominant story in the

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[51] Again here, Étienne does not mention if he would be penalized in any way, by his colleagues, by the department or by the institution if he chose not to address proofs.

institution that Étienne refuses to live out. Not only was this rule not present in his experience as a student, it also bumps against the story of maturity Étienne tells about the students [p. 280, 5–11].

Similarly, Étienne tried to use games in his classroom because a lot of his colleagues do so [p. 284]. This came in contradiction with a story he tells about how he imagines he would act in a similar situation. Had one of his cegep teachers brought a game, Étienne thinks he would have been very displeased. He was way too old for that! The story he tells of students in cegep is a story of maturity [p. 280, 5–11] that bumps with the use of games in the classroom. So for now, as long as nothing has convinced him that games have a place in his classroom, he sticks mostly to a lecture-style teaching in which he solves exercises [p. 284]. He is not fully committed to the practice of using games, even if many of his colleagues are.

We wonder how Étienne decides which stories, based on his experience as a student, he will live out, even if they contradict others' stories, and which ones he will not so as to live out dominant stories because he is a novice teacher. We wonder if some stories to live by, created from past experiences, are more powerful than others. We wonder if some stories are harder to contradict or ignore than others.

Étienne connects the joy of problem solving with showing interesting ideas to students to give them a time and space to love mathematics and live such joy [pp. 282–283]. The joy of problem solving is so much at the core of the stories he tells about loving mathematics from a young age that it may be hard for him to live out stories that in his view would not allow his students to experience such joy.

The absence rule and the use of games contradicts the story Étienne tells about the maturity of cegep students, a key reason why Étienne chose to teach in cegep [p. 280, 5–11]. Perhaps it is hard for him to live out stories that are in contradiction with what's at the root of his choice of profession.

Perhaps asking students to learn a list of formulas (addressed in the previous theme) is not at the core of his stories to live by about teaching and is therefore a concession he is willing to make to conform to his colleagues' work. We therefore believe that the general story Étienne lives out (in which he lives out his own stories, even if they are in contradiction with the dominant stories of his institution or the stories privileged by his colleagues) was shaped by his need to enact the stories that brought him to the profession.

Teaching with a software as a visual tool

Étienne lives a story in which he uses a software he discovered in university [p. 279, 26–29; p. 298, 8–9]. It is shaped by a story he tells of always having trouble understanding things he cannot visualize [p. 279, 22–29] and, at the same time, assuming that his students learn in a similar way.

Teachers should give advice even if students do not follow them

Étienne lives a story in his classroom in which he gives advice to his students on ways to succeed. We believe this story was shaped as he realized how useful it would have been if, back when he was a student, he would have known all he knows now about succeeding in mathematics. As we wondered about how Étienne came to this realization, we remembered that cegep was quite easy for him while university was much harder. While he managed to be successful in cegep through imitation [p. 279, 6–8], we wonder whether he was faced with the fact that his ways of being in the classroom were not adequate for success in university [[52]]. For example, learning material at the last minute was no longer viable and he was wrong to think that understanding a written solution means you've reached complete understanding of the material [see p. 289 for more details]. Étienne found, by undergoing major struggles in university, which ways were unlikely to bring success in the long-term. In other words, Étienne says that if he knew of the stories he developed about success over the years and how relevant they would be for his success, he would have lived them when he was a cegep student [p. 290, 7–8]. Therefore, he tells these stories of success to his students in the form of advice so that they can benefit from his hindsight.

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[52] La difficulté quand il est arrivé à l'université, c'était la programmation et les preuves. Mais ça, c'est un peu de sa faute. Ce sont les choses qu'il n'aimait pas alors il se forçait moins. En ce qui concerne la programmation, il ne peut pas chialer, ils leur faisaient faire du *Maple* à son cégep, c'était obligatoire à partir de calcul différentiel. S'il s'était forcé à mieux comprendre à ce moment-là, il aurait peut-être trouvé ça plus facile. Peut-être que la transition vers un autre language aurait été plus facile. Même chose pour les preuves. Quand ils en faisaient en classe, c'était assez rare, [Étienne] ne faisait rien, car il n'aimait pas ça. Et là, il est arrivé dans un cours de géométrie à l'université et c'était que des preuves ! À partir de là, il s'est habitué à faire des preuves pour la suite. Si c'était à refaire, il se forcerait peut-être plus sur certains aspects. C'est un peu comme ça dans tout. À l'université, il se disait parfois que s'il s'était forcé plus dans le cours d'avant là ça irait mieux.

Alongside living a story of giving advice, Étienne lives a story in which he finds it normal that students do not follow his advice. We believe this is shaped by how Étienne stories his own time as a student. He narrates that he gives advice to and sets goals for his students that he never followed, or would have never followed, as a student himself [p. 289, 1–3]. While Étienne trusts his advice to be relevant, he understands why students may not follow them because he would not have followed them either. He puts himself in the position of his past self, whom he identifies with his students, to try to grasp his students' perspective.

Examples applied in physics are suited for social science students

Étienne lives a story in which he adjusts the examples he shows in class to the students' professional aspirations [p. 286, 14–20]. Living this story, he tries not to give examples of applications in sciences to students in social sciences but if necessary, because examples applied in social science are sometimes scarce, he gives examples in physics. This story was shaped by a memory Étienne has about his time in high school. Indeed, he remembers that students who did not like science would rather hear about physics than any other science [p. 286, 26–31]. Also, Étienne finds easier to include examples in the discipline of physics that refer to elements of everyday life such as speed and velocity [p. 286, 24–26].

He is not ready to teach to career programs

Étienne lives a story in which he purposefully stays away from teaching courses to students in career programs[53] [p. 296, 1–9]. Because he has never taken a course in a career program, Étienne does not feel he can teach them; for now, he sticks with what he knows: the courses he has taken himself as a student [p. 296, 7–8].

Étienne mentions not being comfortable if he had to teach a career course alone, as opposed to a great experience he had when he was involved in a career course during his internship (see Sections 3.1.2.1 and 4.4.1). On that occasion, he was accompanied by the actual teacher [p. 296,

[53] Étienne had a number of experiences, as a teacher and as a student, both in implicit and explicit settings, that seem to have shaped his story of not being ready (or able) to teach career courses. We chose to put this story in the "implicit training—as a student" section because we believe that, in general, Étienne relies heavily on his experience as a student to determine how to be as a teacher (as we have seen throughout this section). We therefore believe that the effect of Étienne's experience as a student on his apprehension to teach career courses is important, as it was important for multiple other stories to live by.

10–20]. This tells us that his internship did not foster enough experience for him to learn from and be comfortable to teach the course on his own, which shaped the story he lives of not feeling ready to teach in a career program.

Étienne also shared an experience in which he spoke with a colleague who was teaching a class for a career program. Étienne's colleague had to create an assessment for his students in which they had to do some programming. Étienne said he would not be able to complete such an assessment himself, let alone mark it [p. 296, 5–8]. Although we don't know much about the stories Étienne lives about marking, it seems that not being able to imagine himself marking that assessment associated with a career course may have strengthened his story that he is not ready to teach career program courses.

Étienne has had another opportunity to reflect on courses in career programs in a university mathematics course aimed for mathematics students who are interested in postsecondary teaching [p. 298]. Those experiences have not been meaningful enough for him to change the story he lives about not being equipped to teach in career programs.

4.4.3 Implicit Training—As a Teacher

In this subsection, we reflect on Étienne's experiences as a teacher, when the nature of the training on how to teach was implicit. We encounter experiences in which Étienne reflect on his new habits as a teacher and his former habits as a student, on experiences in his classroom and on the work of his colleagues.

Understanding as the ultimate goal of studying mathematics

Étienne lives a story in his classroom in which understanding should be the ultimate goal. This story was shaped by a shift Étienne lived as he started to teach, from mimicking to understanding mathematics [p. 279, 3–15]. Indeed, as a student, he relied on mimicking, a method that suggests an inclination to prioritize marks over understanding. When Étienne started to teach, he wanted to be ready for any question he may be asked which required changing his ways of working with mathematics. He started to read the whole textbook to have an overview of the whole course and to research any piece of material he is not 100% sure to understand [p. 289, 36–38]. Étienne believes his new habits as a teacher are the reason why he possesses a newfound understanding of the mathematics he is teaching [p. 279, 3–4]. This allowed him to appreciate the material more than before since Étienne stories understanding as necessary in order to love the material [p. 279, 30]. The new perspective, which he gained as he started to teach, on understanding and loving mathematics is at the root of the story he lives in his classroom about understanding mathematics being the goal.

One example of this change in Étienne's stories to live by about learning mathematics is when he talks about a time when a student came to see him because he had made a calculation error using the Gauss-Jordan method [p. 289, 23–28]. Étienne told the student that if they understood the algorithm, it was a waste of time to chase after the calculation error, something so easy to make when using this method. As a student, however, he would have worked to find where he made a mistake at all costs because he was mimicking so getting exactly the right answer was crucial.

Students need to be firmly guided

Étienne lives a story in his classroom in which he firmly guides his students. He found that this is what they need. This story was shaped after living multiple experiences in which his students did not remember or understand what he said even if he explicitly said it [p. 292]. He found he needs to repeat more, write more on the board, and make explicit any small subtleties of which he can think. When taking the position of the student, Étienne remembers such behaviours from past teachers, and he stories them as deeply irritating [p. 292]. He expects some of his students feel the same about his behaviour, but he feels he has to do it for the sake of the majority of the class.

Students should stay active in class while having a space to listen and understand

Étienne lives out a story in his classroom in which students are given the opportunity to stay active while having a space to listen and understand. This was shaped by experiences he lived in the classroom trying different teaching methods. Indeed, when Étienne started to teach, he storied students as not listening in class [p. 285, 1–3]. Nevertheless, wanting to keep students actively involved so they would be attentive, Étienne decided to use slides. This way, students have to stay active by taking written notes. However, his experience in class showed him that this practice involved a lot of "useless" writing which prevents students from listening and understanding. He therefore started using notes with missing words so students would have to stay attentive to fill in the blanks. This helped Étienne live out his story of promoting understanding [p. 279, 22] as it allowed him to have the students' attention at the precise moments that he deemed particularly important for their understanding.

Some populations tend to know more of the prerequisite knowledge than others

Étienne's experience in the classroom shaped the story he tells about some populations knowing more of the pre-requite knowledge than others. For instance, pre-university science students have a tendency to remember more things from the high school curriculum than social science students. This is the case for a method of solving quadratic equations [p. 286, 2–11]. However, experiences in his classroom showed him that trigonometry is something that is difficult for everybody [p. 286, 11–13]. He is therefore learning, through experiences in his classroom, what common knowledge he can take for granted in the class depending on the student population.

The rate of success may be dependent on the location and the number of students

At first, Étienne did not think more than a few cegep students failed [p. 288, 3–12]. In his experience in cegep, he did not remember anyone failing. Étienne shared an experience in which, to his surprise, 25% of his class failed and he was told by a colleague it was actually pretty good. Trying to make sense of the difference, it triggered a reflection for Étienne about the population of the institution, with respect to the location and the number of students. Indeed, he studied in a city and at an institution that were smaller than the one at which he currently teaches. Therefore, this reflection shaped a story Étienne now tells in which the rate of success may be dependent on factors such as location and number of students—and not necessarily, or only, on his teaching methods.

It is not his role to be paternal, authoritarian, or superior towards the students

Étienne lives a story in which he does not consider it is part of his role as a cegep teacher to be paternal, authoritarian, or superior towards the students. He took a psychology course where he was told that he may become a paternal figure for certain students [p. 287, 20–21]. After one year of being a teacher, it never happened to him and he doubts it ever will. He also justifies this story by the fact that he is almost the same age as his students [p. 287, 22; p. 289, 34–35].

Teaching should be adapted to the students' needs

Étienne tells a story of being inclined to live out a story in which it is necessary to prove every result he shows students because his training in advanced mathematics in university had conditioned him to do just that [p. 295, 2–3]. This was a big part of the culture that governed the classrooms in which he sat in university and it shaped that particular story.

However, he ended up questioning this story as he started to teach in cegep. Indeed, Étienne stories his role as one of helping students succeed in the course [p. 287, 1–2] and it does not serve the students if he addresses mathematics that may confuse them, such as proof [p. 295, 19–21]. In this sense, Étienne wants to live out a story that takes into account the needs of the students [p. 295, 2–21] in relation to their academic and professional goals. Therefore, Étienne asks and shows proofs only when he has to [p. 293, 41; p. 295, 21].

4.4.4 Explicit Training

In this subsection, we reflect on the experiences Étienne had involving explicit and intentional training on how to teach, first as a student (Section 4.4.4.1) and then as a teacher (Section 4.4.4.2). For instance, we encounter experiences Étienne lived during a course for mathematics students who are interested in postsecondary teaching, during the certificate in teaching he completed and as he lived alongside more experienced colleagues.

4.4.4.1 Experiences as a Student

There is more to being a mathematics cegep teacher than what a student knows

Étienne did a teaching internship during the certificate he completed in cegep teaching. This was the first time he went to cegep in the capacity of a teacher and experienced it through the new perspective this brings. The internship shaped the stories Étienne tells about what it means to be a cegep teacher as he learned about the variety of courses he could be asked to teach [p. 296, 1–2], the administrative side of the job [p. 299, 2–6], and the existence of a help center which he never attended as a student [p. 299, 6–7]. Those were aspects of the profession that were not part of his imagined stories of how it would be to become a cegep teacher.

It is better for a teacher to minimally look at their lesson plan while teaching

Étienne lives a story in his classroom in which he is intentionally not looking at his lesson plan too much. This story comes from a time when, during his internship, Étienne got to teach his first class and got feedback from his supervisor [p. 299, 13–17]. His supervisor told him that it would help the students trust him if he would teach without looking at his lesson plan too much so he committed to doing that.

4.4.4.2 Experiences as a Teacher

Trusting experienced colleagues

From how Étienne goes about his days as a novice teacher, he lives and tells a story of trusting what experienced teachers do, mostly what his colleagues do. He gives importance to, and wishes to benefit from, their experience [pp. 293–294]. He looks at the books they choose, the exams they write, how they structure the progress of their courses, and what exercises they give to their students. He justifies this story by saying that he is a novice teacher [p. 283, 6–7; [54]].

He lives this story while keeping in mind that he can, and he will, modify his approaches later on in his career, when he is not as new to the profession. He thought he would be making changes quickly [p. 294], but has since realized that finding the time to make such changes is harder than he expected.

4.4.5 Experiences Related to University Mathematics

In this subsection, we reflect on Étienne's experiences as they relate to university mathematics.

Some people have a natural ability to do mathematics beyond cegep, and some do not

Étienne's time in university mathematics changed the story he tells about the idea of the "mathematics gene." Indeed, he used to believe that anyone could study mathematics at any level. However, the struggles he experienced during his bachelor's degree made him believe that he could not have continued further in studying mathematics [p. 291, 8–9]. These experiences of struggle shaped the story he tells about some people having a natural ability to do mathematics that others do not have. He, however, believes that everyone can achieve the mathematics of elementary and high school, even the beginning of cegep; he does not justify this aspect of the story he tells but we can surmise that such justification is related to the identification he does of the students with his past self as a student. If he could do cegep-level mathematics, everybody can, and since he struggled with university mathematics, this is proof (for him) that some people have a (natural) ability that others (himself) don't have.

[54] Il n'est pas arrivé dans la profession en se disant qu'il allait révolutionner l'enseignement, en emmenant des nouveaux projets et tout. Il commence par la base, préparer ses cours et donner ses cours, répondre aux questions, la correction.

Changing institutions and/or program as shaping stories about mathematics

Étienne narrates how his perception of mathematics changed as he progressed through educational levels and therefore changed institutions as a student [p. 297, 1–2]. He credits the new reality he was introduced to at each institution for shaping his storying of mathematics, such as suddenly being able to divide by zero in Calculus I or when all of a sudden, the square root of a negative number was something he could work with.

Interestingly, it is in the certificate in teaching, and not his years of studying mathematics, that a crucial reflection about the nature of mathematics was triggered for him [p. 297, 7–22]. This reflection was triggered by one of his professor who asked if mathematics was a discipline or a tool for other disciplines, and if mathematics was discovered or created. Étienne holds on to the result of this reflection in his stories to live by about mathematics.

4.4.6 Reflections on Étienne's Stories

In this final subsection, we take a global approach and summarize what we learned about how Étienne's STLB were shaped, per respect to the three chosen strands.

Our work towards understanding how Étienne's STLB are shaped showed us that he is still very much in the midst of creating his identity as a teacher. He is not fully living out the stories he would like to, per respect to teaching, learning and mathematics, claiming as a reason that he is a novice teacher.

The ways in which Étienne stories his students, as if they are exactly as he was, suggest how Étienne's STLB about students are in primarily based on his personal experience as a student. He also stories cegep education in the way he personally experienced it as a student, which seems to prevent him from imagining a story in which he can teach a course of which he was never a student.

Regarding explicit training, Étienne tells interesting stories about how he discovered mathematics all over again, or maybe a different side of mathematics while he went through his certificate in teaching. This jumps to us as a concrete example showing that there are instances for doing and reflecting about mathematics other than university-level mathematics courses, aiming at the ultimate goal of training a mathematician.

Regarding experiences related to university mathematics, it mainly impacted the stories he tells about one's capacities in mathematics. It also came up as a justification for the impulse of proving every result in his classroom, a story he tells but he does not live.

4.5 Sam

4.5.1 Profile

In this subsection, we dress a portrait of Sam. We address his story in relation to his education and up to his entry into the profession of cegep teaching. We also address the most prominent stories to live by about mathematics, teaching, and learning[55] that he shared.

Sam was only average in mathematics throughout his early years of high school, largely because he was not invested when he did not get the material immediately. He does remember that towards the end of high school, he had a teacher who was making the course so difficult that Sam considered it a personal challenge to do well in his class. At that point, he started to get much more invested in mathematics. Sam ended up being in the top percentile of a mathematics competition when he was in the eleventh grade. That is when he started to do really well in mathematics and started to be proud of his performance in it. He is glad he ended up getting into mathematics because he does not know what else he would have done professionally.

In his last year of high school, Sam was in an enrichment class. On that occasion, he learned most of the material of Calculus I. This made his entry into cegep a bit easier. He went on to cegep to do a social science degree with optional mathematics courses (see Section 1.1 for more details on cegep programs), with the intention to study mathematics in university. He was not interested in the other sciences mandatory in the science program—physics, chemistry and biology; this is why he chose to earn a social science degree. Sam's interest was specifically in abstract mathematics, and not in how mathematics relates to real life.

In cegep, he was considered a very good mathematics student. He was well known in the mathematics department and he won awards. He tried to take more advanced courses, tried to push

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[55] In the participants' stories to live by, we focus mostly on their "body of convictions" (Clandinin, 1985, p. 362) about mathematics, teaching, and learning (for more, see Section 2.2.3)

himself and seek out more time with mathematics teachers to talk to them about the material. He got good grades but was not very studious and did not have good strategies for studying.

In university, Sam did a Bachelor of Art with two majors, one of which in mathematics[56]. The transition to university was hard for him, as he was not a very good student anymore. Also, he realized that he did not really know what mathematics was before his university courses. He started to work much harder and discovered a new appreciation for mathematics. He studied mathematics in university for the sole purpose of becoming a teacher of mathematics.

He went on to do a master's in mathematics education (details on the program in Section 3.2.1), where he also took around multiple mathematics courses. He took the course option rather than the thesis option, thinking that because he wanted to become a cegep teacher, doing mathematics courses rather than research was wiser. While being a graduate student in the master's program, Sam had his first teaching experiences as he was assigned to teach a course and to be a teaching assistant and a marker for other teachers.

At the end of his master's degree, Sam applied to teach at the cegeps in his area. He got an interview at the institution where he has been teaching for three years and still teaches today. Initially, Sam's name was put in a bank of names and he got his first contract the next semester, in continuing education (see Section 1.1 for more details). To this day, Sam works on unsolved mathematical conjectures in his free time.

For Sam, mathematics is logical. Almost all ideas are a logical link in a chain, and the basis of all mathematical knowledge is in deductions from previous knowledge.

Sam believes it is crucial to put himself in his students' shoes to be a good teacher. He truly believes the way to do a good job is to lay out information clearly—to lay out what his expectations of his students are, what they are allowed to assume or not, to be honest, and to give them the tools to succeed. He is also sensitive to the fact that students learn differently. Some students may not

[56] We do not specify the other major to maintain Sam's anonymity.

be naturally great at math. This is probably due to a mixture of natural factors and of conditioning of some kind, such as whether or not an interest in mathematics is fostered at a young age.

Sam actively reflects on the nature of assessments to find other methods where being neuro-atypical and having an understanding that does not always shine through in regular evaluations could be acknowledged. Students show understanding if they are able to repeat things back to him, maybe in different words or in a different way.

In general, Sam tries to model a bit of his teaching on what he experienced as a student. Cegep is in that nebulous area between high school and university where students are expected to be autonomous adults, without the associated responsibilities. A lot of his teaching is getting students to a more abstract side of mathematics and having them think about it. His teaching method has much to do with making students aware of and learn from possible misconceptions. By the end of the semester, there should be some transfer of knowledge from him to the students. Sam's role as a teacher is to get students through their course aimlessly, but still in a way that takes it seriously.

Sam comes highly prepared to class. He prepares rigorous lesson plans but does not really look at them while in front of the classroom. He makes sure he knows above and beyond what material needs to be covered. He might not verbalize everything he had planned to say to his students, but he does say some of it. Having a wider take on the knowledge he plans to teach gives him confidence when he lectures and gives him the ability to answer any curveball question his students might ask.

4.5.2 Implicit Training—As a Student

In this subsection, we reflect on Sam's experiences as a student, when the nature of the training he received on how to teach was implicit. For instance, we will encounter experiences in which Sam reflects on his ways of learning, understanding and succeeding as a student.

Reflecting on his experience in university as a way to relate to his students

Sam tells a general story of relying a lot more on his experiences in university to shape specific stories he lives out in his classroom. On the one hand, he was a day student in cegep who had no major difficulties and did not feel the need to study [p. 302, 5–9]. This does not relate to his students' reality, especially since he teaches to students in continuing education. On the other hand, some experiences he shared about his time in university, of experiencing struggles with the material and needing to ask for help, are experiences upon which he relies to connect with and advise his students [p. 302, 5–15]. Sam also went through some personal struggles in university that shaped stories he lives in his classroom of having a hopeful attitude towards failure and an inclination to give second chances and believe in people [p. 316, 1–7].

Teaching as he was taught

Sam is living out a story of teaching in which he is for the most part teaching as he was taught, using his experience as a student as an example of something that is satisfactory, both in terms of the curriculum and the teaching [p. 315]. He justifies this choice by saying that was submitted to a similar teaching and he turned out fine so it must be a safe way to go about teaching.

Teachers should provide a variety of resources to the students

Sam lives out a story as a teacher in which resources are crucial in a course and a variety of them should be provided and made easily available to students [p. 305]. He is committed to mindfully providing extra resources to students who request them. He believes he, as the teacher, has the insight to select resources that are aligned with the course and that this is part of his role [p. 305, 7]. We wonder if this story may have been shaped by Sam's experience with difficulties in university when he could have benefitted from resources other than the teachers' class notes but did not feel he was in a position to come up with such resources. Indeed, Sam tells a story of lacking resources for some of the university courses he took.

Explicitly addressing misconceptions as a way to avoid misconceptions

One story Sam lives out consistently in his classroom is about addressing possible misconceptions [pp. 310–311]. This story was shaped by Sam being able to use the chain rule [p. 311, 3–7] as a cegep student through imitation. In his case, understanding the chain rule came much later in life. This experience taught Sam that mathematical explanations that are correct, used alongside culturally accepted nomenclature, are not necessarily eloquent for students. He therefore tries to show his students the proper way of looking at the concepts right away and mentions misconceptions explicitly so they can avoid them.

Being critical towards traditional assessments which do not (always) assess understanding

The experience mentioned above with the chain rule can also be understood as Sam sometimes being able to do well in mathematics, easily and with great marks, without having reached understanding [p. 313, 1–10]. This, for Sam, is a prime example of the flaw of common mathematics examinations in assessing understanding. This experience shaped the story Sam tells about traditional assessments not (always) assessing understanding.

As a consequence, Sam questions the dominant story of assessment in mathematics when it comes to assessing understanding. He considers other types of assessments than those usually used in mathematics [p. 313, 27–41; p. 314, 1–21]. In other words, his own stories of easiness to succeed without complete understanding shaped the story he lives in which he questions assessments that could be considered traditional.

4.5.3 Implicit Training—As a Teacher

In this subsection, we reflect on Sam's experiences as a teacher, when the nature of the training on how to teach was implicit. We encounter experiences when Sam's teaching was evaluated by students and experience when Sam reflects on the dominant stories of assessments in mathematics education.

A teacher should appear credible to students

Sam lives a story in which his students' perception of him is of paramount importance. Indeed, he narrates an experience of being evaluated by his students as an instructor in university. They told stories of him that painted his personality in a negative light. This led him to want to re-story himself and create a teaching persona, that shows a strong mastery of the material, and a teaching voice where he can use words that distinguishes him from people who did not do mathematics extensively [p. 306]. His training in university mathematics allows him to sustain this story. We also believe that this experience of being evaluated has had an impact on Sam's need to prepare extensively so that his authority would not be discredited [p. 318, 1–6] and to minimize the chance of his students losing respect for him [p. 306, 29–30], all contributing to maintaining his credibility.

Assessing in a traditional way despite tensions

Sam gives assessments that can be seen as traditional. He justifies this by saying that he is not comfortable living out stories far outside the dominant ones [p. 314, 11–13; p. 315, 6–14]. He would not want to disrupt the story students are used to living in mathematics classrooms [p. 315, 9–11].

Sam's choice of living out a traditional story of assessments is also shaped by having to follow rules of the institution, some of which he knows and others which he does not [p. 313, 5–10; p. 315, 11–14], as well as rules of the provincial government [p. 315, 11–13].

Nevertheless, he acknowledges that the stories he lives out create tensions for him on multiple levels. For example, traditional assessments bump with the stories he tells about students not understanding and still succeeding [p. 313, 1–10] and students who show understanding in the classroom and do not do so well in traditional examinations [p. 313, 37–41; p. 314, 1].

Doing mathematics is like applying laws

Seeing students struggle to apply mathematics [p. 311, 19–35] shaped Sam's vision of mathematics. Indeed, seeing students struggle on how wide or narrow is the set of instances on which a formula applies triggered a reflection for Sam about what mathematics is to him and how it works. More than anything, it was an occasion for him to explicitly think about his definition of mathematics, something he does not often do. He came up with a metaphor, whereby he compares the application of mathematics to the application of laws [p. 311, 30–35], in that laws are interpreted strictly, without much room for interpretation. In Sam's eyes, mathematics is like that.

A teacher has to deal with students' prerequisite knowledge

In the beginning of his career, Sam learned that students struggle with prerequisite knowledge. His imagined stories of teaching did not include managing the prerequisites in class nor the anxiety students have towards them. But his experiences in class shaped the story he now lives in which he has to address them. He is learning to live out this story in finding the best ways to deal with these gaps in students' knowledge [p. 320].

Giving the benefit of the doubt with a healthy dose of skepticism

Sam used to live out a story in which he believes in his students and gives the benefit of the doubt. This story was challenged through one experience [p. 316, 8–23] that led Sam to change the story he lived. He now keeps a healthy dose of skepticism in his relationships with students as they can possibly want to take advantage of him.

It takes time to figure out what an average student can do

Sam tells us how his stories about what an average student should be able to do in each course [p. 319] were shaped, and are still being shaped, through multiple rounds of trial. He told us about no longer being able to use past exams that he wrote. Some past exams are too easy; others are too hard. With more experience, Sam seems to get the level right more often. He stories such knowledge as being experiential-based.

Teaching a new course a little bit easier

Sam chose to live a story in which, when he teaches a course for the first time, he makes it a little bit easier. He does that to get a sense of the level the students are at. We wonder if this story was shaped amidst a tension between not wanting to sacrifice the level of difficulty appropriate for the course [p. 303, 18–29] and finding it hard, as a novice teacher, to find the level of the students [p. 319]. This shows that Sam is willing to take the time to figure out what students find easy or hard [p. 319], even if it takes multiple semesters, multiple trials.

4.5.4 Explicit Training

In this subsection, we reflect on the experiences Sam had involving explicit and intentional training on how to teach, first as a student (Section 4.5.4.1) and then as a teacher (Section 4.5.4.2). We encounter experiences Sam lived in the master's program in mathematics education he completed as well as experiences Sam lived as a novice teacher in his cegep institution.

4.5.4.1 Experiences as a Student

It is wise to attend to students' misconceptions

Sam did a master's degree in mathematics education, where he took both mathematics and mathematics education classes. For instance, he studied students' misconceptions in mathematics [p. 310, 1–2]. He narrates that experience in a way that tells us that it opened his eyes to the concept of misconceptions and shaped the story that it might be wise to be attentive to them when attending to students' learning. Attending to students' misconceptions currently is a big part of the story Sam lives out in his classroom, from his use of true or false questions [p. 310, 15–24] to showing students explicitly what is not true [p. 310, 36–38].

It is through his experiences in the classroom that he shaped specific stories about the misconceptions students hold. He encountered misconceptions about integrals of products [p. 310, 7–10], trigonometric integrals [p. 310, 25–36], the chain rule [p. 310, 39–40; p. 311, 1–2], general mathematical rigour [p. 311, 8–18], and how mathematics should be applied [p. 311, 19–35].

It is relevant to learn more than the minimum one needs to know to do the job

In telling us about his experience in the master's program he completed, Sam shares that it allowed him to explore in depth topics he would be teaching [p. 312, 3–12]. This shaped Sam's understanding of the use and relevance of learning more than the minimum one needs to know to do the job, a story he now tells in his classroom to justify some of what his students have to do and learn [p. 312, 13–17].

We also see this story as being shaped by Sam's lack of knowledge in applications. Sam stories his time in university mathematics as allowing him to learn above and beyond what he teaches in cegep [p. 306, 1–8], except when it comes to applications [p. 307]. This matter has more to do with his emotions than anything else; he imagines that if he were more knowledgeable about applications, he would not teach them any differently than he currently does, but he would at least feel like his knowledge is complete [p. 307, 1–5]. He does not want his authority to be discredited should he be unable to come up with examples of how the material is relevant to students' lives if they ask [p. 318, 1–6]. In this sense, this is another justification to his story that it would be relevant for him to know more than what he needs. Sam prepares extensively when he has to present applications to fill the gaps in his knowledge [p. 307]

4.5.4.2 Experiences as a Teacher

Stories to live by shaped by reaching out and living alongside experienced colleagues

Sam lives a story in which his colleagues are mentors. Sam narrates ways in which his colleagues participated in shaping his stories to live by, while acknowledging the tensions that teaching in continuing education creates as he seeks mentorship from experienced colleagues. Indeed, Sam shares how he has faced challenges in his desire to be part of the department and to be mentored by more experienced teachers [p. 301, 15–17, 30–34]. Teaching night classes in continuing education has been one of them. Since he does not teach during the day, he has to go out of his way to reach out to more experienced teachers, who are assigned day courses. Moreover, he does not have an office, meaning he is not on-site during the day [p. 301, 15–16]. However, teachers are open to help Sam when he reaches out, for example about exams. He also takes department meetings, which are not mandatory for him because he teaches night classes, as a great place to learn from his colleagues and to form, confirm, or affirm his own opinions and ideas. In other words, he takes opportunities to live alongside colleagues to shape his stories to live by about mathematics, teaching, and learning [p. 301, 30–39]. But he did not share with us precise examples of what this living alongside looks like.

4.5.5 Experiences Related to University Mathematics

In this subsection, we reflect on Sam's experiences as they relate to university mathematics.

Showing mathematics in a way that is not deceptive but still appropriate for cegep students

Sam stories his experience in university mathematics as unlike anything he had ever experienced before. Not only was it much harder than pre-university mathematics [p. 302, 7–9] but it was significantly different [p. 302, 17–25]. This was the moment when Sam started to be aware of how he was storying mathematics and explicitly question what mathematics really was as he felt he was finally seeing the real thing. This realization shaped his stories of teaching. Indeed, part of the story he wants to live out in his classroom is to show his students the mathematics the way he saw it in university. Sam does not want his students to be deceptively taught like he was in cegep and he wants to give them opportunities to appreciate the mathematics [p. 302, 25–28]. Also, he needs to take into account that cegep students do not have the same background he had when he started university and started to appreciate mathematics [p. 303, 12–17].

4.5.6 Reflections on Sam's Stories

In this final subsection, we take a global approach and summarize what we learned about how Sam's STLB were shaped, per respect to the three chosen strands.

Sam's experience in university mathematics gave him a whole new perspective on mathematics but also on being a student. He now wants students to experience a view of mathematics that is close to the view that was fostered for him in university.

Sam wants to embody an image in his classroom, an image that will show authority and earn him respect from his students. This demands from Sam to show great mastery of mathematics and to be confident in his mathematical skills.

When looking back at his time in cegep, Sam is critical of his own way of succeeding. He tries to teach in a way that would "fix" what he feels he did wrong, by trying to find ways to assess understanding and show students misconceptions before they develop them. In talking about his expectations of teaching cegep, Sam shares a story about being uneasy about how things are generally done, about the curriculum or assessments. With Sam's stories, we learn the struggle a new teacher may have as he is somewhat not completely part of the community.

University gave Sam a whole new perspective on mathematics but also on being a student. Because he struggled in university, he can relate to students who struggle and understands how to support them. He also now wants students to experience a view of mathematics that is close to the view that was fostered for him in university.

4.6 Concluding Thoughts

In this chapter, we explored the ways in which novice teachers' stories to live by [STLB], in relation to mathematics, teaching, and learning, were shaped (justified, modified or affirmed). The three strands we chose allowed us to discern how their lives, and the stories they tell about themselves and who they are becoming in relation to mathematics, teaching and learning, were impacted by implicit and explicit training, as students and as teachers, as well as their experiences as they relate to university mathematics.

Attending to how justifications, modifications, or affirmations came about in novice teachers' stories allowed us to wonder about what experiences, according to the chosen strands, impacted their STLB about mathematics, teaching and learning the most. Already the magnitude of each section is informative of the importance they give to the different experiences that shaped their stories of who they are and are becoming. Indeed, it was obvious at first glance when composing this chapter that some teachers had very little or a lot to say that pertain to one strand or another, which somehow informs us on who they were and were becoming as teachers. How much they felt the need to talk about a certain topic to allow me to understand them as teacher, during our meetings, can help us understand who they are and are becoming as teachers.

When looking at Étienne's stories about implicit training, we see a lot of stories that entail detailed ways in which his STLB were shaped by those experiences. When looking at Albert's stories of implicit training, we found ourselves wondering a lot about how his STLB came to be. Albert did not explain how his identity was shaped over the years nearly as much as Étienne did. We saw a sense of decisiveness and finality in Albert's stories about himself that we did not see in Étienne's, or in Vera's, Michèle's or Sam's. For their part, they tell stories about themselves tainted by temporariness and movement, with a sense of becoming, of being turned towards the future. They tell stories of moving forward in directions that are still unknown to them. They are still, in many ways, in the process of defining their identity as teachers whereas Albert seems to have found what makes him who he is as a teacher, the foundations that drive his teaching. Something we did not see in Albert's stories (in Appendix D) is that he is now focusing on improving courses and programs and experimenting with creating material for new teaching approaches such as flipped classroom.

In other words, because Albert is a lot more set in his ways and practices, we believe he does not have to reflect on them on a regular basis. Therefore, when he tells stories about what he does as a teacher, he is not sharing the reasons why he made those choices. He does not refer to the rationale for his choices because the decisions he made over the years, based on past experiences as a student, as a teacher and in university mathematics, are who he is as a teacher. We see this in the ways he informs us of what he does, in a very factual way. We also see this in the lack of tensions and bumping between the stories he tells about himself and his teaching with the stories of his colleagues or the dominant stories of the institution or the department. He either has assimilated them or he is affirmative in his identity to the point that he does not feel tensions. They do not come up in his mind when he tells stories of who he is as a teacher.

On the contrary, Étienne tells us so clearly and explicitly how experiences have shaped, and are shaping, his STLB per respect to mathematics, teaching, and learning. We tend to believe it is clear because he is actively, daily, building his identity as a teacher. He is making lots of decisions all the time. And because these decisions are made in a mostly unfamiliar context, he has to rely on similar experiences, make connections between common contexts somewhat explicitly. According to Dewey (1938; see section 2.1.5), there is much more thinking in those cases, which can explain why they were shared so explicitly.

The other novice teachers express stories that are similar to both Étienne and Albert. They are set in some ways and still evolving in other ways. Because of each novice teachers' number of years of experience, one for Étienne, five for Albert, and three for the others, we are tempted to describe the process of becoming a teacher starting with a very explicit and rather constant decision-making, based on specific past experiences. There is a focus on "surviving," in the sense of taking as much help as possible, doing things in an acceptable way, things that work within the constraints imposed upon them, knowing that this is temporary. And slowly, their identities become more and more decided, practices and ideas become more and more solid as new experiences as teachers are added to their lives. They start to affirm their identities out loud, to others and to themselves. They start to live out new stories from which they learn. And as time goes by, as they live and relive, tell and retell experiences from inside and outside of school, their identity solidifies. This is not to say that they will not change as new experiences occur or as they live and relive, tell and retell experiences but a foundation is being set. From there, they can build on this foundation and branch out to explore other aspects of being a teacher, such as innovation, curriculum, and programs.

In the next chapter, we continue in this line of thought and address what we learned about the process of becoming a teacher of mathematics in cegep, from the analysis conducted in the present chapter, from the field texts, and from the booklet of stories.

CHAPTER 5 — THE PROCESS OF BECOMING A MATHEMATICS TEACHER IN CEGEP

“Life is not made up
of separate pieces.”
Mary Catherine Bateson, 1994

“Greatest of all pedagogical fallacies
is the notion that a person learns
only the particular thing
he is studying at the time.”
John Dewey, 1938

In Chapter 4 and in the booklet of stories (Appendix D), we attended to the experiences that shape novice cegep teachers’ STLB. In this chapter, we reflect on what this allowed us to understand about our research puzzle[57]: the process of becoming a mathematics teacher in cegep. We did that by exploring the resonant threads, particular plotlines, and patterns we have found and chosen. We lay the stories of the novice teachers side by side, not to see how they bump against each other, but to strengthen our understanding of what a process of becoming a teacher can look like. In this chapter, we speak of different aspects of novice teachers’ stories along different threads, understanding that none of these are completely separate in their lives as teachers.

This chapter is separated into two parts. In the first part (Section 5.1), we reflect on the previous chapter through the lens of our research puzzle. In other words, we look at what can be learned about the process of becoming a mathematics cegep teacher through our reflection on how novice teachers’ STLB about mathematics teaching and learning are shaped. In this first section, we take up the same theme we addressed in the previous chapter: implicit training (Section 5.1.1), explicit training (Section 5.1.2), and university mathematics (Section 5.1.3). In the second part of this chapter (Section 5.2), we explore other threads, plotlines, and patterns in relation to the process of becoming a cegep mathematics teacher that have emerged through composing the field texts, writing the stories (see Appendix D) and the reflections of the previous chapter. We will address bumping stories and tensions (Section 5.2.1), novice teachers’ unique journey to teaching (Section 5.2.2), novice teachers’ inclination to strive towards quality teaching (Section 5.2.3), the

[57] For more details on our research puzzle, see the summary in Section 3.2.3.

connection between the process of becoming a teacher and being a university student in mathematics (Section 5.2.4), and a characterization of the valid behaviours in which novice cegep teachers engaged (Section 5.2.5).

5.1 Looking at the Research Puzzle According to the Three Strands in Chapter 4

In this section, we reflect on what the previous chapter's analysis allows us to say about our research puzzle, namely the process of becoming a mathematics teacher in cegep. We touch upon the three main strands of Chapter 4: implicit training, explicit training and university mathematics.

5.1.1 Implicit Training and the Process of Becoming a Cegep Teacher

We define implicit training (Section 1.2) as a sort of apprenticeship training by imitation which is not in the intended goals of the instructor or the course, nor often in the learning goals of the student. We explore here the connection between implicit training and the process of becoming a cegep mathematics teacher.

5.1.1.1 Experiences as Students

It is widely accepted that postsecondary teachers mainly learn to teach from sitting in classrooms as students. This is a form of implicit training. For example, the Conseil Supérieur de l'Éducation [CSÉ] writes that cegep teachers will have had the opportunity to socialize with the practice of cegep teaching as cegep students (CSÉ, 1997, p. 57). Beisiegel (2009) affirms that mathematics graduate students' identity as teachers is influenced by the implicit teacher training they received during their time as students (p. 42). Stewart (2006) asserts that it is enough for mathematics graduate students to rely on their experiences as students in mathematics to become teachers. This idea is also reported in the case of pre-secondary and secondary teachers who, even though they get trained to become teachers, form their identity as teachers (at least in part) during their time in the classroom as students. For example, Lee and Shallert (2016) report that almost all pre-service teachers with whom they worked "reported having prior images of themselves as teachers before entering the [teacher training] program" (p. 76).

We saw in many ways how the five novice teachers of this study learned from their experiences as students, as these relate to mathematics, teaching, and learning. We talked about this in detail in the analyses in the sections on *implicit training as students* of the previous chapter. There are two ways in which novice teachers' experience as students had an impact on the stories they tell as teachers.

Experiences in learning material for the purpose of succeeding in their courses are the first type of experience that shaped novice teachers' stories of teaching. From these experiences came stories of how to succeed in assessments [Vera, p. 256], methods of solving problems [Michèle, p. 273], or the struggles involved with going from cegep to university [Sam, p. 302, 7–9]. To some extent, all novice teachers, at one moment or another, consider the stories they tell about themselves as students to be a valuable basis on which to make decisions about their students. Étienne [p. 282, 23–25; p. 289, 6–22] and Albert [p. 230, 22–23] explicitly tell stories in which they consider themselves to have been generic students and develop practices on the basis of their memories of being a student. Étienne gives the best example of that as he extrapolates a great number of facts about himself as a student to his students [p. 279; p. 282, 22–25].

Their perspective on how they were taught is another frame of reference for their stories of what a teacher should or should not do. That is, *being taught* provided them with the stories of what a teacher should or should not do and what does or does not work. For example: a teacher should have a great attitude [Albert, p. 234]; a teacher should care about what students actually know [Vera, p. 240]; and a teacher should be an example, a model, to the students [Michèle, p. 263, 12–23]. Remarkably, this refers mostly to the attitudes of a teacher and not so much to their pedagogy or didactic approaches.

The two ways described above in which novice teachers' experiences as students had an impact on the stories they live and tell as teachers confirm for us that novice teachers' experiences as students played a role in their STLB as teachers. This supports what was previously said in the literature (e.g. Beisiegel, 2009; CSÉ, 1997; Stewart, 2006).

Those experiences as students resulted in stories of whom and how they want to be as teachers and in stories they (want to) live and tell as teachers. These can be imagined stories, stories they imagined themselves living out before they entered the profession. The origin of those stories is not always clear, and when they became something significant in their lives is not necessarily clear either. We learned, from the analysis we conducted, how different the experiences that shaped their STLB are, what each of them took from experiences which could be considered, a priori, similar. For example, being a student in a bachelor's program in mathematics can be experienced in many ways and resulting in many different stories to live by, even if each teacher can say they were a student in the same degree.

5.1.1.2 Experiences Outside of School

We also found evidence in the literature that experiences outside of school have an impact on how one becomes a teacher (e.g. Altan & Lane, 2018; Kay Klausewitz, 2005). The impact of experiences outside of school is obvious in the case of Vera's stories of tutoring [p. 239, 1–8] and Michèle's stories of growing up alongside relatives who were cegep mathematics teacher [p. 259].

Experiences outside of school also came up in other subtle ways in my time with novice teachers, in stories that did not make it into the stories in Appendix D. Étienne [[58]] and Albert [[59]] talked about how being a coach or a referee in a sport played a role in readying them to be in front of a classroom. Stories outside of school are part of the stories novice teachers live and tell as teachers.

5.1.1.3 Experiences as Teachers

As previously mentioned, the process of becoming a teacher continues to take place within the new experiences novice teachers live out as part of their new profession. As we have seen in the previous chapter's sections on the *implicit training* each novice teacher experienced *as a teacher*, teachers use the experiences they live in the classroom, as these relate to mathematics, teaching, and learning, to modify the stories they live out as teachers.

For example, Albert [pp. 231–232; p. 224], Vera [p. 249; p. 250], Michèle [p. 271; p. 274], Étienne [p. 285, p. 292], and Sam [pp. 310–311, pp. 313–314] have all told us about stories they live and tell that have changed as they got to know cegep students better. On a more personal level, novice

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[58] Donner les cours de [sport] l'ont aidé tout d'abord à se dé-gêner. Les participants sont plus jeunes donc c'est moins gênant à la base, mais il y a quand même des parents qui le regardaient parfois. Ça lui a fait prendre confiance, apprendre à parler fort, tout ce qui est de donner des explications et des exemples. Ça aide aussi pour le sens de l'improvisation. Il se souvient la première année, il est arrivé au [sport] avec tout son plan, il l'a gardé pour toutes les années qu'il a enseigné le [sport]. Mais parfois, tu donnes un exercice et tu vois que les gens s'ennuient ou encore ça ne marche pas parce qu'ils ne sont pas assez bons. Alors là il faut improviser et changer d'exercices.

[59] Il y a un autre évènement qui l'a aidé, pas à être mathématicien, mais à être enseignant, pour l'aider à avoir un certain retrait face aux frustrations des élèves et être plus impartial. Il a été arbitre de [sport] pendant plusieurs années. S'il y a des joueurs qui se frustrent contre ses décisions ou entre eux, ce n'est pas contre l'arbitre personnellement. Il faut donc apprendre à ne pas le prendre personnel. Parfois il fallait qu'il juge si c'était des vraies blessures ou non, qui avait frappé qui, si c'était un but ou non. C'est lui qui avait l'autorité et les joueurs qui font l'action, un peu comme la position de l'enseignant qui voit ce qui se passe, qui doit juger.

teachers have also learned about what they are comfortable doing as teachers and develop the stories they live and tell as teachers accordingly. Albert [p. 228; p. 233] told us about changing the way he prepares the lessons he teaches to keep the classes interesting for himself. Michèle wants to fight to keep the students' perspective [p. 264, 7]. Étienne describes new habits he developed as a teacher [p. 279] such as reading the textbook. Sam works on building up confidence in his mathematical knowledge[60] [p. 304]. Vera talks about finding a way to assess students in class that she would be comfortable with [p. 246].

5.1.1.4 Stories of Being Unprepared: Limitations of Implicit Training

Above, we have explored ways in which novice teachers' stories have been shaped through their experience in and outside of school, as students and as teachers, through what we called implicit training. In this section, we touch on this implicit training and its limitations.

In the stories novice teachers shared about their experiences being teachers, they told us they are not completely prepared to do everything teachers have to do. We learn ways in which these teachers found there was much more to being a teacher than what they had initially expected. Indeed, we found that much of the work of the teacher is hidden to those sitting in the classroom.

One aspect of the job that is hidden is marking. In the way Michèle [p. 271] stories her struggles with marking at the very beginning of her career, the realizations she had, and how precise her ways of marking had become, there is no doubt that for her there was more to marking than she had been prepared for by her experience as a student. Michèle also stories the connection between marking and how she teaches. This shows that, in her story, marking was pivotal and it took her time to create a practice of marking that felt right.

Something else with which novice teachers struggle is assessing the level of difficulty of a question, of the students, or of an average group. Sam [p. 319] and Vera [p. 250] talk about this struggle when they say that the first time they teach a given course, they teach in a way to make the course easier for the students, just to be on the safe side. They know they have trouble assessing the level of a question, of the students, and of an average group and they do not want to make their

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[60] In this case, the word "knowledge" is used by Sam to refer to his knowledge of mathematics in a broader sense.

students suffer because of this weakness. Vera [p. 249] and Sam [p. 319] talk about the difficulty of knowing what an average group or student should be able to do and of determining the level of their students. Albert, for his part, talks about his journey being comfortable when it comes to evaluating the level of his students prior to an exam [p. 224].

It seems that the fact these novice teachers did not attend more than one cegep institution as students contributed to their lack of awareness of some aspects of the work of teachers. They were not aware of the variation in institutional cultures and populations. For example, Michèle [p. 276, 33–37] and Étienne [p. 293, 28–41] mentioned they had to figure out what were the expectations in a given cegep around proving, as they are not necessarily written or shared and they may change from one institution to another. This idea of variability from one institution to another also comes up in Étienne's story when he questions if the level of the students is different depending on the population and the geographic location of the institution [p. 288, 1–12]. Differences in institutional cultures and populations also come up in Sam's stories about continuing education, a structure he did not even know existed [p. 301]. Institutional variation also comes up in Albert's story when he recalls having learned in a professional development seminar how much freedom he had in teaching [p. 235, 26–33]. He and Cooper (2011, p. 114) emphasize that novice teachers may find challenges in teaching in contexts (e.g. socioeconomical or geographical) far from the ones they have experienced as students. In the stories teachers told us, teaching in unfamiliar contexts is not storied as a struggle but as a reality to which they adapt.

There also seem to be aspects of the work of teachers that were hidden from novice teachers when they were pre-university, daytime, cegep students. Indeed, much of the realm of the work with which mathematics teachers are involved was hidden. Étienne shares how different it was for him to be involved in a career-program course during his internship [p. 296; p. 299] and how he would not feel comfortable taking such a course on by himself.

We also see a limitation in the way novice cegep teachers learn to teach: their isolation. Indeed, as they learn everything there is to know about being a cegep mathematics teacher, they are often alone in their classrooms. This is especially the case for Sam, who explained his isolated state as a novice teacher assigned to a course in continuing education. However, he spoke about the space for exchanges offered by department meetings and how he values this space as an opportunity to learn from others and get a "frame of reference" for his ideas [p. 301, 34–39]. Vera talked about asking questions during the occasional encounter, left almost to chance, with other teachers [p. 248, 7–9]. Even Michèle, who seemed to have more access to colleagues with whom to speak, talked about the helpfulness of having had a space in which to exchange with other teachers during her certificate degree [[61]]. This explicit training opportunity allowed her to confirm what she intuitively knew in relation to teaching [p. 265, 4–8]. There does not seem to be a frequent, structured, and regular designated space in the lives of novice teachers in which they can ask questions and reflect with others on the experiences they live. We continue to address explicit training opportunities in Section 5.1.2.

Finally, Grossman (1989) reflects on another limitation of implicit teacher training in the lack of frameworks (vocabulary and assumptions):

> The inclusion of teachers without professional preparation focuses attention on the problems of learning to teach from experience alone, without the benefit of the frameworks, vocabulary, or assumptions embedded within teacher education. While subject-matter knowledge, good character, and the inclination to teach are important characteristics of beginning teachers, they do not necessarily lead to a pedagogical understanding of subject matter nor to a theoretical understanding of how students learn a particular subject. (p. 207)

We believe that Grossman's affirmation is representative of what we saw in the stories shared with us by novice teachers. Indeed, Michèle tells stories of her experience in a certificate in postsecondary teaching where she talks about learning about frameworks. She said that she already had some intuitive ideas and that these were confirmed during her training. She mentions benefiting from the training in that she gained a vocabulary with which to talk about her intuitive ideas [p. 265, 4–8]. Michèle's stories confirm Grossman's claim that teachers who learn to teach from experience alone lack formal frameworks. While Michèle says that she has some intuitive ideas, she refers to the benefits of learning a vocabulary to talk about these. Nevertheless, in the

[61] Il y avait aussi un espace pour échanger. Par exemple, il y avait un travail où il fallait justement construire essentiellement un énoncé pour un travail de session, et regarder l'énoncé d'un travail de quelqu'un d'autre dans une autre discipline et le commenter, puis l'améliorer. [Michèle] a travaillé avec une enseignante d'histoire, qui n'avait évidemment pas la même manière de voir les choses. Mais ça peut être enrichissant pour tout le monde.

absence of such formal vocabulary, she did develop intuitive ideas about teaching and learning mathematics.

In a similar manner than Michèle talks about her intuitive ideas and lack of framework, Étienne talks about how he sometimes justifies some of his decisions on his instinct. When talking about how he decided to teach with “fill in the blanks”-style class notes [p. 285, 9–10], Étienne stories the way he chooses how to write them as a product of his instinct. Somehow, he knows what he should have the students write but he cannot explain how he knows this—he does not have a framework to talk about the learning difficulties of his students. Similarly, Sam refers to his innate abilities in relation to being a teacher [p. 312, 22–24] and uses these innate abilities, along what he learned in the master’s program, to identify the thinking behind errors students make in class or on assessments—but the master’s program gave him a framework to reflect and talk about these as students’ misconceptions, supported by research and theoretical conceptualizations. In the case of Sam, he does possess a framework from explicit training opportunities but he still tells us about using his innate abilities, abilities which he struggles to explain or make explicit.

Considering these intuitive, instinctive, and innate capacities reported by Michèle, Étienne, and Sam, we surmise that novice teachers, whether they received explicit teacher training or not, develop a *structure* they sometimes use to act and make decisions as teachers.

From our conceptualization of learning (Dewey, 1938), such structure is the result of teachers’ reflections on past experiences (see Section 2.1). In other words, the structure in question is an *informal framework* that is not theorized or accepted by a community, but a framework nevertheless, that informs teachers’ actions and decisions. It is what teachers *know* about being a teacher. Indeed, in Section 2.2.3, we described stories to live by as connecting the concepts of knowledge, contexts, and identity. Per our conceptualization, knowledge is thought of as a body of convictions, which have arisen from experience (Clandinin, 1985, p. 362). In this sense, this informal framework is the knowledge teachers use to act and make decision. As Nardi (2008) wrote, it is “their own interpretive frames for making sense of things like their students’ learning […], their own pedagogical practices […], the way they relate to mathematics educators and educational researchers” (p. 21). The informal nature of some of these structures is, without a doubt, a limitation of these structures. They are biased and limited in scope by the experiences from which they arose, and they don't come with a vocabulary that teachers can use to reflect and communicate about their teaching and their students' learning.

To conclude, we believe that the lack of (formal) frameworks (as opposed to informal frameworks or structures) is indeed a limitation of the implicit training novice cegep teachers experience. They also shared how being introduced to formal frameworks (or vocabulary) is helpful to talk and reflect on their teaching and their students' learning.

5.1.2 Explicit Training and the Process of Becoming a Cegep Teacher

In this section, we reflect on the explicit training novice teachers receive and its role in their process of becoming a mathematics cegep teacher, following the analysis we conducted in the previous chapter. When we talk about "explicit training," we refer to experiences behind which there was an explicit intention for teacher training. We will see that many aspects of novice teachers' STLB in relation to mathematics, teaching, and learning were shaped through this explicit training.

One way in which novice teachers were impacted by explicit training to teach they received as students is surprisingly connected to their storying of mathematics. For Vera, her master's program provided a space in which to think about mathematics and why people love or hate mathematics [p. 238]. Explicit training played a similar role for Étienne: the certificate he did offered a space in which to think about mathematics in a new way [p. 297, 9–13]. Similarly, a course he took about the mathematics in cegep mathematics courses brought him much mathematically as it gave opportunities to work deeply on topics he had learned about in high school [p. 298, 4–7]. In a similar way, Sam, during his master's program, got to explore mathematical topics in depth and, moreover, see the relevance of knowing a bit more mathematics than what he believes is absolutely necessary to teach [p. 306; p. 312].

Another outcome of novice teachers' explicit training opportunities as students is a new awareness. For Vera, explicit training brought her an awareness to how she was being taught; she brought this awareness to all her mathematics classes in university [p. 238]. For Sam, explicit training brought an awareness to misconceptions which now heavily influence how he teaches [pp. 310–311]. For Michèle, explicit training brought an awareness of her own position as a student and prompted her to reflect on how students might focus on their grades or on learning what they think will be useful to them in the future. This awareness now transpires in the story Michèle lives as a teacher as she encourages students to be in school for the mathematical knowledge they can get out of it rather than to obtain certain grades [p. 269, 20–32].

An increased awareness of what being a teacher inside and outside of the classroom means was also reported as an outcome of explicit training. Through his teaching internship, Étienne learned what work teachers have to do outside of the classroom. He learned especially about the realm of courses that exist and about the administrative side of the job [p. 296, 1–2; p. 299, 2–6]. Professional development seminars freed Albert from a lot of constraints he had put on himself and opened a lot of doors for him to get involved in different committees in the institution [p. 235, 22–25].

Finally, the explicit training novice teachers went through as students encouraged the creation of teaching material and fostered the development of new practices. Étienne got the chance to prepare material for courses in career programs both in his internship and in a course on cegep mathematics [p. 298, 10–13; p. 299, 13–14]. He has not yet used the material as he is not yet comfortable with teaching courses in career programs. Sam learned a lot about misconceptions, which now inform many of his teaching practices in class [pp. 310–311]. For Michèle, the certificate was a place where she received many suggestions as well as validation on teaching practices; she now gets to try these out and judge whether they work for her [p. 267]. She also had the opportunity to create material during her certificate. For Michèle [[62]] and Sam [p. 312, 18–24], explicit training opportunities were also a place for sharing and exchanging ideas about mathematics, teaching, and learning.

Regarding the explicit training novice teachers experience while being teachers, it occurred mostly through mentorship from colleagues, whether by the sharing of materials or by direct contact with them. We will reflect more in depth on the role of colleagues in the process of becoming a teacher in Section 5.2.

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[62] Il y avait aussi un espace pour échanger. Par exemple, il y avait un travail où il fallait justement construire essentiellement un énoncé pour un travail de session, et regarder l'énoncé d'un travail de quelqu'un d'autre dans une autre discipline et le commenter, puis l'améliorer. [Michèle] a travaillé avec une enseignante d'histoire, qui n'avait évidemment pas la même manière de voir les choses. Mais ça peut être enrichissant pour tout le monde.

5.1.2.1 The Existing Programs for Training Postsecondary Teachers and their Impact

As we attend to the process of becoming a teacher in terms of explicit training opportunities, we were drawn to reflect not only on how it impacted teachers' stories to live by but on the overall impact it had on teachers. We reflect on the nature of the training and the factors that could have played a role in the teachers' ability to learn from these explicit teacher training opportunities. We focus on how they experienced the explicit training opportunity and what is left of these opportunities in the stories they live and tell as teachers.

Étienne is the only novice teacher in this study that has attended a university certificate designed specifically for cegep teachers (see Section 3.1.2.1 for more details on the program). Aside from the reflection he had been prompted to make about the nature of mathematics [p. 297, 7–22], he did not refer to any of the courses he took when talking about his stories to live by about mathematics, teaching, and learning. Étienne did not take a clear stance on the quality and usefulness of the certificate he completed but because of our theoretical stance, we believe that those courses have not had—at least, not yet—a significant impact on his stories to live by. Otherwise, the courses would have come up in the stories he lived and told as a teacher. He did mention, however, the internship he did as part of the certificate as having shaped more than one of the stories he lives and tell [p. 299].

While Étienne is the only teacher in this study that completed a certificate in cegep teaching, Michèle had mentioned she heard from a few people who completed certificates similar to the one Étienne did. She says *they did not like it* [[63]]. While she refrains from critiquing such certificates because she did not complete any, she does hint that the negative comments may come from the lack of open-mindedness of the enrollees.

Regarding Michèle's own experience in a certificate in postsecondary teaching (see Section 3.1.2.1 for more details on the program), she says she loved the experience and uses what she learned extensively [p. 265; p. 267; pp. 269–270; p. 277]. We hypothesize below why attending the

[63] Il faudrait peut-être qu'elle ait fait les deux pour comparer. Peut-être qu'elle a été vraiment chanceuse, elle a aimé tous ses cours, tous ses profs. C'est certain qu'elle était assez ouverte d'esprit, elle était prête à se faire présenter des idées et à voir comment elle pourrait l'appliquer en maths, plutôt que d'avoir l'idée que non, ça ne s'applique pas en maths. Certains ont un peu cette idée que rien ne s'applique en math.

certificate in postsecondary teaching worked so well for Michèle (as opposed to the apparent lack of significance that the certificate in cegep teaching had for Étienne).

We believe that since Michèle attended the certificate in postsecondary teaching and taught in cegep at the same time, she was able to contextualize the assignments she had to do as a student in the certificate into the course she was teaching at the time. For example, when she was teaching Calculus II, she was tasked with creating a lesson plan using technology in the course she was taking in the certificate; she could create such a lesson plan for Calculus II and then use it in her own classroom. In that way, she created material and engaged in reflections (as required in the courses in the certificate) that were directly useful for her own practice. Michèle mentioned that she immediately saw the impact of taking the certificate on her teaching [p. 265, 20–21]. Maybe having been a teacher for two years also helped her gain more from the certificate, allowing her to contextualize or anchor the lessons in the certificate in her own teaching experiences. On the other hand, Étienne entered the certificate without teaching experience. This may have made it harder for him to discern the specific information he may need in his future teaching.

Regarding Vera's experience in a master's degree in mathematics education, we have argued elsewhere (Mathieu-Soucy, Corriveau, & Hardy, 2019) that she was more prepared to learn from the teaching she received as a university mathematics student because she was already taking the stance of a teacher [p. 238]. We take a similar stance regarding Michèle's experience in the certificate for postsecondary teaching. Both Vera's and Michèle's position sitting in those classrooms was that of a teacher; this allowed them to benefit in some particular, meaningful way from the explicit training in postsecondary teaching. Étienne, on the other hand, had never been a teacher before. This, we believe, prevented him from getting as much out of the explicit training as he may have otherwise. From our stance on learning and on experience, we could say that he was not ready to learn from the experiences he lived through the certificate in cegep teaching—he didn't have a prior sequence of experiences that would make those new experiences *educative* (Section 2.1.3). Either he could not adapt to the experience or the experiences were not adapted to him (see Section 2.1.3 for more on teachers' readiness to learn from given experiences).

Albert's stories suggest that the explicit training experiences he had shaped the stories he lives and tell as a teacher (Section 4.1.4). His storying suggests that this was the case *because* Albert attended these training opportunities *while* being a teacher. However, Sam's experiences in the master's program in mathematics education have also shaped the stories he lives and tell as a teacher, even if he had those experiences prior to any teaching experience (see Section 4.5.4). Therefore, it is not only in-service teachers who benefit from explicit teacher training.

5.1.3 University Mathematics and the Process of Becoming a Cegep Teacher

Following our reflections in the previous chapter on how novice teachers' experiences in relation to university mathematics have shaped their stories to live by, we reflect in this section on the extent to which being a mathematician, and having spent time in the culture of university mathematics, is part of the process of becoming a cegep mathematics teacher.

The stories we wrote (Appendix D), as well as the field texts we composed and the reflections we conducted in the last chapter, all indicate that training in mathematics impacts the stories to live by of some novice teachers more than others. For instance, from the stories Albert tells about himself as a teacher, we see that he retained a lot from his time in university mathematics. Indeed, his experience of university mathematics plays a significant role not only in the stories he tells about himself but also in the stories he lives and tells as a teacher. For instance, his times doing university mathematics has shaped the stories of what he wants his students to get out of their time in his class [e.g. pp. 225–226] as well as the type of mathematics he wants to teach [p. 227]. Vera, on the other hand, barely mentions her time in university mathematics; she mostly refers to having gained mathematical knowledge[64] [p. 252, 1–8] through that experience.

Nonetheless, each novice teacher storied some positive impacts of their studies in university mathematics on their new profession. For instance, Vera's studies taught her mathematics that can be helpful to support students who want to learn more than what is in the cegep curriculum [p. 252, 1–8]. Michèle, for her part, acknowledges the deep knowledge of mathematics her studies in university brought, although she does not teach everything that she knows about a certain topic [p. 261, 4–5]. Étienne found that pushing his limits in learning mathematics helped him get a new and profound understanding of cegep-level mathematics which he uses in his teaching [p. 279, 16–21]. Studies in university mathematics brought Sam a new vision of mathematics which he now

[64] In this section, we use the word "knowledge" to refer to novice teachers' knowledge of mathematics in a broad sense: namely what they know in, and about, mathematics.

tries to convey in his teaching [pp. 302–303]. These studies also brought him confidence, which is key to his identity as a teacher [p. 306, 27–36]. His training in university mathematics also allowed him to discover a new vocabulary [p. 306, 9–19] that he now uses.

When it comes to the negative impact, Albert and Étienne report on having to fight the instinct to recreate what they experienced in university classrooms, such as writing exam questions in a form students have not yet experienced [Albert, p. 226, 25–30] and to prove every result and theorem mentioned in class [Étienne, p. 295]. However, they did not seem to suggest this was something difficult to overcome.

On another note, novice teachers mention that their time studying university mathematics has supported their process of becoming as they navigated the unknown of their new profession. For instance, Vera's training in mathematics gives her the confidence to stand in front of a classroom [p. 252, p. 253]. At the beginning of her career in particular, she was able to "fall back" on her knowledge of a topic when she felt overwhelmed by the stress of everything else that comes with teaching—time issues, class management, writing and speaking clearly, just to name a few. However, she does not believe that any more mathematical training, such as a master's in mathematics, would have helped her be a better teacher [p. 252, 9–13]. Michèle shares that these studies increased her ability to take on challenges [p. 261, 14–17], a skill she can use in any aspect of her life, in particular in teaching. Novice teachers also reported on their university programs as having provided them with the capacity to learn or relearn new concepts fast (in order to teach them) [Michèle, p. 261; Albert, pp. 225-226].

Therefore, training in university mathematics brought novice teachers much more than knowledge in mathematics as they become teachers. It shaped their ways of doing mathematics as well as the ways they became teachers. In the next subsection, we will expand more about the mathematics knowledge novice teachers got from their studies as we address the mathematics they need to know to be a cegep teacher and the knowledge of mathematics they developed as teachers.

5.1.3.1 Not Knowing Enough about Mathematics to Be a Teacher

The conventional image of postsecondary teachers, teachers of advanced mathematics, depicts them as being highly trained in mathematics. Novice teachers' stories nuance this idea. Indeed, they may not be trained in all the mathematical areas with which they need to be familiar as cegep teachers.

The novice teachers in our study tell stories of lacking mathematical knowledge in certain areas. Applications constitute one issue that comes up many times: Michèle [p. 275; [65]], Étienne [p. 295, 22–28], Sam [pp. 307–308], Albert [[66]] all discuss it in some way or another. Vera does not explicitly talk about lacking mathematical knowledge, but does mention having had to learn about some applications of mathematics since teaching in cegep [p. 253, 7]. The novice teachers have a need to justify the relevance of the topics they teach to students; showing relevant applications is one way to fulfill this need. The study of applications of mathematics in university and a deeper and more diverse knowledge of applications would also give them confidence in their capacity to come up with and fully grasp applications that can justify the material to inquiring students. It seems their university programs focused on pure mathematics; but as cegep teachers, they do not train only future mathematicians. And, as Michèle says [[65]], as novice teachers, they already have a lot to learn. To learn about applications at this point in their career is difficult time-wise.

Still regarding the mathematics novice teachers know, some of the stories that were shared with us depict teachers having to learn completely new concepts. Michèle tells us about having to learn new concepts of which she had never heard, such as the Simplex method [p. 261, 9–13]. Vera had to learn a large amount of new mathematics when she taught in career programs [p. 253, 7–11]. Étienne is afraid to teach in career programs in part because of the unknown material [p. 296, 2–3] and refers to a time when he taught an application in economy, and, even though he had taken an economics class as a student, he did not understand the application that he taught [p. 281; p. 295, 22–28].

Therefore, we believe that novice teachers found gaps in their knowledge of mathematics as they became teacher. This is an indication that university programs in mathematics do not (always) put

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[65] Il y a des cours [de modélisation] qui sont seulement pour les futurs enseignants au secondaire, mais il y aurait pu avoir quelque chose pour les futurs enseignants de cégep. […] [Michèle] et [Albert] nomment des applications des mathématiques comme la reconnaissance faciale, les algorithmes de *Google* et la lecture de CD abimés. [Michèle] trouve que ce serait tellement enrichissant de pouvoir se le faire expliquer, car ils n'ont pas le temps de le rechercher en plus de tout ce qu'ils font. Soit il n'y a pas de cours de la sorte, soit ils ne sont pas accessibles.

[66] [Albert] dit qu'ils n'ont pas besoin de cours appliqués en pédagogie, juste de cours de mathématiques appliquées.

emphasis on the same (type of) mathematics than the cegep curriculum does, such as applications. In the next section, we address a new kind of mathematical knowledge novice teachers storied they encounter as they became cegep teachers.

5.1.3.2 A New Type of Mathematics

As we talked about mathematics with novice teachers, they shared with us experiences where they achieved new understanding of concepts they already knew. Michèle talked about attaching new meaning to concepts with which she was familiar prior to university [p. 273, 1–5]. Étienne talks of viewing logarithms in a new way as a result of his work in a mathematics course for students interested in postsecondary teaching [p. 298] and understanding basic cegep content for the first time when he revisited it as a teacher [p. 279, 1–3]. Albert talks about understanding statistics for the first time when he had to teach a statistics course [p. 225, 22–25]. Sam tells us that he had to learn linear algebra all over again [p. 309] and that he used his experience of re-learning linear algebra to inform his teaching of the material.

These stories suggest that novice teachers' new position as *teachers* brings them new ways of going about mathematics with which they are familiar. We wonder if this observation connects somehow to an idea commonly identified in the literature over the past decades—that there is a difference between mathematics and the mathematics of the teacher. Now that the teachers are looking at familiar mathematics with the goal of teaching it, they look for something different from what they looked for as students learning the same material for the first time. We can think of the distinction Shulman (1986) makes between content knowledge and pedagogical content knowledge, where pedagogical content knowledge "goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge *for teaching*" (p. 9). Alternatively, perhaps the novice teachers' more developed mathematical maturity and wider mathematical experience allow them to find interest in different aspects of the same concepts.

We conclude that novice cegep teachers' training in university mathematics provides them with a plethora of mathematical knowledge, deepens their mathematical knowledge, and pushes their limits. That said, there are concepts that are taught in cegep and which the novice teachers may not have come to be in contact with as students, even after completing a graduate degree in mathematics. Applications are one aspect of mathematics that was often brought up by our participants to exemplify mathematics they had to learn on the job. Finally, novice teachers speak of having to detach from certain cultural aspects of university mathematics as they become part of cegep institutions.

5.2 Emergent Threads, Plotlines, and Patterns about the Research Puzzle

In this second part, we explore other threads, plotlines, and patterns in relation to the process of becoming a cegep mathematics teacher that have emerged through composing the field texts, writing the stories (see Appendix D) and reflecting on the previous chapter. We will address tensions and bumping stories (Section 5.2.1), their unique journey to teaching (Section 5.2.2), novice teachers' inclination to strive towards quality teaching (Section 5.2.3), the connection between the process of becoming a teacher and being a university student in mathematics (Section 5.2.4), and a characterization of the valid behaviour in which novice cegep teachers engaged (Section 5.2.5).

5.2.1 Bumping Stories and Tensions: What Prevents Novice Teachers from Living Out Stories

"The contradiction here
is that while learning to teach is
individually experienced
and hence may be viewed as
individually determined,
in actuality
it is socially negotiated."
Deborah P. Britzman, 2003

As we attended to the experiences that shaped stories to live by of novice teachers in the previous chapter, we noticed that teachers do not always end up living out the stories they wish to in their classroom. Indeed, we noticed some tensions[67] that resulted from bumping between different stories, sometimes with their own stories, sometimes with the stories of others, and sometimes with stories that dominate in the institution or the culture surrounding them, which sometimes prevented them from living out stories they desired to live out. We considered these tensions as a result of the forces at play in the lives of novice teachers, forces that inevitably shape the stories

[67] We understand tensions as bumping between stories (see Section 2.2.4 for more details on tensions and bumping stories).

they live and tell, shaped their lives, and shape their process of becoming teachers. In this section, we explore different forces at play, sometimes of internal nature when it involves their own stories, sometimes of external nature when it involves stories of others or of their storied context, and how the bumping between stories shaped the stories teachers live and tell.

New aspects of the work of a teacher

Tensions may arise as novice teachers discover new aspects of the work of a teacher they had not expected. For example, Michèle told us about how easy it was to lose the perspective of the student [p. 264, 7] as she navigated trying to keep students' perspectives while accomplishing the work of the teacher. This story made us realize that Michèle had an imagined story of being a teacher where she could easily put herself in her students' shoes. She realized, however, how challenging it may be to live out this story while fulfilling her new role, which includes, for example, covering certain topics in a certain amount of time. She made us feel the tensions that may arise as she realized that her imagined stories could not be fully enacted.

Indeed, we are drawn to remember that Michèle was "becoming a teacher" in many ways in the years prior to her actually being at the front of a cegep classroom. Indeed, we argue that she was already "becoming" when she thought about being a teacher over the years, heard her relatives talk about their practice, and probably imagined herself teaching. And because this "becoming" was from the perspective she had as a student, it seems she created imagined stories of teaching that she now has trouble sustaining as a teacher. There is definitely a tension that appears as she realizes the demands of the profession, which she had never experienced before and which, most likely, were not a big part of the imagined story she constructed over the years. She is, metaphorically, on the other side of the glass now that she is the teacher. She has only imagined herself as a teacher from the point of view of a student and it turns out she could not see everything that being a teacher entailed; at the same time, she does not want to forget what it is to be a student. It has turned out difficult to continue living stories she created as a student as she is forced by her new roles and responsibilities to live out new stories. In cases like these, novice teachers (will) create new stories to live out because their imagined stories of being a teacher are not adequate to their reality.

Stories that turned out to be flawed

Tensions may appear as novice teachers' stories of students turn out to be flawed. A tension became apparent with Vera's imagined stories of students [p. 255, 1–5] when she realized that students were not as mature as she expected. We believe she created this story while she was a student at university. This tension came from a misrepresentation of the population in cegep and she had to adjust the kinds of stories she wanted to live out in her classroom. Indeed, she realized that students were not as inclined to tackle challenges as she expected.

Another example is Étienne who told us about hating certain behaviours of former teachers, such as their repeating of the same facts over and over [p. 292, 1–2]. He now realizes that he has to enact some of those behaviours [p. 292, 3–4]. This realization came from a new perspective on what it takes to reach out to students who are not as attentive as he was as a student and therefore need the repetition.

In cases like these where novice teachers' expectations were based on flawed stories, they change the stories they lived in order to live a story that supports their new experiences.

Contradicting stories

Tensions may occur when multiple stories that novice teachers want to live out bump with one another. For example, Étienne shares how he would want his students to experience a problem-solving course. However, he does not seem to be able to blend this goal with his idea of what cegep instruction is supposed to provide to students [p. 282, 1–35]. He seems to be constrained by his personal and restrictive vision of what cegep education should look like and at what it should aim.

Another example is when Sam talks about the fact that the mathematician in him does not care about applications but that the teacher in him wants to live a story in which he is confident about addressing applications in a way that is interesting [pp. 307–308]. This tension is reinforced by the fact that he has to cover applications as part of the cegep curriculum.

In these cases, both teachers picked only one story to live out, at least until they can find a way to find coherence between them.

Lack of experience, preparation, and time

Lack of experience seems to be an incredibly important force at play in the process of becoming of novice cegep teachers. Indeed, the lack of preparation to teach may cause tensions especially when novice teachers try to live out uncommon stories.

To live out innovative stories of education, stories different than the dominant[68] stories of mathematics teaching, one needs time to imagine the stories, lay them out, and then live them. Most novice cegep teachers have not lived within a space in which they were encouraged and given the time to look outside the box. Michèle [p. 265] describes the certificate she did as one such a space and she is the most innovative novice teacher in this study. Additionally, novice teachers have too much to figure out in the beginning. Most of what they do consist of new experiences. In that sense, trying to live stories outside of the norm may be unrealistic. As Michèle explained, it may take a while for solid opinions, justifications, and explanations to be formed and for a novice teacher to be ready to have a healthy conversation that challenges existing ways of doing [p. 270, 8–14]. In Sam's story, his reluctance to make decisive changes seems to come from the fact that he is not ready to do so.

The lack of time to be innovative comes up also, implicitly, in the story of Vera as she tells us about teaching more than ten different courses in three years [p. 253, 1]; and more explicitly in the story of Étienne who said on many occasions that he wants to make changes, such as changes to the lesson plans he was given, but has not found the time and space to make such changes yet [p. 283, 9–11; p. 294, 1–5].

Other teachers' stories

Tensions may occur as novice teachers' stories bump with other teachers' stories. Étienne spoke of wanting to spend time in his classroom on showing students interesting aspects of mathematics, something which his colleague, with whom he was working closely, did not want to do [p. 282,

[68] We talk about "dominant stories" to refer to the stories that are most lived or told in a certain context at a certain moment.

36–42; p. 283, 1–11]. Étienne did spend time on showing students interesting facts as he decided to live out the story he desired anyway.

Michèle [p. 269, 33–41; p. 270, 1–7] also spoke of bumping stories with colleagues' stories as she tried to implement new ways of assessing students, ways that contradicted the stories to which other teachers were accustomed. As much as she may want to change how assessments are traditionally done, she tells stories of being one voice against many. Some of those other voices were undoubtedly more experienced and more decisive. Michèle shares her struggles of affirming herself and how she becomes better at expressing herself with time [p. 270, 8–14]. Here, Michèle is up against a dominant story lived by her colleagues, and she cannot, in this particular case, do something differently because of departmental rules. In this sense, she cannot live out her desired story.

Regarding tensions with colleagues' stories, we were reminded of what Britzman (2003) said: "[t]he construction of the real, the necessary, and the imaginary are constantly shifting as student teachers set about to accentuate the identities of their teaching selves in contexts that are already overpopulated with the identities and discursive practices of others" (p. 221). Britzman is explaining that novice teachers do not become teachers by themselves; they are part of an institution in which other individuals had been becoming teachers and evolving for quite some time. Colleagues are often seen as an authority or power figure over novice teachers (Britzman, 2003, p. 223) and novice teachers' identity is often derived from the identity of their colleagues (Walshaw & Savell, 2001, p. 515). In this sense, it may take courage to voice diverging opinions, especially as novices among experienced colleagues who may have been enacting the same—sometimes dominant—stories for many years.

Dominant stories in the department, the institution, and mathematics teaching

We address here tensions as novice teachers' stories bump with dominant stories of the department, the institution, or mathematics teaching. It is not necessarily clear whether the stories reported below are the department's dominant story, the institution's dominant story, or mathematics teaching's dominant story. However, they are reported by the novice teachers as dominant ones and we infer on their origin from the stories they shared.

Tensions may occur as novice teachers' stories bump with dominant stories of the department. As a general rule, Étienne decided to follow the lead of his more experienced colleagues. This created some bumps between the stories he had to live out as a result and the stories he would have chosen otherwise. For example, Étienne would not have asked students to learn a list of formulas based on his own volition, but he does so anyway [p. 293, 16–21].

Tensions may also occur as novice teachers' stories bump with the stories of the institution. For instance, Étienne stories cegep students as being mature and independent; this bumps with the dominant story of the institution given the policy that limits the number of student absences to three. Étienne refuses to live out the dominant story in this case [p. 280, 7]. On another note, Albert wants to teach only "true" mathematics [p. 227, 1–12]. This bumps with the dominant story of his institution, in that textbooks cover material that Albert says is not true, as per his definition of "true" mathematics being the mathematics done in university.

Michèle decided, after obtaining her certificate in postsecondary teaching, to stop giving the average grade of assessments [p. 269, 28–32]. This is not usually done in mathematics education in cegep, according to her. Regardless of this, she decided not to give the average grade so as to motivate students to focus on themselves. This is a story that is fairly easy to live out. It does not involve other teachers but she may encounter resistance from her students as they may be accustomed to getting the average grade of assessments, a piece of information they may use to assess whether they did well on a given test.

In those cases, these novice teachers may or may not be able to live out the stories they want, depending on the institutional status that the stories causing the bump have. As we have argued in Section 4.4.2, there seems to be a hierarchy of stories to live by. For example, there are no official rules that prevent a teacher from giving a list of formulas. Therefore, Étienne could give the formulas, but he decides to follow another story, the one in which he decides to do what more experienced teachers are doing, or what seems to be the accepted practice in the department. This story to live by about trusting the more experienced teachers (or aligning to belong) seems to have more pull than his desire to give out the list of formulas. As for the institutional rule that prevents students from missing more than three classes, this is an official rule of Étienne's institution. However, he does not enforce it. We believe he does so in order to live out the story that students are mature (Section 4.4.2), a story that is at the root of his choice of profession. We believe that the story of students being mature has more pull on him than his story of following a rule of which he had never heard before. As for Albert's bumping stories, his identity was much defined by mathematics (see Section 4.1.5); therefore, it is not surprising that his inclination to teach only true mathematics would overcome the story that he should follow the textbook with precision.

Tensions may arise as novice teachers' stories bump with dominant stories of mathematics teaching. Sam contemplates changing ways in which teaching and assessing are done in these dominant stories, such as written in-class examinations with traditional problems to solve, for multiple reasons [pp. 313–314]. He justifies not making such changes on the basis that he does not want to disturb what students are used to in their mathematics education. Further, he turned out to be great at mathematics after being trained via existing methods, so it is possible his students will too.

We wondered what it would be like for a novice teacher to want to live stories that are fundamentally different from the dominant teaching approach to mathematics. We imagine that living out a different story would put novice teachers in a vulnerable situation. We believe this to be especially true in the case of Sam as he teaches night classes and has little contact with more experienced teachers. Living out stories that are fundamentally different from the dominant narrative may be a daunting task for any novice teacher as they navigate the day-to-day tasks of teachers and there is no set system in place to support innovative practices in the institution.

Mathematical culture in cegep

Tensions may occur as novice teachers enter the mathematical culture in cegep. Sam tells the story of how much university mathematics has changed his vision of mathematics and how his education before that did not represent mathematics properly [p. 302]. He wants to familiarize his students with abstract mathematics but they don't have the level to understand it. He therefore has to filter his mathematical self [p. 315, 13–14]. Étienne, for his part, has to be consciously aware of his impulse to engage in behaviours associated with the university mathematics culture (such as proving every result) because this is not what his students need nor want [p. 295].

Albert lived multiple tensions as he became a teacher [e.g. p. 221, 8–38]. His STLB about mathematics and teaching bumped against the stories he had to live in order to teach in cegep (see Section 4.1.5). The contradictions were quite significant in terms of his identity as a "mathematics person," and he had to make changes for his STLB to be viable with respect to his position as a cegep teacher. For example, a story he lived in university was that mathematics in cegep was not "real" mathematics but he developed a story that validated cegep mathematics.

In this case, the teachers decided to change their stories to fit into the culture of cegeps. This shows a commitment to participate in the cegep rather than to continue to live out stories that are the norm in university mathematics. It can be seen as a commitment to become cegep mathematics teachers.

In conclusion

To conclude, there are certainly many ways in which novice cegep teachers may experience tensions from bumping stories, be they stories of their own or of others, at the personal, departmental, institutional, and mathematical level. We became aware, in the previous chapter, of a hierarchy between stories that determines which stories are lived out when there are tensions. From the stories of the five postsecondary novice teachers, we learned that there seem to be forces at play that make it challenging for them to implement stories different from the dominant ones as they enter the profession.

There is no way for us to know at this point what the next few years will look like for each of the novice teachers as far as living out new stories, stories for which they are sometimes already aiming, already imagining. When we look at Albert's stories, the most experienced teacher of the five, we can reflect on how he is dealing with innovative practices. For example, as briefly mentioned in Chapter 4, Albert is involved in the transformation of programs and courses: he is working towards building material for flipped classrooms and active learning. It would be harder to foster such an interest for innovative practices and be involved in so many projects if, for example, he was still figuring out how to mark regular exams or how to assess the level of his students. In other words, Albert seems to be comfortable enough in practices that may be considered as the "basics" of teaching. He has determined how to assess the level of his students [p. 224], how to prepare for a lesson [p. 233], what notation to use [pp. 231–232], what his goals are, the mathematical maturity he wants to foster in his students [p. 225, 16–18], and what he aims for depending on the population to whom he is teaching [p. 230]. Perhaps Albert is comfortable enough in these "basics" because he already knows how to navigate institutional software, printing, implicit norms of the institution, and so on. Perhaps he is now part of the more experienced teachers, which allows him to do more of what he wants as his opinions or ideas are more valued. This is something we saw happening in the group meeting we conducted with Albert, Étienne, and Michèle (see Section 3.1.2 for details on this group meeting): we saw the three of them interact and saw that Albert was not necessarily the first to speak up but when he did, the others would listen quietly. These days, Albert has more time to put into reflecting about and creating new material. In light of Albert's stories, we believe it is possible for novice teachers to get settled into their profession after a few years and slowly live out different stories, as Albert did, for example, when he changed the notation he used [pp. 231–232]. Later on, they may be able to make other changes as they gain experience and freedom.

5.2.2 Their Journey to Teaching

In this section, we attend to the journey each novice teachers of this study took to get to the profession of mathematics cegep teacher. Our main assumption in the first chapter of this dissertation was that postsecondary teachers are trained mainly in mathematics, as mathematicians (see Section 1.1.1 for more on this). This study made us realize this assumption may not properly capture the reality of most cegep mathematics teachers. Indeed, the only education the novice teachers of this study all have in common is their elementary and secondary education. Otherwise, they came to their current profession with cegep diplomas in sciences or social science, and with a bachelor of science in mathematics or of arts with a major in mathematics. They come with a master's in mathematics or in mathematics education, with a certificate or a graduate program in teaching, with professional development experiences and some time in a doctoral program in mathematics. As Clandinin and Connelly (2000, p. 145) said, people can, indeed, hardly be reduced to categories. In the case of our study, in terms of school preparation, novice teachers can hardly be reduced to former mathematics students. There is so much nuance and details to add for each of them so as to understand their process of becoming teachers.

Something that may come to mind is that it does not matter how they got to being mathematics teachers, they all love mathematics and they all love to teach. It is interesting how this affirmation does not seem to be representative of the novice teachers of this study either. Mathematics was not Vera's first choice. Étienne and Michèle do not talk about their experience studying mathematics in a purely positive light, especially university mathematics. Sam talks about how he does not enjoy all parts of mathematics; he enjoys the pure but not the applied. Albert mentions that he came to teaching because he needed a job. This goes to show again how unique each journey and each teacher are—but also that some stereotypes we build around mathematics teachers maybe fundamentally flawed.

Given the strands of experiences shaping novice teachers' STLB we identified in the previous chapter—implicit training, explicit training, and university mathematics—there is much evidence that becoming a teacher does not start when one gets their first contract. There is more to becoming a teacher than explicit teaching training and mathematics training. This is an important point to keep in mind when we address questions of creating training for cegep teachers.

5.2.3 "Genuinely Wanting to Do a Good Job"

Postsecondary mathematics teachers are often portrayed as individuals who do not care about teaching, or about students, and are therefore painted as bad teachers. Teaching methods used in university mathematics education are cited as a significant reason why students choose to leave the discipline of mathematics (Martin, 2001; Seymour, 2000, both cited in Beisiegel, 2009). Kline (1977) also points out that the discipline itself is at stake: "The greatest threat to the life of mathematics is posed by the mathematicians themselves, and their most important weapon is their poor pedagogy" (p. 5).

The image that postsecondary teachers are bad teachers is found in many places. It is first found in the novice teachers' stories about their time in university. For example, Michèle talks about professors whose main interest is research and how this focus seems to have a negative impact on their teaching [p. 262, 21–22]. Vera shares a story of professors who ignored students' questions [p. 240].

This image can also be found in mathematicians' writing about their work as educators. For example, Hardy (1940) states that he loves to lecture but hates to teach (p. 48). Stewart (2006) encourages newcomers to focus on the traditional ways of teaching and avoid trying to go outside of the prescribed syllabus (p. 168). Krantz (2003) states that "[i]f the professor so chooses, s/he does not even have to entertain questions" (p. 48). Burton (1999) writes: "Of course with each new generation of teachers who have not encountered the excitement and frustration and whose learning has always been dependent on a didactic and transmission-based model, there is no alternative experience for them to draw on in their own practices" (p. 140).

We also see a similar picture in research papers. Keynes and Olsen (2001) report on university professors who are reluctant to adopt new methods of teaching without solid evidence that these promote learning in the areas they deem important (p. 113). Barton et al. (2014) mention the resistance from mathematics faculty towards education and pedagogy (p. 148). Selden (2005) describes mathematicians who blame the students' laziness for their difficulties in university mathematics and are unable to conceptualize why the material might be hard (p. 141).

These instances mentioned and many others, paint a negative picture of postsecondary mathematics teachers and teaching. However, the stories about the lives and experiences of novice teachers paint a different picture. For example, here is in extract of one account of my time with Sam, referred to in his stories [p. 318]: "Sam genuinely wants to do a good job. He gets paid the same amount and would still advance the same in his career even if he were mediocre as a teacher. In truth, what he does as a teacher is just about his own satisfaction […]." He tells us that he cares about enacting quality teaching and even though this may not advance him professionally, he truly puts in the efforts for himself. This is a feeling we get from the others as well. There is a sense that the five novice teachers alongside whom we lived, all care about being quality teachers and enact great practices adapted to their students. We expand below on ways in which this desire of novice teachers was expressed in the stories they told about themselves as teachers.

First, there are multiple stories in which novice teachers exhibited care for their students' experience in the classroom. Sam wants to make their attendance in class worthwhile and the class entertaining [p. 303, 26–29]. Michèle asks her students to evaluate her course, asked what schedule they preferred, and chose accordingly [p. 277, 7–13]. Étienne [pp. 289–290] talks about actively maintaining the point of view of the students in the hope of making the course what they need. He also gives his students some time to enjoy the mathematics by showing them concepts and ideas outside the curriculum [p. 282, 36–42; p. 283, 1–4]. Vera wants to make her classroom a place in which her students learn rather than watch mathematics being done [p. 246, 21–23]. Albert wants to maintain a great attitude in his classroom in order to keep a positive atmosphere and facilitate learning [p. 234, 2–10].

Many stories reveal care regarding students' learning and thinking. Sam reports on reflecting, both in university and as a master student, about students' thinking [pp. 310–311, p. 312]. Sam [pp. 310–311] and Michèle [p. 274] both report on being interested in students' difficulties and wanting to find creative ways to help them. Vera strives to use her experience of learning mathematics to help her students learn [p. 239]. Albert's goal is to prepare students for their future [p. 225, 9–10] and Étienne's role is to help them pass the course [p. 287, 1–2]. Albert feels a pull towards doing less lecturing and letting the students work and discover [p. 235, 18–22].

On a similar note, novice teachers told stories about changing their practices as they got to know their students better. For instance, Étienne started out having students write down their notes but realized they could not listen and understand while they were writing so he changed his material [p. 285, 1–6]. Albert changed the way he writes exams in order for students to be able to show what they can do [p. 229]. Vera learned to be aware of the choice of numbers in a problem so as not to confuse students [p. 248]. Sam addresses misconceptions that he identifies in his students [pp. 310–311]. Michèle adjusted the way she uses word problems as the context she used in some of those problems previously confused her students [p. 268, 4–14].

We also discern a desire to innovate and an interest in pedagogy. For example, Michèle is motivated to learn about and try new and innovative methods of teaching [p. 265; p. 268; pp. 269–270]. Albert is motivated to try new practices and pursue change [p. 235, 22–25]. Sam loves any opportunity to talk about pedagogy in department meetings [p. 301, 34–39], just as he did during his masters' program [p. 312, 18–24]. Étienne wishes to implement different ways of doing mathematics in cegep in the future [p. 283, 9–11] and is willing to try to implement games [p. 284].

Along the same line of thought, novice teachers shared stories of wanting to invest their criticisms towards past experiences as students into improving their own students' experience. These were stories of novice teachers wanting to provide experiences that are better than those they had as students. For instance, Vera is attentive to the mathematical knowledge students actually have; this is in contrast with the attitude of a professor she's had who refused to answer questions about mathematical knowledge he expected students to know [p. 240]. Michèle shows students where she is taking them and explicitly shows connections between concepts [p. 262, 13–17], elements she deemed missing in her own university education. She also shares what she learned about how to work in mathematics and how to go about problems [p. 273]. Sam gives his students insight about what mathematics really is [p. 302–303]; he feels his pre-university education had misled him about this. He also provides learning resources [p. 305], a tool he sometimes lacked as a student. Étienne uses a software to help students understand the material by visualizing it, as it seems he lacked opportunities to visualize in school [p. 279, 22–29]. Albert wants to make his classroom a pleasant environment as bad attitudes from a teacher has affected his learning in the past [p. 234].

Novice teachers also take up practices that are inspired by positive experiences they had had in classrooms. For example, Michèle talks about teaching in ways that are similar to those of her favourite analysis professor [p. 262, 7–9]. Étienne gives his students a detailed list of what he will cover in each lesson or week as one of his former chemistry teachers had done [p. 285, 11–14]. Vera uses a schedule and a list of suggested problems, a practice she got from her university experiences [p. 241, 2–5]. When Albert teaches, he keeps in mind a professor who taught with a lot of rigour and structure [p. 234, 12–17].

The few stories reported here show that the novice cegep teachers we met defy the stereotypes of postsecondary teachers as not interested in providing quality teaching. What comes out to us in this section is how much teachers care. They care about teaching and all that it entails. There is also a sense that they want to work towards improving, towards becoming not only teachers who care, but *better* teachers who care. They want to get better and to do better. Improving is part of their stories (Albert [p. 229; pp. 231–232] and Étienne's [p. 285] shifting practices, Vera [p. 250] and Sam's [p. 319, 9–13] stories of caution, and Michèle's story of improving her marking methods [p. 271]).

5.2.4 Being a University Student in Mathematics and the Process of Becoming a Cegep Teacher

As we attended to stories of novice teachers' time in university, we realized that it was not only the mathematics that played a role in their identity, as discussed in the previous section, but also their position as students in university. In Section 5.1.1.1, we address the implicit training novice teachers received as students at all levels. Here, we are interested specifically in how were their lives as novice teachers, and their process of becoming, shaped by their experiences as university students of mathematics.

When we look in the literature, we learn that the time university mathematics students spend in the classroom has them learn what teaching in postsecondary settings looks like. Beisiegel (2009, p. 263) describes the graduate students as looking "to their professors for how and who they should become." Indeed, we often see postsecondary teachers (including graduate-student instructors and teaching assistants) portrayed as enacting the same teaching they had received in university, performing mostly lecture-style teaching and demonstrating little interest in improving practices and attending to students' thinking and learning. As we have seen in Section 5.2.3, such behaviours are not representative of the stories shared with us by novice cegep teachers. We will consider various explanations for how graduate students replicate the teaching they receive in university and try to understand how these play out for cegep teachers.

Regarding the participants in Beiseigel's work (2009), she affirms that:

> the structures of the [graduate students'] programs, their teaching assistant work, and the suggestions that were put forth by the department either through direct communication or the lack of it seemed to point to a particular, sanctioned way of being and becoming a mathematician, a way of being which implied that teaching was unimportant and determined solely by what had been observed in other professors' classrooms." (p. 255)

They also learn that "their teaching must be free from who they are as people and that they must attend only to the mathematical content of the course." (Beisiegel, 2009, p. 55) In this sense, Beiseigel talks about forces at play in the lives of graduate students that indicate to them which behaviours to enact: not to spend time on teaching and to replicate what they experienced as students. This behaviour is requisite for being part of the community.

Beiseigel's words resonated with stories Albert told about his passage in university mathematics. Indeed, Albert says he "lost track of teaching" [69] while in university. From what he shared about his life in university, we wonder whether Albert could not live out stories of teaching while living out the stories of a talented mathematics student who was looking to reach profound understanding of the material he was taught [p. 236, 7]. Maybe finding interest in teaching was in contradiction with having interest in what mattered the most in the department: real mathematics, marked by creativity, invention, and revolution [p. 221, 14–18]. Maybe an interest in cegep teaching, in particular, meant being interested in lower-level mathematics, which was critiqued because it was in opposition to what "real" mathematicians were doing. The prevalent discourse in university was that such lower-level mathematics does not have any of the creativity that characterizes research in mathematics [pp. 221–222]. However, Albert did not continue to live out such stories as a teacher and we narrated those changes in Section 4.1.5.

From Albert's stories, we conclude that what Beiseigel describes of the experience of graduate students may also occur to cegep teachers. However, as seen in Section 5.2.3, novice teachers in this study do not enact a disinterest for teaching. We hypothesize that novice cegep teachers' ability to not replicate university teaching, despite having undertaken the same degrees through which mathematics graduate students go, may have to do with their teaching occurring in an institution that is not a university. Vera [p. 256], Sam [p. 317, 30–31], and Michèle [p. 250, 1–6] comment on the fact that cegep is a transitional institution, an institution that marks the transition from high school to university. This could be a reason why they approach teaching differently: the transitional nature of cegep suggests that they should not teach like university professors do. But how do they know how they should be and how they should become? We hypothesize that they use their stories of being students in cegep, stories they lived and relived over the years. We also believe they learn how to be through their interactions with colleagues, in their office, in the hallways, and in department meetings. Further, the absence of a research component in the profession of cegep teaching marks an important difference between the cases of graduate students and novice

[69] Déjà au primaire, au secondaire et au cégep, il savait déjà que l'enseignement l'intéressait, mais à l'université, il a comme perdu de vue l'enseignement.

teachers; indeed, graduate students are told that teaching is not worth their time and should not get in the way of their research (Beisiegel, 2009, p. 287).

Deshler, Hauk, and Speer (2015) explain graduate students' inclination to replicate the teaching they receive in university on the basis of their comfort, ability to thrive, and success in the existing setting:

> Like most mathematicians, novice college[-level] mathematics instructors' experiences as learners typically include a history of success in undergraduate mathematics, a notable absence of precalculus courses taken as an undergraduate, and great familiarity with lecture-based mathematics classes. So, not surprisingly, mathematics TAs report the greatest comfort with lecture teaching and find some of the greatest challenges in working with students whose backgrounds or experiences are unlike their own […]. Yet, throughout graduate school and over a career, instructors most often teach students whose expertise and experience with mathematics is quite distinct from their own. (p. 639)

A "history of success in undergraduate mathematics" is not necessarily what we observed in the stories of the novice teachers in this study. Instead, we encountered stories of struggle. For Sam [p. 302, 7–10], Michèle [p. 260, 8–12], and Étienne [p. 291, 8–15], their entry into university as undergraduate students marked the first time they struggled in school. They had an easy time in cegep, but they see their experience in university as a good way to relate to their struggling cegep students. Their struggle in university may have been an opportunity for them to reflect on what they need from a teacher—and this is a reflection they can now use to influence their teaching. For example, Michèle shares with her students the tricks she developed to solve problems successfully, which she developed on her own but feels her professor could have shared with her [p. 273, 7–10]. Albert, for his part, seems to have had a great experience in university mathematics classrooms as a student; his experience therefore aligns with the quote above. He avoided replicating the culture of university in cegep for reasons we explore elsewhere (Section 4.1.5).

Also, the quote above from Deshler, Hauk, and Speer (2015) specifies a difference between the backgrounds of graduate students and those of the students they teach in their positions as TAs. We do not believe this to be a problem for cegep teachers because they are aware that the role of the cegep pre-university programs is to train future university students. There are, however, challenges in training students in career programs, as we have seen in Vera's [p. 253], Étienne's [p. 296], and Albert's [p. 230, 11–20] stories.

Deshler, Hauk, and Speer (2015) also comment that "a good TA development program produces instructors who can learn from their own practice and who know to seek collegial support" (p. 642). It is interesting that the novice teachers in this study are already enacting those two behaviours, as we have seen in Section 5.2.3 and in how they reach out for help from colleagues (as discussed in the section on the explicit training the novice teachers experienced as teachers).

As we attended to cegep teachers' behaviour in their process of becoming, we were intrigued about what these behaviours tell us about the process of becoming a cegep teacher of mathematics. As we lay the behaviours of cegep teachers alongside the behaviours of graduate students in the work of Beisiegel (2009), we noted significant differences which led us to wonder about the *valid* behaviour cegep teachers engage in as part of their process of becoming mathematics teachers. We develop this idea in the next section.

5.2.5 Valid Behaviour in Becoming a Mathematics Cegep Teacher

As we wondered about the behaviour of novice cegep teachers of mathematics in their process of becoming, we came to identify what may constitute *valid* behaviour for them. We realized, on the basis of the work we had done to understand the lives of novice cegep teachers, that engaging in reflection and improvement of teaching, while in-service, may be part of the valid behaviour. Indeed, because of the overarching interest in teaching that comes through significantly in the stories of novice teachers, putting serious work into learning to teach and into all that being a teacher entails while in-service seem to be part of the valid behaviour. In other words, a diligent behaviour towards figuring out how to be a teacher is what brings novice teachers to become part of the profession. We develop these ideas in this section.

First, the official requirements to become a cegep teacher, having a disciplinary bachelor's degree (CSÉ, 1997, p. 57), validates the behaviour of learning to teach in-service—as opposed to pre-service. Indeed, the educational requirements to becoming a cegep teacher suggest that all there is to know before starting to teach can be found in university degrees in mathematics. In other words, at the outset of the novice teachers' interest in teaching in cegep, there is an assumption that individuals are ready to engage with the teaching of mathematics in cegep straight out of university, and, more specifically, right after completing a mathematics degree. This does not only imply that a bachelor's degree in mathematics is sufficient, but also that it is the only prerequisite to start teaching in cegep; other necessary training comes through the actual experience of teaching in cegep.

Novice teachers also encounter an implicit message that suggests becoming a cegep teacher happens without any formal structure of training or mentoring, which again validates the behaviour of learning to teach in-service. One way this message is being disseminated is that while some institutions offer some form of training, these programs are not mandatory and none of our participants suggested they were particularly recommended or emphasized. For example, professional development seminars in Albert's institution were not mandatory [e.g. Albert, p. 235]. Michèle [[70]] reports on a mentoring program given in the first institution at which she taught, but we did not hear of a similar initiative in the institutions in which the participants of this study worked at the time of our meetings.

In saying that the valid behaviour of cegep teachers is to learn to teach in-service, we are not arguing that teachers "make themselves" (Britzman, 2003, p. 230). On the contrary, they are supported by a community that is willing to help and whose members have likely learned in the same way. We did not hear stories of colleagues who were unwilling to help the novice teachers navigate the system, the curriculum, the institution, the classroom, or the students. In the lives of the novice teachers we encountered, help from colleagues is widely implemented, albeit not part of an official structure.

The availability and willingness of experienced colleagues to help their less experienced counterparts also validate the behaviour of learning to teach in-service. Indeed, it suggests that it is normal for novice teachers not to know everything and to accept invitations to learn from and rely on experienced teachers. For example, material is shared with newcomers [Étienne, p. 294; Vera, p. 253; Albert, p. 233] and fellow teachers and administrators seem available to answer

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[70] Personnellement, [Michèle] n'a jamais eu de problème avec les évaluations. Ils étaient assez stricts [au premier cégep où elle a enseigné]. Ils venaient les observer en classe. Il y avait des enseignants-observateurs, accompagnateurs. Chaque nouvel enseignant était suivi par trois enseignants.

questions [Vera, p. 247; Sam, p. 301; Michèle, p. 271]. We, however, know that not all departments treat their new teachers the same; for instance, we recall a story of Albert about other departments that do not support their teachers by sharing documents [[71]].

We hypothesize that in such environments where colleagues are available and willing to help, the novice teachers in our study learned that they are not expected to know everything there is to know about being a cegep teacher but that they have in themselves what it takes to figure it out. We get the sense that they know they have a lot to learn and that that's par for the process of becoming a cegep teacher. The valid behaviour is therefore to work on becoming a teacher over time, which is validated by colleagues encouraging novice teachers to become one of them. Novice teachers tell many stories aimed towards the future, stories that indicate that they are moving along in the process of becoming a teacher.

We have seen stories of process that happened over time as novice teachers have narrated experiences where they figure out how and who to be as a teacher. Some examples are Michèle's story about marking [p. 271] and Albert's story about finding the level at which his students were [p. 224]. These stories of the process of becoming tell a story of novice teachers trying new approaches over time as they figure out what works best; for instance, Michèle's stories of experimenting and figuring out what works [p. 265; p. 267], Vera's story of figuring out how to conduct weekly assessments [p. 246], and Étienne's story of finding ways to personalize others' lesson plans [p. 294, 1–5]. The teachers tell stories in which they are intentional about learning and getting inspiration from their colleagues and have to adjust those practices to themselves over time. This observation runs counter to Renard's (2003) affirmation that "the things that come with time" are what novice in-service teachers at secondary or pre-secondary level "find the most problematic" (p. 63). This assertion does not seem to reflect the struggles of novice cegep teachers.

Indeed, as mentioned before, novice cegep teachers do not seem to story struggles as a roadblock, but as a stepping stone in the process of learning to teach. For example, Michèle mentioned feeling frustration in response to the close-mindedness of her colleagues towards changing assessment

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[71] Et ça, ce n'est pas pareil dans tous les départements. Dans les [séminaires de développement professionnel], il a parlé à d'autres enseignants, comme des gens en administration par exemple, et il y a des domaines où c'est plus compétitif : « arrange-toi avec tes plans de cours ».

methods. She concluded that she would collect more information and hopefully convince her colleagues another time [p. 270, 5–7]. Étienne spoke of a tension he felt when thinking about implementing the problem-solving course but is hopeful to implement it when he has more experience [p. 283, 9–11]. We get a sense that they feel they have a lot to learn and accept that going at it one step at a time is valid; experimenting and figuring out teaching is the way to go and mistakes and struggles are part of the process. This idea is supported by the words of every novice teacher who talked about trial and error in teaching as a normal part of the process of becoming a teacher [Michèle, p. 276; Vera, p. 251; Sam, p. 317; Albert, p. 224]. These last observations suggest that the behaviours of working towards learning to teach in-service are also validated by the novice teachers themselves.

The novice teachers' take on their stories of struggles as a stepping stone in their process of learning to teach contrasts with the negative take typically described in studies of the first teaching experiences of novice teachers in pre-secondary or secondary school. For example, Orland-Barak and Maskit (2011) use the words "hostile" and "adverse" to describe the characteristics of teaching that novice teachers discover in these two levels. Pillen, Beijaard, and den Brok (2013) report that the tensions experienced by novice teachers in these two levels are mostly negative (p. 256). Renard (2003) talks about "horror stories" (p. 62) that occur in the first few years of teaching in secondary school. It seems as if the pressure on novice cegep teachers is lesser than the pressure on novice teachers at pre-secondary and secondary levels. Maybe because cegep teachers do not have training to become teachers per se, there are fewer expectations and therefore less pressure to perform. This may be why the first few years of novice cegep teachers were not narrated to us in as negative a light as that depicted in the research we read about novice teachers at the pre-secondary and secondary levels. Cegep teachers are not expected, by themselves nor by their colleagues or the institution, to know how to be a teacher. It is expected that they have never been teachers and do not know all there is to becoming a teacher.

On the downside, the valid behaviour we identified in novice cegep teachers suggests that they should somehow know *what* they need to work on or know for what to reach out for help. For example, Sam's story of being hired as a teacher in continuing education, a position for which he is not assigned office space nor required to attend department meetings, tells us a lot about the expectations put upon him. He should be able to figure out, on his own, the resources he needs or the areas in which he needs guidance [p. 301] since he needs to get out of his way to meet with other teachers. Because novice teachers mostly have to reach out for the help they may need, a situation such as Sam's, may hinder their inclination to do so.

Another example is the multiple stories novice teachers shared about receiving lesson plans, class notes, or exams from other teachers. However, they still need to know how to enact those lessons plans or class notes and administer and grade those exams. The fact that support is need-based and ask-based deprives newcomers of the insight of experienced teachers about what they think a beginner may need to know. Such insight comes from their own experience of becoming a teacher or from seeing other beginners going through the process.

In conclusion, an aspect of the valid behaviour novice teachers engage in[72] is that they are ready, after their training in mathematics, to become teachers. And from our reflection above, it is on the shoulders of the novice teachers to figure out what becoming a cegep teacher means, what needs to be learned, what they know, and what they don't know. One could think that these are high expectations to put on beginners. We reflect on this idea in the next section.

5.2.5.1 How Do They Deal with the Expectation to Learn as They Go?

"Although much pedagogical knowledge
has been characterized as common sense,
knowledge is not hanging, ripe and fully formed,
in the classroom,
waiting to be plucked by inexperienced teachers."
Pamela L. Grossman, 1989

We wonder how novice cegep teachers deal with the expectation that they are fully equipped to engage into the teaching profession, and therefore ready to enact the valid behaviour described in the previous section, after having studied mathematics in university. One could argue that such expectations may feel heavy to newcomers, as Grossman's quote at the top of this section suggests;

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[72] We cannot reflect on the idea of valid behaviour novice teachers engages in without thinking about the ideas of legitimate behaviour and community of practice (Lave & Wenger, 1991). Since our research is focused on the individual process of becoming a teacher, it did not allow us to rightfully reflect on the ideas of community of practice. Indeed, the common aspects of mathematics teaching in cegep were mostly hidden in the stories we were told. While our focus on individuals did not allow us to engage into Lave and Wenger's theory (1991), our results do suggest that it could be relevant to consider cegep mathematics teaching, and the process of becoming a teacher, through Lave and Wenger's lens.

as novice teachers enter the profession, how to be and what to do as a teacher may not seem to be up for grabs. That said, we do not get a sense that the expectations weigh heavily on the novice teachers we met.

In a discussion I had with both Michèle and Albert (see Section 3.2), they spoke about the absence of applications of mathematics in their training in university mathematics. They argued that it would be useful to know more about mathematical applications because they are teachers [[73]]. I asked whether they thought future cegep teachers should have their own university program, much like elementary and high school teachers have their own. They both replied in the negative. Both Michèle and Albert suggest that it is their job as cegep teachers to bring mathematics and teaching together [[74]]. In another discussion, Albert said that his training in mathematics was adequate because it was his decision to apply mathematics to teaching and that his mathematical maturity that allowed him to do so [p. 225, 6–8]. They believe it should be on them to do the work of drawing upon their time in university to figure out how to be a teacher of mathematics in cegep.

In the third meeting I had with each of the participants, I asked whether the profession was as they expected it to be and if there was something they wished they had known before starting to teach in cegep (see Appendix C, session 3, question 3). Overall, when I asked whether the profession was what they expected, they all said that for the most part, it was. In their stories, we can piece together elements they did not know about the profession; nevertheless, none of the novice teachers mentioned they wished they received more training in teaching or more guidance on how to perform their work. This shows, yet again, that they are comfortable with the responsibility of figuring out how to be a cegep teacher under the current conditions.

Still we wonder about the root of the expectation that the learning of how to be cegep teachers of mathematics will occur in-service. Indeed, those interested in teaching mathematics in cegep are told that after they complete a bachelor's in mathematics, they will be ready to start teaching in

[73] [Michèle] et [Albert] nomment des applications des mathématiques comme la reconnaissance faciale, les algorithmes de *Google* et la lecture de CD abimés. [Michèle] trouve que ce serait tellement enrichissant de pouvoir se le faire expliquer, car ils n'ont pas le temps de le rechercher en plus de tout ce qu'ils font. Soit il n'y a pas de cours de la sorte, soit ils ne sont pas accessibles.
[74] Il n'y a pas de programme pour [les futurs enseignants de mathématiques au cégep] alors ils font des maths, puis peut-être un peu de pédagogie, et ensuite, c'est à eux de mettre ça ensemble.

cegep and take part in the profession. We wonder what exactly makes them ready to become cegep teachers at that stage of their lives. Is it the training in advanced mathematics from their bachelor's degree? Is it the amount of time they spent in classrooms with postsecondary teachers of mathematics? Is it the extensive amount of time they spent learning mathematics in classrooms since kindergarten? Is it a question of maturity? We do not know.

Chapter 6: Conclusion

“Final research texts do not have final answers
because narrative inquirers do not come up with questions.
These texts are intended to engage audiences
to rethink and reimagine
the ways in which they practice
and the ways in which they relate to others.”
D. Jean Clandinin, 2013

“The knowledge developed from narrative inquiries
is textured by particularity and incompleteness—
knowledge that leads less to generalizations and certainties […]
and more toward wondering about and imagining alternative possibilities […]”
D. Jean Clandinin, 2013

The present research has allowed us to get to know five novice cegep teachers of mathematics. In the two years I spent with them and their stories, I have sought “to make sense of life as lived.” (Clandinin & Connelly, 2000, p. 78). In this conclusion, we look back on our journey up to writing this dissertation. We go over the main steps of the study, what we learned as well as the limitations of the study. We continue by addressing training for mathematics cegep teachers and conclude with thoughts on our choice of doing a narrative inquiry [NI].

6.1 Main Steps of this Study

The overarching goal of this study was to explore the process of becoming a teacher of mathematics in cegep, our research puzzle. Chapter 1 first situated our research puzzle in the history of the cegep institution, which led us to attend to the training provided for cegep teachers, as well as the available training for postsecondary teachers, elementary teachers, and high school teachers. We concluded that there is still much to learn about the experiences of novice postsecondary teachers in order to effectively think about training. This led us to want to engage into an exploratory empirical study on the process of becoming a cegep mathematics teacher. We then looked into research on becoming a teacher. It gave us a better idea of how other researchers, especially at elementary and high school level, address this process.

Our theoretical vision, developed in Chapter 2, is based on Dewey’s theory of learning from experience. We understand novice teachers’ learning as happening through a myriad of (educative) experiences they lived in all aspects of their lives. Dewey's work also allows us to talk about novice teachers' encounter with unfamiliar and challenging experiences. We then develop a conceptual framework constituted by the work of Clandinin, Connelly, and their team. We hold a vision of experience as happening narratively and this influenced our decision to study novice teachers' experience narratively. We think of people's lives happening according to temporality, interactions, and place. Tensions and (changing) stories to live by became key for us to attend to novice teachers' lives. We conclude the chapter by defining our object of study, the experiences of novice teachers in relation to mathematics, teaching, and learning.

As mentioned above, we chose to study novice teachers experiences in relation to mathematics, teaching, and learning in the process of becoming teachers. We chose to do that narratively using Narrative Inquiry [NI] and we explain how we went about this in Chapter 3. I met with five novice teachers, with between 1 and 5 years of experience teaching mathematics in cegep. The meetings were individual (except for one, see Section 3.1.1) and we met 7 times over a semester. Those meetings took place in the fall 2017 and winter 2018 and were about mathematics, teaching, and learning (Appendix C). We created an account for each meeting, these accounts became the field texts of this study.

From the beginning of this work, we were committed to follow experience and see where it led us. And as we attended to the field texts, keeping in mind our interest in the process of becoming a teacher, we were led to focus on how the participants were storying the ways past experiences played an active role in their day-to-day activities as teachers. This topic became what we aimed at bringing understanding to in the hope of bringing light to our research puzzle.

Following this decision, we added into Chapter 1 a new section in which we attended to the literature on past experiences that play a role in the process becoming a teacher, a section we added after completing our time in the field. While existing literature recognized that one's experiences as students, teachers, and outside of school play a role in the process of becoming a teacher, we concluded that a more fine-grained information on the experiences that turned out to be significant in the process of becoming in the case of individuals, and on how these experiences are significant, is missing and would be key in a well-informed reflection on appropriate training for cegep mathematics teachers. We then created the following goals:

(Goal 1) to reflect on the nature of the experiences that shape (justify, modify, or affirm) novice cegep teachers' stories to live by in relation to mathematics, teaching, and learning; and

(Goal 2) to explore the ways in which teachers' stories to live by are shaped (justified, modified, or affirmed).

From that point on, we created stories (in a booklet of stories, Appendix D) around stories to live by being shaped, from the fields texts we had composed following the meetings with participants. In Chapter 4, we analyzed those stories according to our goals. In Chapter 5, we reflected on what attending to our goals allowed us to understand about our research puzzle, the process of becoming a mathematics teacher in cegep. In that chapter, we also addressed other threads, plotlines, and patterns that emerged from the booklet of stories and the field texts about our research puzzle. These two chapters feature the main results of this dissertation, which we describe in the next section.

6.2 Impact of the Study

I began this dissertation by writing my narrative beginnings—how I came to this study on a personal level. My personal stories led me to ask the following question: how do cegep teachers walk through those first few years as a teacher? And from this question alone we developed this whole dissertation around the research puzzle of understanding how one becomes a mathematics cegep teacher. In this section, we look at the understanding we were able to develop through this study.

First, the analysis conducted in Chapter 4 underlined an important aspect of the process of becoming, in that it happens amid a multitude of experiences that shape(d) the identity of each individual that becomes a teacher. We chose to attend to these experiences according to three main strands: implicit training, explicit training, and university mathematics. These three strands became lenses through which we could emphasize different experiences that play a role in the process of becoming a teacher. In that sense, the strands do not label experiences as *steps* in the process of becoming, but rather as ways of seeing and reflecting on those experiences.

Also, the analysis we conducted showed that each teacher's stories to live by were shaped by experiences of different natures. Simply the difference in length of the sections describing experiences with respect to the three strands (implicit and explicit training and their relation to university mathematics) suggests the significance of those experiences in shaping the novice teachers' STLB. Furthermore, looking at these common strands across all 5 teachers, we saw the variety in the nature of the experiences. For example, when it comes to experiences as students, novice teachers sometimes reflected on their ways of (or strategies in) learning and sometimes they reflected on the teaching they received. Also, experiences that could a priori easily be seen as *the same*, such as a bachelor's in mathematics or starting to teach in cegep, were not storied in the same way and did not shape the teachers' stories to live by in the same way. Teacher training and professional development of novice mathematics teachers could be designed to take into account the ways in which novice teachers story their experiences and the lives they live (and imagine and want to live) in relation to teaching, learning and mathematics.

Our study also brings to light the tensions that novice mathematics cegep teachers experience as their stories bump with each other and with other stories (colleagues' stories and institutional stories). Through the stories the participants shared with us and our analyses of such stories, we were able to see and reflect on the tensions that impact the stories novice teachers end up telling and living in the midst of becoming teachers. The conceptualization of becoming as a process starting before teachers have their first contract and continuing over at least their first years of teaching, allowed us to identify tensions between the imagined stories about teaching, learning, and mathematics that teachers had developed over the years prior to beginning to teach and the stories they are living in their first years of teaching. From our theoretical stance and the literature, tensions play a key role in shaping teachers' STLB. Understanding the tensions at stake in becoming a teacher and how novice teachers go about resolving or living alongside those tensions can be a meaningful tool for reflecting about and designing teacher training programs and professional development.

An overarching theme in the reflections of Chapter 5 is how the stories of becoming that we heard from our participants were different from what we read in the literature about novice teachers at other levels. Indeed, we saw how novice cegep teachers do not, as opposed to graduate students teaching in university, repeat the same teaching style that is prevalent in university, how the first few years of teaching in cegep were different than the ones in elementary or high school, and the valid behaviour novice cegep teachers engage in is much different from the reported behaviour of novice teachers at elementary, high school, and university levels. These reflections help highlight important differences between cegep institutions and other educational institutions, at least in relation to its teachers and the teaching that happens between its walls. Our analysis suggests that these differences need to be taken into account when reflecting on teachers' education and professional development.

6.3 Limitations

In this section, we address the limitations of this inquiry. First of all, we are aware many factors that may impact the lives and entry into the profession of novice cegep mathematics teachers were not represented in this study. Indeed, two of the participants were teaching in one institution and three in another. And their accounts about the institutions' cultures and what we know anecdotally from our own experiences suggest that some aspects of cegeps' cultures that seem to impact novice teachers STLB are essentially different from one institution to another. In that sense, we do not know of the experiences of novice teachers beginning their practice in other institutions and how each specific institutional culture may impact their lives. In the same line of thought, all the participants had been students in cegep themselves and earned a cegep degree. As we have seen in the stories collected for this dissertation, past experiences as cegep students often came up as playing a role in shaping novice teachers' STLB. However, there's a population of cegep mathematics teachers that are from out of province (and out of the country). In this sense, we could not discuss the lives of cegep teachers for whom cegep institutions were something new.

There are two particular characteristics of our participants that we wish to highlight here as we suspect they are not representative of the majority of novice cegep teachers. First, four out of the five participants had found relatively stable jobs within their first or second year of teaching. Only one of them has taught in multiple institutions and expressed serious struggles in finding work. Second, all five participants had engaged in one way or another in formal training in teaching—via a master's degree, a certificate, or professional development seminars. We are not confident that this is representative of the population of (novice) cegep mathematics teachers. We suspect these two distinctive characteristics are the result of how we recruited participants. On the one hand, and as is explained in Chapter 3 (Section 3.2), we reached out to find participants through contacts in the institutions who would distribute the recruitment email for us. Teachers who struggle to find work, work in multiple institutions or learn if they will work at the last minute are harder to reach through institutional emails; their address may not have been active or they may check them with less frequency if they were not teaching at the time of recruitment. Furthermore, even if our recruitment message reached them, they might not have felt comfortable accepting to participate as they likely did not know if (when, where, and what) they would be teaching at the moment the study would have taken place.

On the other hand, teachers who had experiences in didactic or pedagogy training may be drawn to a study in mathematics education which they may see as an opportunity to further reflect on issues that are already a concern to them. Teachers who had no such experiences may not see anything in participating for them or may fear being inadequate or exposing themselves to be judged.

6.4 Training for Mathematics Cegep Teachers

"Although many wonders shaped my research puzzle,
I did not begin the inquiry with the goal of finding
single answers to particular questions.
Rather, questions opened spaces
for rethinking and reimagining possibilities."
Lynne Driedger-Enns, 2014

In this section, we explore what this doctoral study has enlightened for us in regards to the training for mathematics cegep teachers. We started this dissertation by reflecting on the preparation of mathematics cegep teachers and we reflect here on what our inquiry, as well as the time spent with novice cegep teachers, has taught us on the matter of training to teach mathematics in cegep. We will address these matters according to the questions of when could the training take place (Section 6.4.1) and what could the training entail (Section 6.4.2).

6.4.1 When Could the Training Take Place?

From what we learned of the experiences of novice teachers, we get a sense that novice teachers would benefit from training in-service at the beginning of their career, rather than (or in addition to) pre-service training. Indeed, Michèle tells us how it was useful to do the certificate *while* she was teaching. She told us of the multiple ways in which it changed her day-to-day life in the classroom and how she was being attentive to every information she could get because she could apply it right away in her teaching and see changes rapidly. Albert also tells us that his professional development seminars had an impact on him. We contrast this to Étienne's experiences doing the certificate before he started to teach and how scarcely such experiences came up in his stories of teaching. The three of them went through different programs (see Section 3.2.1) but have in common that the training they received was not meant specifically for teaching mathematics.

Both Sam and Vera went through a program specifically aimed for postsecondary teachers of mathematics as well as for preparing researchers in mathematics education. In both cases, the experiences in the program come up in their stories of teaching. Both of them refer to putting themselves in the position of a teacher while interacting with other students of the program and/or taking university mathematics classes. From this, we get a sense that it is not only the moment when the training is dispensed that is important but the stance the future or novice teacher takes as they are going through it. If the novice or future teacher struggles to take a teaching stance while in the training program, they may struggle to see how and why what is being addressed is relevant and imagine how they will apply it in their teaching. Training that happens in-service would likely make it easier to take a teacher's stance. We can contrast these ideas with Étienne's experience in a pre-service certificate that had an internship component. The internship experience does not seem to have been sufficient for him to take a teacher's stance while in the program; furthermore, the internship seems to have resulted in "negative" stories he tells himself about not being able to teach certain cegep courses (see Section 4.4.2).

The stories around assessment reinforce this idea that in-service training may be (more) beneficial (than pre-service). The participants told us stories about looking at and using exams and assessment written by other teachers. However, they still feel the need to experiment for themselves what a "good" assessment looks like. In-service training could allow them to put in place different assessment strategies while having a space to discuss them and get feedback thus enriching their reflections about them.

Another aspect of the stories reinforces to us the claim that in-service training at the beginning of the teachers' careers would be highly useful. For instance, we found that Albert's stories of teaching were a lot more decisive. Indeed, he is set in his practices in a way that the others are not. We see that as the other four novice teachers wonder about, question, and discuss alternatives to their practices. This, and the literature (e.g. Harrington & Sacks, 1984), support that the first few years of teaching are crucial in the formation of a teaching identity, including teaching practices, and that later on, teachers start to get set in their ways. Then, their identity will most likely change a lot less drastically and frequently.

In other words, we have heard stories of novice teachers, in their first few years of teaching, being open to change, eager to learn, and to get better. However, these stories also showed that novice teachers of mathematics in cegep do not always have the tools to do that. Offering in-service training, structured mentoring, and support during those first years may help make the most of their beginnings; of their eagerness to be better, their openness to change, and the elasticity and adjustability of their teaching identities.

6.4.2 What Could the Training Entail?

In this subsection, we explore different types of training, as well as possible content, for mathematics cegep teachers. We base our exploration on the stories we heard and the readings we did.

We believe the stories we have created could be used in some training opportunities for cegep teachers. We were inspired by Desgagnés' (2005) "récits de pratiques," where the teacher shares tensions they encountered and those narratives are then used in initial training for pre-service teachers. Desgagnés sustains that sharing the tensions is as much a training opportunity for the teachers who are doing the sharing as for the teachers reading and reflecting on the narrated experiences.

On another note, Sam and Michèle talked about a space to confirm or infirm intuition, a place to share, that benefitted them in their respective explicit training experiences. This reminded us of He and Cooper (2011) who observed that "focus groups appeared to allow [novice secondary teachers] to create their own professional learning community, where they gained strength and support from each other" (p. 112). This idea of learning community also resonates with Dewey's (1916, p. 7) idea that "the very process of living together educates. […] A man really living alone (alone mentally as well as physically) would have little or no occasion to reflect upon his past experience to extract its net meaning." Such meetings between groups of novice teachers, which could take many forms in size and length, would also attend to the need for the creation of common elements of socialization. This creation was mentioned as mandatory for the future of the profession by the Conseil Supérieur de l'Éducation [CSÉ] (1997, p. 57; see section 1.1.2).

The CSÉ also tells us that if bachelor programs placed greater emphasis on communication and the ability to take an epistemological view of their discipline, it would better meet the needs of all graduates, in particular if they subsequently opt for teaching (CSÉ, 2000, p. 56). Participants mention how starting to teach has made them see mathematical concepts differently, which could be supported or triggered in explicit teacher training opportunities.

Finally, almost all novice teachers expressed that they lacked awareness about the administrative side of being a cegep teacher, the array of courses they have to teach (knowing *of* the courses, knowing *about* the courses, and knowing the *content* of the courses) and about mathematical applications. We believe this gives us clear pointers on what could be addressed in teacher training.

6.5 What Narrative Inquiry Has Allowed Us to Do?

Choosing narrative inquiry [NI] impacted this study tremendously. This is not a perspective that is often used in mathematics education and we address in this section what this choice brought to our study.

Because of our choice of using NI, we decided to follow experience and see where it would lead us. We chose a research puzzle, the process of becoming a cegep mathematics teacher, and aimed to follow the experiences of novice teachers in relation to mathematics, teaching, and learning. We entered the field with an open mind in order to let the teachers tell us about themselves as they become teachers. And as we listened to novice teachers talk to us about their experiences related to mathematics, teaching, and learning, we realized that much of the stories they tell about themselves as teachers revolved around stories to live by being shaped by past experiences. In other words, these narrations of stories to live by being shaped came up often in how teachers spoke of their lives as teachers, and of whom, and how, they are and are becoming. We believe we would not have known how prevalent this discourse is in the stories they tell if we had not let them talk about mathematics, teaching, and learning with an open mind—which our choice of NI approach compelled us to do.

NI has also kept us focused on considering the novice teachers' whole lives. It has allowed us to see how novice teachers' whole lives, from their family life to their involvement in sports, from their time in the classroom as students to their time as teachers, all played a role in shaping the stories novice teachers now live and tell about their profession. Our study allowed us to see how varied novice teachers' lives are and that restricting our understanding of their lives, as well as of their identities as teachers, to their university degrees in mathematics is immensely diminishing of what comes into play in the actual process of becoming a teacher.

"There's a lot of beauty in ordinary things. Isn't that kind of the point?"
-Pam Beesley Halpert
The Office, "Finale," 2013

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APPENDIX A: RECRUITMENT MATERIAL

Dear (name of the colleague or acquaintance),

Hope this email finds you well. I am currently a Doctoral student at Concordia University working under the supervision of Claudia Corriveau and Nadia Hardy. My project is called: From Mathematics Students to cegep Teachers: A journey under study.

I am writing to you to solicit your help to reach out to potential participants. I would like to solicit the participation of new cegep mathematics teachers that have approximately between zero and six semesters of experience. Attached to this email, you can find a letter explaining the project and what participation would entail. I would really appreciate if you could transfer that letter to anyone you know who might fit the criteria I mentioned above.

My sincere thanks for your help,

Sarah Mathieu-Soucy

Cher/Chère (nom du collègue ou de la connaissance),

Je suis étudiante au doctorat à l'Université Concordia, sous la supervision de Claudia Corriveau et de Nadia Hardy. Mon projet s'intitule: From Mathematics Students to cegep Teachers: A journey under study.

Je vous écris pour solliciter votre aide pour rejoindre d'éventuels participants à mon étude. Je voudrais solliciter la participation de nouveaux enseignants de mathématiques du cégep qui ont approximativement entre zéro et six semestres d'expérience. Vous trouverez ci-joint une lettre expliquant le projet et en quoi consiste la participation. J'apprécierais vraiment que vous puissiez transférer cette lettre à toute personne que vous connaissez qui pourrait répondre aux critères que j'ai mentionnés ci-dessus.

Mes sincères remerciements pour votre aide,

Sarah Mathieu-Soucy

Letter that will be handed to potential participants

Title: The experience of new cegep mathematics teachers - Invitation to participate in a study

Dear Sir or Madam,

My name is Sarah Mathieu-Soucy and I am PhD student at Concordia University.

Since you are a new mathematics teacher in a cegep institution, I send this email to request your participation in a study about the experience of new teachers of mathematics in cegep. Your participation in the study would include about 15 short weekly meetings, lasting between 30 minutes to an hour, which would take place during (the given semester). Those meetings are in the form of a discussion and therefore do not require that you put extra time outside of these meetings.

Your participation to this study would be on a voluntary basis and under no circumstances you would need to discuss your involvement in this study with anyone.

I remain available to provide further information, by email or by phone. Our conversations will not be disclosed outside the research team.

Thank you for your attention.

Best regards,

Sarah Mathieu-Soucy

Titre : L'expérience des nouveaux enseignants de mathématiques au collégial - Invitation à p6articiper à une étude

Madame, Monsieur,

Je m'appelle Sarah Mathieu-Soucy et je suis étudiante au Doctorat à l'Université Concordia.

Puisque vous êtes un nouvel enseignant de mathématique au collégial, je vous envoie ce courriel pour solliciter votre participation à une étude concernant l'expérience des nouveaux enseignants de mathématiques au collégial. Votre participation à l'étude comprendrait environ 15 courtes rencontres hebdomadaires, d'une durée de 30 minutes à une heure, qui aurait lieu pendant (la session concernée). Ce sont des rencontres sous forme de discussion et ne sollicitent donc pas de temps de votre part hors de ces rencontres.

Votre participation à cette étude serait sur base volontaire et en aucun cas vous avez à discuter de votre décision de participer avec qui que ce soit.

Je reste disponible pour fournir tout renseignement complémentaire, par courriel ou par téléphone. Nos conversations ne seront divulguées en aucun cas hors de l'équipe de recherche.

Je vous remercie de votre attention.

Sincères salutations,

Sarah Mathieu-Soucy

APPENDIX B: CONSENT FORMS

UNIVERSITÉ Concordia UNIVERSITY

INFORMATION AND CONSENT FORM

Study Title: From mathematics students to cegep teachers: a journey under study
Researcher: Sarah Mathieu-Soucy
Researcher's Contact Information: sarah.msoucy@gmail.com/514-222-0827
Faculty Supervisor: Nadia Hardy/ Claudia Corriveau
Faculty Supervisor's Contact Information: nadia.hardy@concordia.ca/ claudia.corriveau@fse.ulaval.ca

You are being invited to participate in the research study mentioned above. This form provides information about what participating would mean. Please read it carefully before deciding if you want to participate or not. If there is anything you do not understand, or if you want more information, please ask the researcher.

A. PURPOSE

The purpose of this doctoral research is to learn more about the process of becoming a mathematics teacher a cegep level. Our interest lies in the teachers' relationship with mathematics and mathematics education. Our goal is to hear about significant experiences in order to understand the changes in the relationship under study over time and to know more about what caused those changes.

B. PROCEDURES

If you participate, you will be asked to participate in 7 interviews, one hour long at the most. At those occasions, we will ask you to share one or more event that you found significant. Those interviews will be audio-recorded and will take place at a time that is convenient to you outside work hours, in your workplace.

In total, participating in this study will take at most 8 hours of your time over the 15 weeks of the semester.

C. RISKS AND BENEFITS

There is no foreseeable risk associated with your participation. You will be interviewed in your workplace about your work. You are free to share what you feel comfortable sharing and no pressure will ever be put on you to share anything else. By being asked to reflect on your practice, you might become more aware of your own ways of doing, assess your practice and make changes if you feel it is necessary. You might also benefit from continuing your career with a more reflexive mind that could help in evolving in the profession.

D. CONFIDENTIALITY

We will gather the following information as part of this research: audio-recording of each interview, notes from the interviewer and any other document that the participant will feel useful to convey their experiences.

We will not allow anyone to access the information, except people directly involved in conducting the research. We will only use the information for the purposes of the research described in this form. The information gathered will be identifiable. That means it will have your name directly on it when in the hands of the research team. However, it will not be possible to make a connection with you in any publication. We will protect the information by keeping it in a locker, in the main supervisor's office. The audio-recording of the interviews will be kept on a hard drive dedicated to this project, protected by a password. We intend to publish the results of the research. However, it will not be possible to identify you in the published results. We will destroy the information five years after the end of the study.

E. CONDITIONS OF PARTICIPATION

You do not have to participate in this research. It is purely your decision. If you do participate, you can stop at any time. You can also ask that the information you provided not be used, and your choice will be respected. If you decide that you don't want us to use your information, you must tell the researcher before June 1st 2018.

There are no negative consequences for not participating, stopping in the middle, or asking us not to use your information. We will inform you of any new information which may affect your willingness to continue your participation in the study.

F. PARTICIPANT'S DECLARATION

I have read and understood this form. I have had the chance to ask questions and any questions have been answered. I agree to participate in this research under the conditions described.

NAME (please print) ____

SIGNATURE ______________________________

DATE ______________________________

If you have questions about the scientific or scholarly aspects of this research, please contact the researcher. Their contact information is on page 1. You may also contact their faculty supervisor.

If you have concerns about ethical issues in this research, please contact the Manager, Research Ethics, Concordia University, 514.848.2424 ex. 7481 or oor.ethics@concordia.ca.

CONSENTEMENT ÉCLAIRÉ À LA PARTICIPATION À UNE ÉTUDE

Remarque : Le masculin est utilisé pour faciliter la lecture.

Titre de l'étude : D'étudiants en mathématiques à enseignant au collégial : étude d'une transition
Chercheur : Sarah Mathieu-Soucy
Coordonnées du chercheur : sarah.msoucy@gmail.com/ 514-222-0827
Professeur-superviseur : Nadia Hardy/ Claudia Corriveau
Coordonnées du professeur-superviseur : nadia.hardy@concordia.ca/ claudia.corriveau@fse.ulaval.ca

Nous vous invitons à prendre part au projet de recherche susmentionné. Le présent document vous renseigne sur les conditions de participation à l'étude; veuillez le lire attentivement. Au besoin, n'hésitez pas à communiquer avec le chercheur pour obtenir des précisions.

A. BUT DE LA RECHERCHE

Cette étude doctorale a pour but d'en apprendre davantage sur le processus de devenir enseignant de mathématiques au niveau collégial. Notre intérêt réside dans la relation des enseignants avec les mathématiques et l'enseignement des mathématiques. Notre objectif est de recueillir des expériences significatives de la vie des enseignants afin de mieux comprendre les changements dans la relation étudiée sur une période de temps et aussi d'inférer sur la cause de ces changements.

B. PROCÉDURES DE RECHERCHE

Si vous participez à l'étude, vous devrez participer à 7 entrevues d'une longueur maximale d'une (1) heure. Nous vous demanderons à ces occasions de partager un ou plusieurs évènements que vous aurez trouvés significatifs. Ces entrevues seront enregistrées de manière audio et se tiendront à un moment qui vous est opportun hors des heures de travail, à votre lieu de travail.

Somme toute, votre participation s'étendra sur 15 semaines.

C. RISQUES ET AVANTAGES

Il n'y a pas de risque prévisible associé à votre participation. Vous serez interviewé dans votre lieu de travail, au sujet de votre travail. Vous êtes libre de partager que ce que vous êtes à l'aise de partager et aucune pression ne sera mise sur vous pour partager quoi que ce soit d'autre. En étant invités à réfléchir sur votre pratique, vous pourriez devenir plus conscient de vos propres façons de faire, d'évaluer votre pratique et apporter des modifications si vous le jugez nécessaire. Dans la poursuite de votre carrière, vous pouvez également bénéficier d'un esprit plus réflexif qui pourrait aider à évoluer dans la profession.

D. CONFIDENTIALITÉ

Dans le cadre de cette étude, nous recueillerons les renseignements suivants : l'enregistrement audio des entrevues, des notes prises par le chercheur durant ces entrevues ainsi que tout autre document que le participant jugerait adéquat pour bien véhiculer ses expériences.

Aux fins de surveillance de l'étude, des organismes de règlementation pourraient examiner l'information recueillie. À titre de participant, vous acceptez de leur donner accès à l'information.

Excepté les situations précisées ci-haut, seules les personnes qui mènent cette recherche auront accès aux renseignements fournis. Nous n'utiliserons l'information qu'aux fins de l'étude décrite dans ce document. Les informations recueillies seront identifiables. Cela signifie qu'il y aura votre nom directement sur les documents lorsque ceux-ci seront dans les mains de l'équipe de recherche. Cependant, on ne pourra pas vous identifier dans une publication qui a l'intention de publier les résultats de cette étude. Nous détruirons les données cinq ans après la fin de l'étude.

Nous protègerons l'information fournie en conservant la documentation papier dans un casier dans le bureau de la superviseure principale. Les bandes sonores seront conservées sur un disque dur utilisé seulement à cette fin, protégée par un mot de passe.

E. CONDITIONS DE PARTICIPATION

Vous pouvez refuser de participer à la recherche ou vous en retirer à n'importe quel moment. Vous pouvez aussi demander que l'information que vous avez fournie ne soit pas utilisée ; le cas échéant, votre choix sera respecté. Si vous prenez une décision en ce sens, vous devrez en avertir le chercheur avant 1er juin 2018. Nous vous informerons de tout nouvel élément d'information susceptible d'affecter votre volonté à poursuivre votre participation à l'étude. Vous ne subirez aucune conséquence négative si vous décidez de ne pas participer à l'étude, d'interrompre votre participation à celle-ci ou de nous demander de ne pas utiliser votre information.

F. CONSENTEMENT DU PARTICIPANT

Je reconnais par la présente avoir lu et compris le présent document. J'ai eu l'occasion de poser des questions et d'obtenir des réponses. Je consens à participer à l'étude dans les conditions décrites ci-dessus.

NOM (en majuscules) ____

SIGNATURE ____

DATE ____

Si vous avez des questions sur l'aspect scientifique ou savant de cette étude, communiquez avec le chercheur. Vous trouverez ses cordonnées sur la première page. Vous pouvez aussi communiquer avec son professeur-superviseur.

Pour toute préoccupation d'ordre éthique relative à ce projet de recherche, veuillez communiquer avec le responsable de l'éthique de la recherche de l'Université Concordia au 514-848-2424, poste 7481, ou à oor.ethics@concordia.ca.

APPENDIX C: INTERVIEW PROTOCOLS

Introduction

- Introduce myself, my education and research experience.
- Interest in their experience as a new teacher.
- Specifically related to the relationship to mathematics, teaching and learning
- Interest in their experiences, anecdotes, stories, opinions and impressions, not what they believe to be universal or a norm.
- I want to know about the experiences that are meaningful to them.
- Each session will be a little different, plan 7 meetings, every other week.
- Read and sign consent form.
- Ask about their education (factually).
- Announce the purpose of the first meeting: mathematics and them

Session 1 – Mathematics and them

1. As a cegep teacher, do you have the impression that the mathematics you are doing are different than what you were doing as a student? Or is the way of doing it different?
    a. If yes, what is different? Can you give me an example of what you were doing and what you are doing now?
        i. Do you also see resemblance, in the mathematics or in the way you are doing it?
    b. If no, what does it mean for you to do mathematics? What are mathematics for you? What is mathematics about? Did you ever ask yourself that question? In what context? (ask to everyone)
2. Tell me about your story with mathematics. When\how did it start? (Clandinin, 2013)
3. Do you have criteria for interesting mathematics/mathematical problems? (Burton, 2004)
    a. Have they always been the same?
4. Tell me about significant events in your history with mathematics.
5. What do you like the most in mathematics? (Burton, 2004)
    a. Are there things you don’t like in mathematics?
    b. Has it changed over time?
    c. What do you like the most or the least doing with your student in mathematics?
6. Can you recall a specific event which changed your perception of mathematics?
7. Can you identify any influence in your journey in mathematics? (person, family, event, topic, problem, article) (Burton, 2004)
8. Do you think mathematics is hard or easy, complicated or simple?
9. What do you think your student will remember or learn about what is mathematics or what it means to do mathematics during your time together?

Session 2 – Mathematics and their students

1. What idea about what is mathematics and what it means to do mathematics do your students have when they get into your class?
    a. Do you think it changes during your course?
2. Your students have been doing mathematics for a very long time. What are the differences between their mathematical experiences in high school and cegep? Especially in your class?

    a. What similarities in their mathematical experiences?
    b. Are their experiences similar to those you have experienced?
    c. What are the differences or similarities in your mathematical experiences when you moved from high school, to cegep, to university, and then back to cegep as a teacher?
3. Sometimes you give students a problem and you can see that they find it interesting. What makes a problem interesting for your students?
    a. Do you think the criteria change over time?
    b. Do you think the students agree with you on what problem is interesting?
4. (In relation to their own answer) In general, we see in classes students who like and do not like mathematics. Those who love mathematics, what makes them like mathematics? Those who do not like mathematics, what makes them not like mathematics?
    a. Are there things that students who do not like mathematics appreciate?
    b. Are there things that students who like mathematics do not appreciate?
5. (In relation to their own answer) In general, one sees in classes students who find the mathematics difficult and others easy.
    a. For those who find it difficult, what do they find difficult? What makes it difficult?
        i. Do these students still find some things easy?
    b. For those who find it easy, what do they find easy? What makes it easy?
        i. Do these students still find some things easy?
    c. What is the relationship between difficulties and interest in mathematics?
6. Have you ever heard of this idea that someone might be "built" or not for mathematics? Or the idea of the "math gene"? What do you think of these ideas? (Burton, 2004)
7. Questions that came up from last week

Session 3 - Teaching and being a teacher

1. Can you tell me about how you started as a cegep teacher: hiring process, arrival in institution(s), expectations of the administration, expectations of other teachers and students, reception of new teachers, etc.
2. You've been in the profession for a number of years, is it what you expected?
3. Is there anything you would have liked to know about being a cegep mathematics teacher before you got started?
    a. What aspects would you like to learn more about in the near future?
4. Has your opinion/idea of the profession of mathematics teacher in cegep changed since you started teaching here?
5. Tell me about your teaching experiences outside of cegep (tutoring, TA, etc.)
    a. Do you feel like it helped you?
    b. What is special about teaching at cegep? How is it different from your other teaching experiences?
6. You have done a lot of mathematics classes in your life, tell me what the best teachers did; what the least good teachers were doing.
    a. What do you think of the teaching you received in mathematics?
    b. Have you always enjoyed the same type of teaching throughout your studies?
7. If you were to describe the three main characteristics of who you are as a teacher, what would you tell me?

   a. How do you show these traits in your teaching?
   b. What aspects have changed since you started teaching? What aspects remained the same?
   c. What prompted you to teach this way?
   d. Do you always teach in the same way, in all classes, for all groups? What makes you change?
8. In your opinion, what are your roles as teacher of mathematics in cegep in the classroom?
   a. Have you always assigned that role to yourself?
9. Questions that came up from last week

If context-related response: the place/role of contexts in teaching, how they use it to teach.
If answer in relation to the management of class: how the management changes the way to do or to present the mathematics.

Session 4 - Teaching Others

1. What do you think the purpose of cegep mathematics courses should be?
2. In your opinion, are the contents taught in cegep adequate for that purpose?
   a. If so, why and how?
   b. If not, what is missing? What should be taken out?
   c. Could there be other mathematics to achieve this goal? Anything other than mathematics?
3. What should students be able to do in mathematics when leaving cegep?
   a. What are they actually able to do?
   b. What is the connection between the mathematics taught, what students are capable of doing in terms of mathematics and what they should be able to do?
   c. If so, where does this difference come from? What happened?
4. I would like us to look at the course material you brought.
   a. How do you prepare your classes? What do you use? How?
   b. What does a typical course look like?
   c. What does each element bring?
   d. How would you describe your style or teaching approach?
5. Which mathematics do you most like to teach? Like the least? Why?
   a. Is it related to your own learning of the concept or to your teaching experiences?
6. I would like you to tell me about the way you assess your students.
   a. How do you make decisions in relation to assessment? What do you take off points for? Personal reasons, experience, administrative constraints?
   b. What are you assessing precisely?
   c. Is it a challenge for you to create assessments? Why?
   d. How do you know that a question is adequate?
   e. Have you ever regretted giving a test or a question? For what reasons?
   f. How do you prepare your students for your assessments?
7. Does what you do as a teacher have an impact on your students?
   a. On their vision of mathematics? On their success in mathematics?
   b. What kind of impact would you like to have?
   c. Do you see this impact or traces of it? Examples.
   d. Are there things you do not think you can influence or change?
8. Questions that came up from last week

Session 5 – Personal Learning

1. What were your difficulties in mathematics? Or what did you find difficult in mathematics?
    a. How did you overcome them?
2. When you were a student, how were you able to say that you understood something in mathematics?
    a. What made you confident in your understanding?
    b. Has it always been like this?
    c. How did/do you learn?
3. What made you good at mathematics?
    a. Did/do you think you were a good mathematics student?
    b. How did you approach your difficulties in mathematics?
4. Would you say that you have been adequately prepared for post-secondary mathematics?
5. During your mathematics training, did you find ways to improve in mathematics?
6. In your education in mathematics, what helps you today?
    a. What are you missing, or has a negative effect on your teaching? What would you have liked to know?
7. Questions that came up from last week

Session 6 - Learning of others

1. How can you say that your students have understood something in mathematics?
    a. Do you think students have tools to know if they understand?
    b. What needs to be done for students to learn?
    c. What needs to be done for students to understand?
2. Do you have good students?
    a. How would you describe a good mathematics student?
    b. Do you see yourselves in what you described?
3. What are the difficulties of students in mathematics?
    a. Do you think students are aware of their own difficulties in mathematics?
    b. Do they have tools to understand their difficulties?
    c. How can students overcome their difficulties?
    d. What is their responsibility in relation to their own difficulties?
4. As a teacher, how do you detect students' difficulties?
    a. What responsibility do you have as a teacher as far as the students' difficulties?
    b. How do you know that a question is at the level of the students?
5. What are students adequately prepared to do mathematics in your class? What are they not prepared properly to do?
    a. [In relation to their answer] How can a student improve in mathematics?
    b. Have you ever observed this kind of behavior?
    c. What would be the ideal situation in terms of what students would know when they arrived in your class? What is happening in reality?
6. What do you think about how students are assessed in mathematics in your institution?
    a. What flexibility do you have on the way you assess students? (Institutional or cultural constraints)
    b. How do you prepare your students for assessments?
    c. In an ideal world, how would you assess your students?

   d. Are there differences with what you actually do in class?
   e. For you, are assessments part of the learning opportunities in class? If so, what do they learn?
7. Questions that came up from last week

Session 7 - Mentor

Questions to Ask Participants About Preparations

- **Scenario**: You are a mentor for a new mathematics teacher in your institution. They ask you to take a look at their preparation for the course where they will present the concepts of limit and continuity. They want your opinion.
  [Present the first 2 situations separately (present the first one, discuss, then present the other, discuss, compare, then compare), conclude with the 3rd preparation].
  - Does it look like what you do? If there are differences, which ones?
  - Do you think this is an appropriate approach for cegep students? (Why?)
  - Would you change things? (What? Why?)
  - What do you think of the choices made there? In the way the whole thing is presented? What do you think of the selected definitions, selected theorems and selected examples?

Questions to Conclude Our Time Together

- What did you think about or what problems did you have the first time you gave differential calculus? What is the biggest challenge when you teach differential calculus?
- What is the challenge for students?
- What is the biggest challenge in becoming a mathematics teacher in cegep?
- If the previous answer is not relevant to mathematics, ask: when you started teaching, what was the biggest challenge specifically related to teaching mathematics? Is it still the same?
- Is there anything important in your life as a novice mathematics teacher in cegep that we have not discussed together at all over our time together?

<u>CLASS PREPARATION #1</u>

Continuity

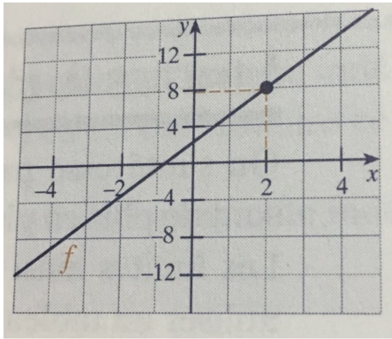
<u>Intuition</u>: a function $f(x)$ is continuous at point a, if $f(x)$ approaches f(a) when x approaches a.

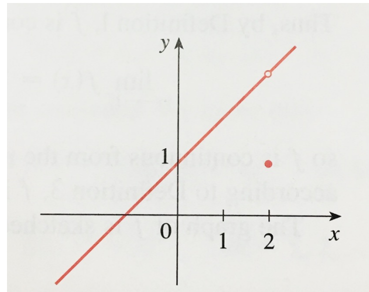
In other words, a continuous function f has the property that a small change in x (the abscissas) produces only a small change in $f(x)$ (the image). In this sense, if f is continuous at $x = a$, the difference between $f(x)$ and $f(a)$ is small when x is close to a.

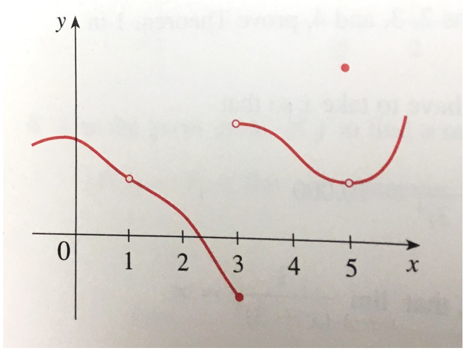
<u>Geometric Intuition</u>: We can think of a continuous function in a certain interval as a function so the graph has no break, or a graph that can be drawn with a single stroke of a pencil, without raising the pencil off of the page.

Geometrically, this also means that the points $(x, f(x))$ of the graph of f converge to the point $(a, f(a))$ when x is close to a. This ensures that the graph is not interrupted in $(a, f(a))$ by a jump or a hole.

Examples to address in class (1):

1. 

2. 

3. 

Examples to address in class (2): All polynomials have a continuous graph (induction proof too complex) but we can intuitively see it as there is no hole in the domain.

Limit

<u>Definition (3)</u>:

Let *f* be a function. If a function $\tilde{f}$ exists such as

a) $\tilde{f}(x) = f(x)\ if\ x \neq b$

b) $\tilde{f}(x)$ is continuous in *b*

then the function *f* has the limit $\tilde{f}(b)$ in *b*, and we write $\lim\limits_{x\to b} f(x) = \tilde{f}(b)$

Note: we read $\lim\limits_{x\to b} f(x) = \tilde{f}(b)$ as "the limit of $f(x)$ as *x* approaches *b* is $\tilde{f}(b)$"

Example to do in class in detail (4): Let $f(x) = \frac{x^3-2x^2}{x-2}$ and $x \neq 2$. Find $\lim\limits_{x\to 2} f(x)$.

Important items of the resolution:

- *f* is not continuous x=2
- $\tilde{f}(b) = \begin{cases} \frac{x^3-2x^2}{x-2} = x^2 & \text{if } \ \mathrm{x} \neq 2 \\ 2^2 = 4 & \text{if } \ x = 2 \end{cases}$, function is continuous in *x*=2

- *Question to address in class (5)*: If *f* is continuous in *b*, does $\lim\limits_{x\to b} f(x)$ necessarily exists?

<u>Theorem (6)</u>:

If *f* is continuous in *b*, then $\lim_{x \to b} f(x)$ exists and $\lim_{x \to b} f(x) = f(b)$

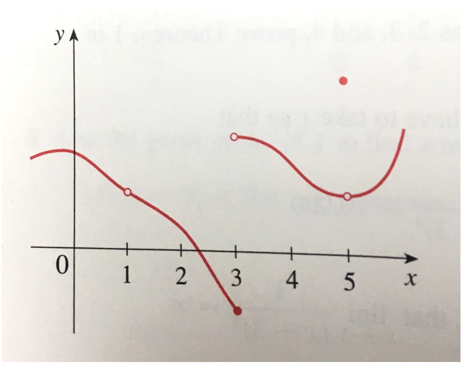
Example to do in class in detail (7): Find $\lim_{x \to 4} f(x)$ where $f(x) = x^2 + x - 6$.

Important items of the resolution:
• *Since polynomials are continuous functions, and f (4) = 14,* $\lim_{x \to 4} f(x) = 14$

• *Question to be raised in class (8): Does the limit necessarily exist if the function is not continuous at the point we are interested in?*

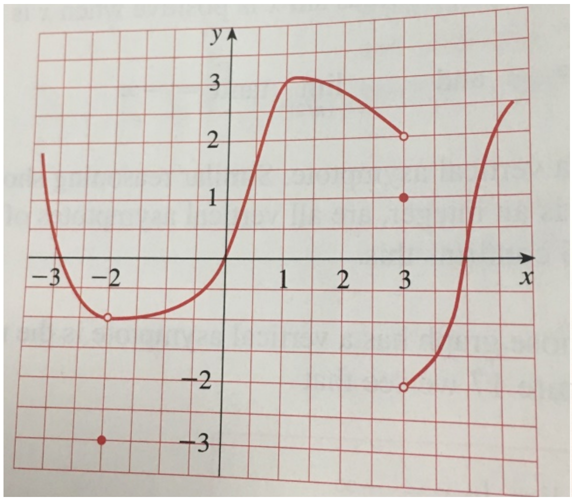
Definition (9):
Right-hand limit: We write $\lim_{x \to c^+} f(x) = L$ if we can make the value of $f(x)$ as close to *L* as we want by choosing *x* sufficiently close to *c*, immediately to the right of *c*.
Left-hand limit: We write $\lim_{x \to c^-} f(x) = L$ if we can make the value of $f(x)$ as close to *L* as we want by choosing *x* sufficiently close to *c*, immediately to the left of *c*.
We write $\lim_{x \to c} f(x) = L$ if and only if $\lim_{x \to c^+} f(x)$ and $\lim_{x \to c^-} f(x)$ are both equal to L.

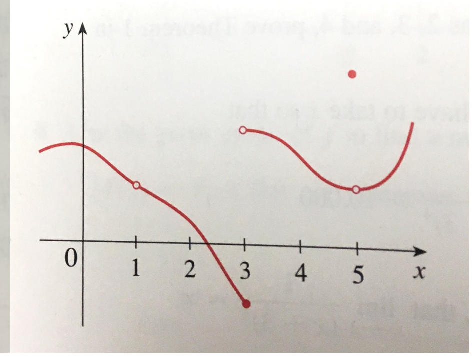
Remark (10): Thus, the limit does not necessarily exist if the function is discontinuous at the point of interest. For example, the function at *x* = 3 is not continuous. The limit on the left is not the same as the limit on the right, so the limit does not exist. The scenario is different in *x* = 5 or the function is not continuous, but the limit exists as the limits on the left and right are the same.

4. 

Exercises to do in class (11): Determine the following limits per respect to the graphs represented below:

a. $\lim_{x \to -2} f(x)$
b. $\lim_{x \to 1} f(x)$
c. $\lim_{x \to 3^-} f(x)$
d. $\lim_{x \to 5^+} g(x)$
e. $\lim_{x \to 1} g(x)$
f. $\lim_{x \to 3} g(x)$





f(x) *g*(x)

Next class: we will address the notions of infinite limits, limits to infinity. We will study the properties of limits and the indeterminate forms.

CLASS PREPARATION #2

Let's start with an example: $f(x) = \frac{(2x+3)(x-1)}{(x-1)}$.

This function exists for all values of *x*, except for *x*=1. Therefore, if *x*≠1, we can say that $f(x) = \frac{(2x+3)(x-1)}{(x-1)} = \frac{(2x+3)\cancel{(x-1)}}{\cancel{(x-1)}} = (2x+3)$ when *x*≠1.

It would still be interesting to know what is happening around *x*=1, when *x* is close to 1, but not equal to 1. First, let's look at the values for *x,* taking values between 0 and 1, then values between 1 and 2. In other words, *x* approaches 1, through values that are larger or smaller than 1.

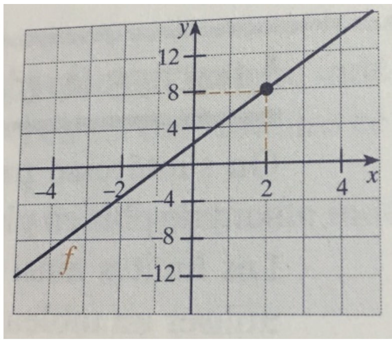
x	0	0.25	0.5	0.75	0.9	0.99	0.999	0.9999	0.99999
$f(x) = 2x + 3$ $(x \neq 1)$	3	3.5	4	4.5	4.8	4.98	4.998	4.9998	4.99998

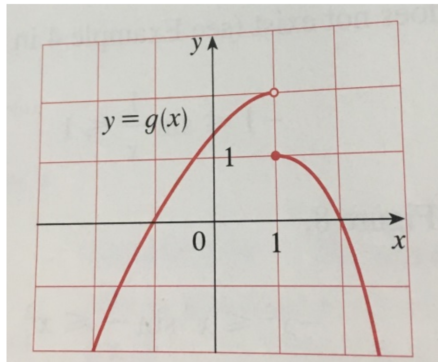
x	2	1.75	1.5	1.25	1.1	1.01	1.001	1.0001	1.00001
$f(x) = 2x + 3$ $(x \neq 1)$	7	6.5	6.0	5.5	5.2	5.02	5.002	5.0002	5.00002

We notice that we seem to be able to find a value of *f*(*x*) as close as we want it to 5. In other words, the difference between *f*(*x*) and 5 can be as small as we want by putting the difference between *x* and 1 as small as you want.

In this case, we will say that the limit of $f(x)$ when x tends to 1 is 5. More generally, when we are interested in any point c, we will say that the limit of $f(x)$ when x tends towards c is L, we will write: $\lim_{x \to c} f(x) = L$

For example (12):

5. 

6. 

On the second example: we realize that there are two ways to get to x=1, which does not give the same value of g(x) ...

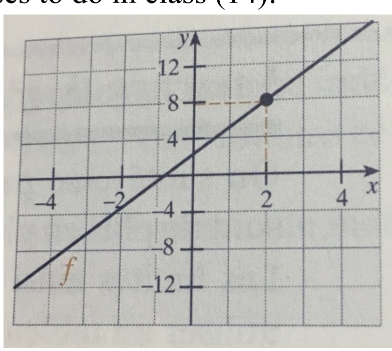
Definition (13):

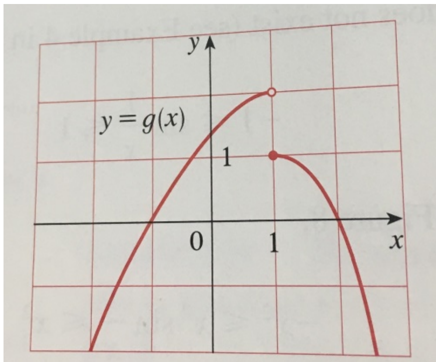
Right-hand limit: We write $\lim_{x \to c^+} f(x) = L$ if we can make the value of $f(x)$ as close as L as we want by choosing x sufficiently close to c, immediately to the right of c.

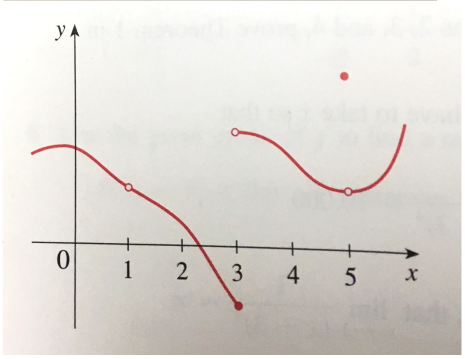
Left-hand limit: We write $\lim_{x \to c^-} f(x) = L$ if we can make the value of $f(x)$ as close as L as we want by choosing x sufficiently close to c, immediately to the left of c.

We write $\lim_{x \to c} f(x) = L$ if and only if $\lim_{x \to c^+} f(x)$ and $\lim_{x \to c^-} f(x)$ are both equal to L.

Exercises to do in class (14):

7. 

8. 

9. 

Question: In the last example, we can notice that the two limits are equal for x = 1 and x = 5 ... but there is a hole! What to do?

> *Note (15): It is not essential that the point which interests us belongs to the domain of the function nor that the image of this point is equal to the limit. The functions that have the property that* $\lim_{x\to b} f(x) = f(b)$ *is continuous in x=b.*

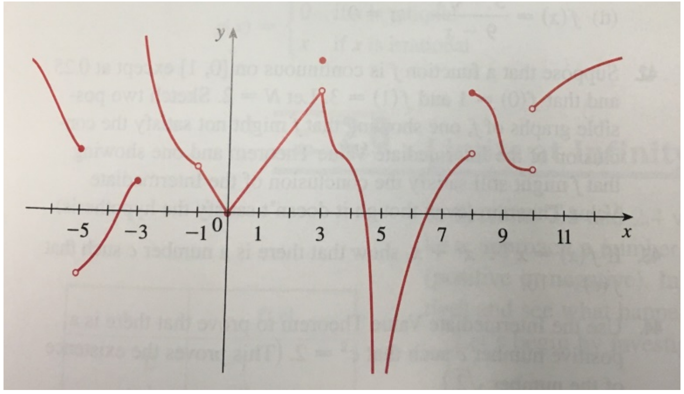
Definition (16):

A function f is continuous in a point x=c if

a) $f(c)$ is defined
b) $\lim_{x\to c} f(x)$ exists
c) $\lim_{x\to c} f(x) = f(c)$

If the function is not continuous in x=c, we say that it is discontinuous at this point.

Exercise to do in class (17): Have your say on the continuity and existence of the limit at points x = -5, -1, 0, 3, 8 and 10.

10. 

Question to take to the next class: What happens with the limit at $x = 5$?

At the next class: we will see the notions of infinite limits, of limits to infinity. We will study the properties of boundaries and indeterminate forms.

CLASS PREPARATION #3

Chain rule

Theorem (18):

If $y=f(u)$ is a differentiable function that depends on the variable u and if u is a differentiable function that depends on the variable x, then $y=f(u(x))$ is a differentiable function that depends on the variable x and its derivative is given by the product $\frac{dy}{dx} = \frac{dy}{du}\frac{du}{dx}$.

Theorem (19):

If u is differentiable in x and if f is differentiable in $u(x)$, then the composition $f \circ u$ is differentiable in x and $\frac{d}{dx} f[u(x)] = \frac{d}{du} f(u) \frac{du}{dx}$.

Example (20):

Find the derivative of $g(x) = \sqrt[4]{\frac{x}{1-3x}}$

Solution:

Let $g(x) = \left(\frac{x}{1-3x}\right)^{1/4} = u^{1/4}$ where $u = \frac{x}{1-3x}$ is the inside function and $u^{1/4}$ the outside function. We have $g'(x) = \left(u^{1/4}\right)' u'(x) = \frac{1}{4} u^{-3/4} u'(x)$, which gives us

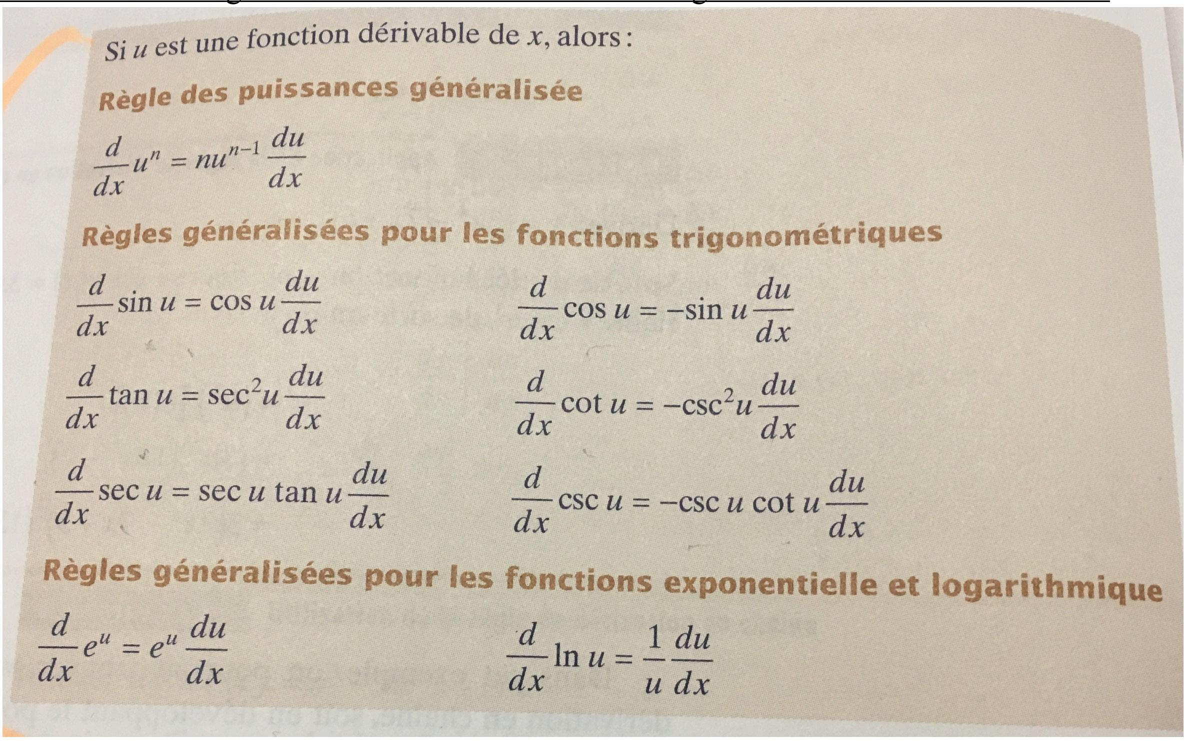
$$g'(x) = \frac{1}{4}\left(\frac{x}{1-3x}\right)^{-3/4}\left(\frac{x}{1-3x}\right)' = \frac{1}{4}\left(\frac{x}{1-3x}\right)^{-3/4}\left[\frac{(1-3x)(1) - x(-3)}{(1-3x)^2}\right]$$

$$= \frac{1}{4}\left(\frac{x}{1-3x}\right)^{-3/4}\left[\frac{1}{(1-3x)^2}\right] = \frac{1}{4x^{3/4}(1-3x)^{5/4}}$$

Example (21):

Find the derivative of $g(x) = \sin(3x^2 + 5x - 7)$.

<u>Refer the students to the generalized formulas in the following table for the in-class exercises:</u>

11. 

Si u est une fonction dérivable de x, alors :

Règle des puissances généralisée

$$\frac{d}{dx}u^n = nu^{n-1}\frac{du}{dx}$$

Règles généralisées pour les fonctions trigonométriques

$$\frac{d}{dx}\sin u = \cos u\frac{du}{dx} \qquad \frac{d}{dx}\cos u = -\sin u\frac{du}{dx}$$

$$\frac{d}{dx}\tan u = \sec^2 u\frac{du}{dx} \qquad \frac{d}{dx}\cot u = -\csc^2 u\frac{du}{dx}$$

$$\frac{d}{dx}\sec u = \sec u \tan u\frac{du}{dx} \qquad \frac{d}{dx}\csc u = -\csc u \cot u\frac{du}{dx}$$

Règles généralisées pour les fonctions exponentielle et logarithmique

$$\frac{d}{dx}e^u = e^u\frac{du}{dx} \qquad \frac{d}{dx}\ln u = \frac{1}{u}\frac{du}{dx}$$

<u>Exercises to do in class (22)</u>:

- Find the x-value of each point of the following curve $f(x) = (x+1)^3(2x+3)^2$ where the tangent is horizontal.
- Find the slope of the tangent to the curve $j(x) = (3x^2 + 5x - 7)^{-5}x^3$.
- Find the derivative of $h(x) = e^{-3x}\sin(x)$.

Notes and references for inspiration and images:

Bradley, G.L., Franco, A., Marcheterre, B., & Smith, K.J. (2001). *Calcul Différentiel*. Québec: Éditions ERPI.

Stewart, J. (2016). *Single variable calculus: Early transcendentals* (Eight edition.). Boston, MA, USA: Cengage Learning.

The goal of Preparation #1 was for it to be different than what teachers usually see and teach. At the time of its creation, my office was situated in a storage room where all of Anna Sierpinska's personal books were stored. I picked a few of the oldest calculus books I could find (the ones that were in a language I spoke) and found one where continuity was introduced before limits and there was no images. I was thrilled to find such an interesting approach, which I adapted in a class preparation. I put the book back on its shelve and was eager to present it to the novice teachers.

A few months later, we were asked to give up our office and storage space for a statistics association. We cleaned out the room and were relocated. A year later, there are still no statisticians in the room but my book is gone. The library felt so permanent that I did not think of taking the reference. It was one of those things which was there for the first 3 and a half years of my doctoral journey and somewhat assume would be there until the end. Rookie mistake.

APPENDIX D: BOOKLET OF STORIES

Booklet of Stories

Albert's Stories

Dimension technique

Depuis qu’Albert est enseignant, il parle des mathématiques selon trois dimensions : la dimension technique, la dimension compréhension et la dimension créative. Le côté technique est d’utiliser efficacement des objets et outils. La dimension compréhension est de comprendre ce que sont ces outils et objets, ainsi que d’être capable d’interpréter les résultats et de pouvoir choisir le bon outil face à un problème. La dimension créative comprend les actions de réfléchir, d’inventer et de révolutionner les idées. Aujourd’hui, Albert considère que ces trois dimensions font partie intégrante en mathématiques, malgré ce qu’il a initialement retenu de ses études universitaires.

Pendant ses études universitaires, il a cessé de voir les mathématiques enseignées au primaire, au secondaire et au cégep comme étant de « vraies » mathématiques. Il a donc débuté comme nouvel enseignant au cégep avec une attitude de supériorité à l’égard des mathématiques des niveaux inférieurs, uniquement parce que l’enseignement concernait un niveau plus bas. De son avis, cela est une conséquence de la culture qui régnait dans le département de mathématiques à l’université où il a étudié. Albert était imprégné de cette culture non seulement dans les cours enseignés, mais aussi à l’heure du midi où professeurs et étudiants se rejoignaient pour manger et discuter. En particulier, professeur X disait que ce qui est enseigné au primaire et au secondaire réfère seulement à la dimension technique, et que cela est totalement à l’opposé des vraies mathématiques comme le font les mathématiciens. Il décrit l’action de faire de vraies mathématiques par le côté créatif, c’est-à-dire réfléchir, inventer et révolutionner les idées. Par contre, Albert ne peut exprimer que son expérience de recherche en mathématiques, le travail du mathématicien, résonne avec cette idée où la dimension créative prend toute la place. En effet, Albert a participé à l’avancement des connaissances en mathématiques lors d’un stage de recherche réalisé pendant ses études au baccalauréat. Il s’est livré à une exploration d’un concept en combinatoire algébrique qui a duré deux semaines, jusqu’à ce que quelque chose de nouveau dans la discipline capte son attention, un nouveau résultat qu’il souhaitait par la suite démontrer. Il y a passé plusieurs semaines afin de prouver sa découverte de façon rigoureuse. Alors qu’Albert croit qu’il n’aurait pu trouver ce nouveau résultat mathématique sans la période d’exploration initiale, il demeure que la composition de la preuve a pris du temps et s’appuyait sur la dimension technique des mathématiques. C’est ce qui lui a aussi permis de valider sa découverte et d’en convaincre tous les autres. Albert a alors réalisé que l’aspect technique est un élément clé des mathématiques lorsqu’il est devenu enseignant et qu’il s’est mis à réfléchir de manière explicite aux mathématiques suivies durant ses années d’études universitaires. Il voit donc les mathématiques qu’il enseigne aujourd’hui comme étant de vraies mathématiques, même si les cours de niveau collégial comprennent beaucoup de travail technique. Il a aussi redécouvert ces mathématiques de son œil plus avancé, suite à ses études universitaires, ce qui lui a permis de les apprécier du point de vue de leurs implications dans d’autres domaines. Et surtout il a constaté qu’elles font partie d’un passage obligé pour les étudiants, une étape plus qu’essentielle en vue d’atteindre un niveau mathématique plus avancé et conséquemment il a réalisé que son sentiment de supériorité n’était pas justifié.

Pour en revenir à professeur X, il menait ses cours d’une manière avec laquelle Albert était en opposition. Professeur X assumait que s’il démontrait un résultat en classe, devant ses étudiants, alors ceux-ci devenaient capables de refaire la démonstration à tout moment et d’appliquer l’outil ou le résultat dont il est question. Pour ce professeur, c’est le concept ou l’idée qui importe et il est suffisant de se la faire présenter pour l'utiliser en résolution de problèmes. Avec cette vision, ce professeur n'encourageait, ni ne facilitait, la pratique du côté technique. Il ne donnait pas d'exemples résolus en classe ni ne proposait de séries d'exercices. Mais pour Albert, cette façon de faire ne peut fonctionner. En effet, pour s'approprier et comprendre de la matière, il faut l'utiliser. De plus, des commentaires négatifs qu'il avait entendus de la part des étudiants qui y prenaient part l'ont fait voir que ce n'était pas une approche viable maintenant qu'il est devenu enseignant.

Dimension compréhension

Pour Albert, il ne suffit pas seulement de maitriser le côté technique d'un concept, la dimension compréhension est vraiment nécessaire. Il se rappelle d'un cours de statistiques suivi quand il était au baccalauréat et qui s'adressait à des étudiants de différents programmes, dont des étudiants en actuariat. Albert n'appréciait pas l'enseignement donné dans ce cours. Selon lui, les preuves étaient escamotées et le but projeté était d'apprendre une technique ou une formule, et de remplacer les variables par des nombres. Il n'y avait pas de justifications. Pour Albert, ce n'est pas intéressant, car il sait déjà comment « mettre des chiffres dans une formule » ! En ce sens, il adhère au point de vue de professeur X à savoir qu'il manque souvent l'aspect compréhension des mathématiques, particulièrement au primaire et au secondaire. Par exemple, il arrive que des étudiants du cégep disent à Albert que personne ne leur a expliqué les règles de manipulations des logarithmes au secondaire, ils devaient seulement les apprendre par cœur. Selon eux, personne ne leur a expliqué le lien entre les exposants et les logarithmes, par exemple entre $x^a * x^b = x^{a+b}$ et $\log(ab) = \log a + \log b$. Albert essaie donc d'expliciter ces liens entre les propriétés des logarithmes et des exposants à l'inverse d'enseignants qui, trop souvent, ne montrent pas le « pourquoi » et n'explicitent pas les liens.

Apprendre la technique seule, sans compréhension, n'est pas bénéfique à long terme si le but est d'aller plus loin en mathématiques. Sans la compréhension, les étudiants utilisent les règles d'une manière erronée. Souvent, ils ne se rendent pas compte qu'ils ont fait une erreur et ne comprennent pas ce qui est erroné lorsqu'ils sont pénalisés. Ainsi, Albert considère que, particulièrement dans un parcours scientifique, il est nécessaire d'expliciter les justifications et les démonstrations mathématiques. Les étudiants doivent viser la compréhension profonde, et c'est son objectif dans sa façon d'enseigner pour les programmes préuniversitaires. Mais parfois, il n'a pas le choix de s'en tenir à la base quand les preuves dépassent le niveau trop élevé des étudiants. Par contre, dans le cas du cours de statistiques qu'il a mentionné, il s'adressait principalement à des étudiants qui, une fois dans la profession d'actuaire, n'auront qu'à appliquer les formules. Alors il peut comprendre comment le cours a été développé. Il enseigne donc d'une manière similaire dans les cours associés à un programme technique, où l'application est ce qui sera attendu des étudiants plus tard.

Niveau des étudiants

Albert trouve que c’est difficile de juger si les questions qu’il pose en examen sont d’un niveau adéquat pour les étudiants. Au début, c’était vraiment de l’essai-erreur. Albert se fiait aux questions que les étudiants posaient en classe, mais ce n’est pas nécessairement représentatif. Il y a des étudiants faibles qui ne posent pas de questions et des étudiants très forts qui en posent. C’est difficile de savoir si un concept qui donne du fil à retordre aux étudiants forts est problématique pour tout le monde, ou si c’est seulement quelques personnes qui sont très vocales et Albert a l’impression que le problème est généralisé. Pour avoir une meilleure idée de la compréhension des étudiants, Albert invite maintenant les étudiants à travailler sur des problèmes en classe. Cela lui permet de juger leurs démarches, de préciser ce sur quoi il devrait travailler en classe et de saisir leur compréhension et capacité. Il peut donc ajuster le niveau de difficulté de son examen.

Maturité mathématique

En devenant enseignant, Albert a réalisé à qu'il avait acquis de la maturité mathématique au travers de ses expériences au baccalauréat, à la maitrise et au doctorat et combien cela lui est utile. Cette maturité mathématique englobe la capacité à visiter ou à revisiter des concepts mathématiques et à pouvoir les apprendre et les comprendre rapidement. Elle englobe aussi l'aisance à raisonner mathématiquement et l'intuition liée à la méthode à choisir pour résoudre un problème. La maturité mathématique, c'est ce qu'Albert cherche à développer chez ses étudiants. En effet, c'est cette maturité qu'Albert a utilisée lorsqu'il a décidé d'appliquer des connaissances mathématiques à l'enseignement. Il croit également qu'il s'agit d'un atout important pour quiconque devra utiliser les mathématiques dans sa profession. Aux yeux d'Albert, son rôle est de construire le futur de ses étudiants avec eux. Il veut donc contribuer à ce qu'ils soient adéquatement équipés à utiliser des mathématiques dans leur vie, par des expériences qui participeront au développement de leur maturité mathématique. Ainsi, le but d'Albert comme enseignant n'est donc pas relié qu'à des concepts ou techniques que les étudiants devraient maitriser à la fin de son cours. D'ailleurs, il ne s'attend pas à ce que les étudiants aient tout compris à la fin de son cours, où encore qu'ils se souviennent de tout ce qu'ils ont vu. Ça lui est aussi arrivé à l'université de quitter un cours sans avoir compris certains concepts et de les avoir compris dans un autre cours. L'important c'est de donner des opportunités en vue de développer leur maturité mathématique, c'est-à-dire ce qui englobe des compétences qui leur seront utiles pour leur futur.

Premièrement, en lien avec la capacité à visiter ou revisiter des concepts mathématiques et de pouvoir les apprendre et les comprendre rapidement, il y a des choses qu'Albert n'avait pas compris quand il était au cégep ou même au baccalauréat et en les lisant dans le but de les enseigner, il les comprenait instantanément. Par exemple, Albert appliquait le test Khi-2, concept qu'il avait abordé pour la première fois à l'université, de manière très mécanique, sans comprendre. Par contre, il a dû l'enseigner au cégep à sa première session d'enseignement et en lisant sur le sujet, il a tout saisi, non seulement le concept, mais aussi ses applications. Il considère que son expérience en mathématiques à l'université a entrainé son cerveau à faire des liens et à comprendre un concept rapidement. Le cerveau s'entraine et s'adapte au travail demandé. Albert considère aussi que d'avoir expérimenté des mathématiques plus poussées et plus avancées que le niveau collégial lui a permis d'avoir plus de facilité avec les mathématiques moins avancées. Comme un entrainement physique, il s'est entrainé avec des poids très lourds à l'université et enseigner au collégial, c'est reprendre des poids très légers. Il est évident que ça semble plus facile. En ce sens, Albert fait résoudre à ses étudiants beaucoup des problèmes en vue de développer leur expérience mathématique.

Le deuxième aspect de la maturité mathématique qu'Albert tient à développer avec ses étudiants est le raisonnement mathématique. Dans cette optique, Albert se donne donc comme rôle d'aider les étudiants à développer les types de raisonnement en faisant de la métacognition avec lui-même. Dans presque tous les exemples, il se questionne ouvertement avec eux et leur explique son raisonnement. Albert espère que de voir son raisonnement les incite à raisonner d'une manière similaire quand ils seront seuls.

Finalement, il souhaite qu'ils acquièrent et développent leur capacité à choisir quels outils ou méthodes utiliser pour résoudre un problème. En effet, en continuant comme étudiant au doctorat, où Albert était beaucoup moins encadré que dans ses stages de recherche, il a réalisé que oui, la technique et la compréhension sont importantes, mais de savoir quels outil ou méthode utiliser devant un nouveau problème est aussi crucial. Au doctorat, Albert faisait face à un problème potentiellement sans solution, et personne ne pouvait lui dire s'il était sur la bonne voie, et si la solution s'écrivait en 2 ou 500 pages ! En comparaison, Albert peut prendre n'importe quel livre du cégep et il sait qu'il existe une solution, faisant intervenir des objets ou techniques qu'il connait, à tous les problèmes qui s'y trouvent. Afin de choisir exactement quel chemin prendre pour résoudre un problème, Albert exploite l'intuition qu'il a développée au travers de ses expériences mathématiques, en particulier au niveau universitaire où les examens comportent généralement des questions différentes de celles qui avaient été vues en classe ou qui font référence à de la matière qui n'est pas explicitement à l'examen. Selon lui, cette intuition se développe en faisant un grand nombre de problèmes. Par exemple, le premier constat de l'existence d'une preuve par contradiction est un peu déroutant et cela exige quelques preuves pour s'habituer ce type de structure. Par la suite, un simple coup d'œil permet de constater qu'une proposition peut être démontrée par contradiction.

Pour les étudiants, qui ont beaucoup moins d'expériences mathématiques qu'Albert, il n'est pas simple de déterminer quelle méthode choisir pour résoudre un problème. Dans le but de les aider, Albert explicite en classe les choix qu'il fait en vue de les entrainer à faire un même type de raisonnement par eux-mêmes. Il souhaite qu'ils se posent eux-mêmes les questions « qu'est-ce que je dois faire maintenant ? », « quel problème est devant moi ? », « quel est mon objectif ? ».

De plus, il n'est pas surprenant de constater que faire le choix d'une méthode soit aussi difficile pour les étudiants. En effet, dans le cadre scolaire préuniversitaire, les évaluations portent généralement sur une quantité restreinte de matière de sorte que l'apprenant a une idée de ce qu'il devra utiliser pour résoudre les problèmes qu'on lui demande. Conséquemment, les étudiants sont très concentrés sur la matière à l'examen et ne pensent pas à puiser ailleurs. Par contre, se laissant influencer par son expérience universitaire, Albert a posé une question à l'examen qui différait un peu de ce qui a été vu en classe, ou encore était matière à une évaluation précédente. Les étudiants étaient complètement désemparés. Par exemple, ils avaient fait en classe des exemples de solides de révolution avec des axes verticaux et horizontaux. Il a présenté un problème avec un axe oblique à l'examen et aucun des étudiants n'a pu le résoudre. D'une même manière, les étudiants échouent parfois aux questions qui demandent seulement de visualiser, car ils semblent trop concentrés sur un ensemble restreint de techniques et connaissances. Il a donc appris à ne pas trop sortir des questions classiques ou abordées en classe lors des évaluations. Par contre, Albert tient compte de la future profession de ses étudiants où il appartient au professionnel de décider des concepts ou techniques utiliser. Il dit à ses étudiants que dans leur domaine de travail, ça ne sera pas comme dans un problème d'examen où on leur demandera « dérive cette fonction »! Ce sera à eux de par leurs connaissances et acquis de sortir les fonctions du problème s'il y en a, et de les résoudre, dériver ou intégrer par exemple, et ce, en s'appuyant sur la formation acquise et selon la pertinence de la solution. Il lui faut donc garder en tête l'objectif de développer leur maturité mathématique afin de les préparer en vue du futur.

Enseigner quelque chose de faux

Aux yeux d’Albert, son rôle est de préparer les étudiants pour leur avenir. Ainsi, il n’aime pas leur enseigner des concepts qui se révèleront faux à un niveau d’enseignement. Par exemple, dans les livres du cégep en calcul différentiel, la limite est définie comme étant sur tous les nombres réels. Par exemple, $\lim_{x \to 0} \sqrt{x}$, n’existe pas, comme quand tu approches par 0^-, la fonction n’existe pas. Par contre, à l’université, on apprend que le calcul de la limite se fait sur le domaine de la fonction et comme $\sqrt{x}$ est définie sur $[0, \infty)$, la limite existe. C’est préoccupant pour Albert. Il mentionne à ses étudiants en classe son désaccord avec ce livre et qu’il enseigne la *vraie* définition. Il importe donc pour lui d’enseigner de « vraies » mathématiques, des concepts qui perdurent, visant que tous ceux qui appliqueront le calcul différentiel le feront avec la vraie définition des limites plus tard. Ils n’utiliseront pas la version abrégée du livre de cégep. Selon Albert, c’est convenable de ne pas enseigner un concept qui n’est pas immédiatement utile et de ne pas y référer tant qu’il n’apparait pas. Par contre, il refuse d’enseigner volontairement quelque chose de faux.

Il n’aime pas non plus enseigner des techniques qu’il sait qu’elles seront bientôt désuètes. Par exemple, certaines intégrales que les étudiants résolvent par substitution trigonométrique, méthode complexe, pourront facilement se résoudre, plus tard, en changeant en coordonnées polaires.

Résoudre les problèmes d'un examen

Quand Albert écrit un examen, il crée des problèmes sans les résoudre pas et cela lui a déjà joué des tours. Par exemple, en algèbre linéaire, il a demandé de trouver la projection orthogonale d'un sommet d'un triangle dans le plan. Il avait choisi 3 points au hasard, avec des coordonnées entières. Par hasard, la réponse à la question était un des points donnés dans la question. Aux yeux d'Albert, ce n'est pas une erreur importante de sa part même si les étudiants, confus, trouvaient cela étrange. Albert considère cette confusion superflue et croit qu'elle provient de quelque chose qui est en dehors de la matière à examen. Maintenant, il y est attentif. Il résout mentalement la plupart des questions. Par exemple, la dérivée de $ln(-4x+1)$, il la résout dans sa tête, $\sqrt[5]{2x^2+3}$ aussi. Trouver l'équation de la droite tangente ou normale, sur une belle parabole en $x=2$, il n'a pas calculé l'équation de la droite normale, mais cela convient même s'il y a des fractions. Il s'assure que les fonctions exponentielles ou logarithmiques, par exemple, sont utilisées avec des chiffres simples, car les étudiants n'ont pas le droit à la calculatrice. Mais il ne résout toujours pas ses examens au complet !

Changer la forme des questions d’examens sur les taux liés

En calcul différentiel, Albert enseigne le cours de sorte que le dernier examen soit sur les taux liés, l’optimisation et l’analyse de courbe. Comme il n’y a pas beaucoup de matière, mais que chaque problème associé à ces sections est long à résoudre, Albert donnait à l’origine des examens ayant très peu de questions. Dans ce cas, si les étudiants se trompaient au début, le reste de leur démarche était erroné et Albert devait les pénaliser d’une manière importante. Il a donc décidé, à la place, de demander des problèmes où les étudiants n’ont qu’une partie du travail à effectuer. Par exemple, dans un problème d’optimisation, les étudiants doivent seulement nommer les variables, schématiser la situation, trouver la formule à optimiser avec une seule variable indépendante. Il y a aussi un autre type de question où Albert donne aux étudiants le nom des variables et ce qu’il faut optimiser. Il demande ensuite de décrire la situation et de trouver les points critiques. Il sépare le travail en deux, en demandant le début dans certains numéros et la fin pour d’autres. Ainsi, comme l’examen comporte plus de questions, même si les étudiants échouent une question, ils ont plus d’opportunités de se reprendre.

Adapter son enseignement aux différents programmes

Albert enseigne différemment selon les étudiants qui se trouvent devant lui. Par exemple, avec les étudiants de la concentration sciences, il sait qu'il doit être dur avec eux. C'est pour leur bien. Car ils doivent être très rigoureux. En sciences humaines, il aimerait que les étudiants soient soumis aux mêmes critères de rigueur, mais généralement ce n'est pas possible. Ils ne sont pas motivés, en partie parce qu'ils ne réinvestissent pas la matière des cours de mathématiques ailleurs, au contraire des étudiants de sciences qui vont l'utiliser dans leur cours de physique par exemple. Albert sait qu'il y a quelque chose qui devrait être fait pour les motiver, mais il ne sait pas comment. D'habitude, avoir une bonne note n'est pas une motivation suffisante pour un étudiant. Si Albert se fie à ce qui le motivait quand il était étudiant, une bonne motivation se crée lorsque la matière va servir à long terme.

Dans les programmes techniques, Albert insiste tout de même sur la rigueur, mais il est moins rigide. S'il y a seulement une erreur de notation dans un examen, il la souligne et la laisse passer, si elle est occasionnelle. Par exemple, si les étudiants ont à inverser une matrice ou à trouver un déterminant 3x3, et qu'ils se trompent avec des erreurs de signes, c'est une erreur de base et normalement il enlèverait des points. Par contre, Albert laisse passer de telles erreurs avec les étudiants des programmes techniques comme ce n'est pas eux qui vont faire les calculs dans leur profession. Le but de la formation technique concerne leur compétence à appliquer les mathématiques. Qu'ils aient de la difficulté à multiplier 2 et 3, ça le dérange un peu, mais il se dit qu'ils vont perdre des points ailleurs dans l'examen. Il y a plusieurs autres aspects d'un examen sur lesquels il peut enlever des points.

Alors que dans les programmes préuniversitaires, les étudiants n'apprennent pas juste pour être capables d'appliquer, ils apprennent aussi pour comprendre. Ils doivent avoir la compréhension profonde de la matière, ce qui les aide à former leur capacité d'analyse. Les préuniversitaires devront comprendre, pas nécessairement les mathématiques, mais un certain concept. Former de futurs scientifiques, en programmes préuniversitaires, est donc différent.

Changement de notation

Selon Albert, la notation est le cœur du cours de calcul différentiel et donne du fil à retordre aux étudiants. Ils ont de la difficulté à comprendre la signification de ce qui est écrit et de ce qu'ils écrivent. Ça se manifeste quand ils évaluent une fonction. Par exemple, $f(x+\Delta x)$ devient $f(x)+\Delta x$, notamment $f(x)=x^2$ est évalué de cette façon $f(x+\Delta x)=x^2+\Delta x$. Cela se manifeste aussi lors de la dérivation en chaine. Pour dériver $f(x)=(x^2+4x)^{10}$, les étudiants écrivent directement cette expression :

$$f'(x) = ((x^2+4x)^{10})'\,(x^2+4x)'$$

Les étudiants ne voient pas que l'expression $((x^2+4x)^{10})'$ inclut déjà la dérivée de l'intérieur. Le produit comprend donc deux fois la dérivée de l'intérieur, rendant l'égalité fausse. Et comme ils obtiennent la plupart du temps tout de même la bonne réponse, $10(x^2+4x)^9 \cdot (2x+4)$, celle du corrigé, ils ne se rendent pas compte de l'erreur avant l'évaluation. Il y a parfois des étudiants qui vont dériver l'intérieur directement pour obtenir $10(2x+4)^9$, erreur plus évidente à détecter.

L'abondance de ce type d'erreur a poussé Albert à modifier sa manière d'enseigner. En donnant le cours de calcul intégral, il s'est rendu compte que les étudiants ont de la difficulté avec les changements de variable, qui sont généralement faits en utilisant une notation « u ». Alors, pourquoi ne pas enseigner directement comme ça en calcul différentiel ? Il a donc adopté la notation « u ». En ce qui concerne l'évaluation de fonction, de même que la composition de fonction, il les fait travailler sur ce qu'est $f(u)$, identifier le u, comment le poser et le composer. Il propose des exercices où il ne faut faire que cela. Il va aussi parfois écrire des séries d'expression où, à tous les endroits où il y a x, il laisse l'espace vide, donc $f(\ )$. Ensuite, il va écrire 2 dans les espaces vides. Ensuite, il va mettre un bonhomme sourire ou un sapin ou un $g(x)$. Les étudiants n'aiment pas cette multitude de symboles, mais Albert vise à les confronter à leur malaise. Il commence à un niveau facile, comme $f(2)$ et il monte augmente graduellement la difficulté.

Pour la dérivée en chaine, il a aussi adopté exclusivement la notation « u » au détriment de la notation prime « $'$ ». Par exemple, avec $f(x)=(x^2+4x)^{10}$,

$$\frac{df}{dx} = \frac{du^{10}}{du} \cdot \frac{d(x^2+4x)}{dx}$$

$$= 10(x^2+4x)^9 \cdot (2x+4)$$

Le délai est plus long avant que les étudiants arrivent à dériver des fonctions composées à cause de la notation. Après une semaine de pratique à dériver des fonctions composées, Albert constate qu'ils s'améliorent significativement. Il a ainsi éradiqué un grand nombre d'erreurs qu'il voyait souvent avant. Il peut maintenant leur dire qu'en calcul intégral, c'est ce qu'ils faisaient en calcul différentiel.

Cette nouvelle notation ne règle cependant pas tous les problèmes que les étudiants peuvent rencontrer. Par exemple, certains d'entre eux ne comprennent pas toujours la nécessité des parenthèses, et ça se manifeste avec cette technique. Par exemple, ils ne mettront pas la parenthèse autour de $2x + 4$:

$$= 10(x^2 + 4x)^9 \; \cdot \; 2x + 4$$

Il n'y a pas de parenthèses, mais ils se souviennent qu'il s'agit d'un terme qui est multiplié. Ils mettent un espace plus important à droite du point de multiplication. C'est comme si $2x + 4$ était un mot, car les symboles sont collés, comme s'il y avait une parenthèse. Dans ces cas-là, Albert leur enlève des points de notation. Il n'a pas encore trouvé comment éradiquer cette erreur !

Improvisation en classe

La première session qu'Albert a enseigné, il donnait un cours de statistiques à deux groupes différents. Comme c'était la première fois qu'il enseignait, il a ouvert le manuel et résolu plusieurs problèmes avant le début de la session. Il a préparé ses cours de manière assez détaillée, avec des définitions explicites ou des théorèmes, les idées clés des preuves et des énoncés de quelques exemples de différents niveaux, afin que les étudiants s'exercent. Il a également accès à un dossier en ligne avec le plan de cours que d'autres enseignants ont utilisé ainsi qu'aux directives du gouvernement pour chaque cours. Pour le cours de statistiques, il a décidé d'utiliser les notes trouées d'une autre enseignante. Comme il devait enseigner de sorte que les étudiants puissent remplir ces notes, il devait préparer les exemples provenant des notes trouées à l'avance, puis les faire en classe avec les étudiants de chaque groupe. C'était très ennuyant. Il a donc été motivé à improviser dans ses cours. L'expérience de donner le même cours plusieurs fois lui permet de moins se préparer comme il connait mieux le cours. Parfois, il invente des problèmes ou demande des suggestions aux étudiants. Ainsi, pour montrer aux étudiants le besoin de la règle de dérivation en chaine, Albert propose au départ de dériver un polynôme au carré, disons $(4x + 3)^2$, où il est assez simple de développer l'expression puis de dériver le polynôme $16x^2 + 24x + 9$, ou encore d'utiliser la règle du produit avec $(4x + 3)(4x + 3)$. Puis il enchaine avec le même polynôme, mais avec un exposant avec lequel les autres méthodes seraient extrêmement difficiles à appliquer, disons $(4x + 3)^{1238}$. Par contre, il aurait pu proposer n'importe quel polynôme, disons $(2x + 4)^2$ et $(2x + 4)^{2111}$, et développer les mêmes idées. Les étudiants comprendraient de la même façon, et c'est moins ennuyant pour lui. Improviser lui demande aussi de s'ajuster rapidement, ce qui garde son travail excitant. Par exemple, pour enseigner un calcul de tangente, il a demandé une fonction aux étudiants. Ils voulaient un logarithme, alors il a pris $ln(2x - 1)$. Comme les étudiants n'ont pas le droit à leur calculatrice aux examens, Albert voulait que ce soit possible de trouver facilement le point de tangence alors il a mentalement choisi l'ordonnée $y = 2$, pour ensuite résoudre $\ln(2x - 1) = 2$ et obtenir $x = \frac{(e^2+1)}{2}$. Devoir rapidement trouver des paramètres qui ne complexifient pas un problème est un défi et garde le travail d'Albert intéressant.

Finalement, Albert a conclu que d'avoir à l'écrit chaque détail de ce qu'il va présenter en classe ne l'aidait pas. Il s'arrêtait souvent pour regarder ses notes et s'égarait parfois dans ses notes. Puisqu'il a une vision globale des cours qu'il enseigne et qu'il sait où il veut emmener les étudiants, il considère comme nuisible d'avoir des notes écrites. Il prépare donc ses cours à l'aide de la moitié d'une feuille, écrite à la main, qu'il jette quand le cours est fini. Il y écrit, sous forme de liste, ce dont il veut parler à l'aide de mots clés. Il peut donc écrire « examen » s'il souhaite faire un retour sur l'examen, « dérivée en chaine » pour aborder ce sujet, « p. 125 # 1 et # 2 », s'il veut résoudre ces problèmes avec les étudiants en classe puis une courte liste de numéros à donner en exercice. C'est tout ce qu'il prépare et il apporte cette feuille en classe, avec le manuel.

Type d'enseignant

Albert se décrit comme un enseignant patient, et sensible au fait que la matière couverte au niveau collégial n'est pas nécessairement facile pour les étudiants. Il essaie d'être toujours heureux de donner sa matière, content d'être en classe. Il essaie de prendre leurs commentaires et leurs questions avec un sourire. Il croit que cette attitude positive déteint sur les étudiants, et que d'avoir une attitude positive face à la matière aide les étudiants à apprendre. Conserver une attitude positive aide aussi Albert à être heureux dans la vie de tous les jours et à apprécier son emploi. Il se souvient d'une enseignante qu'il a eue à deux reprises quand il était au cégep. Il pouvait sentir qu'elle n'aimait pas tellement ce qu'elle faisait. Comme les étudiants peuvent se rendre compte de ce genre de chose, il désire vraiment mettre de l'avant une bonne attitude envers la matière et ses étudiants. C'est plus agréable pour tout le monde et les étudiants apprennent mieux.

S'il pense à son expérience à l'université, il a eu de bons professeurs qui étaient très différents les uns des autres. Il pense par exemple à un professeur d'algèbre qui paraissait peu sociable et était très sérieux. Il disait bonjour aux étudiants puis se tournait au tableau et travaillait avec le tableau. Tout était très rigoureux et démontré sans aucune ambiguïté. Tout était inscrit, étape par étape, même les plus faciles. Il était très structuré et strict, et rien n'était laissé au hasard. Albert aimait bien ce cours qui représentait bien les mathématiques : rigueur et structure. Il s'y inspire pour son enseignement, mais essaie de le faire avec le sourire, en interagissant avec les étudiants et en leur laissant du temps pour travailler.

Albert vise aussi à donner l'impression aux élèves qu'il connait sa matière et que ce qu'il fait est valide. Il n'y avait rien de pire pour Albert quand il était étudiant que d'avoir l'impression que l'enseignant ne sait pas tout à fait ce qu'il fait. Ça lui est arrivé d'avoir un chargé de cours à l'université qui devait s'y reprendre, jusqu'à 3 fois, pour montrer une preuve en classe. Albert avait l'impression qu'il ne pouvait se fier sur les connaissances de cet enseignant et il ne veut surtout par que ses étudiants aient cette opinion sur lui.

Séminaire de développement professionnel

Albert n'a pas suivi de cours universitaire en vue de devenir enseignant. Cependant, à son entrée au cégep comme enseignant, il a suivi des séances de développement professionnel. Par exemple, il a suivi un cours où il fallait créer un échéancier avec les méthodes d'enseignement. Il a choisi de faire ce travail pour un cours de mathématiques dans un programme technique. Il a aussi développé une quantité de projets pour ce cours. Ce projet l'a motivé à s'impliquer dans la restructuration de ce programme. Il a découvert qu'il aime réfléchir à l'architecture de la connaissance et à la manière dont elle est imbriquée dans les programmes. Il aime penser à l'enseignement et la pédagogie, à la manière dont un programme est structuré et à l'organisation des compétences et de leurs articulations.

Dans un autre séminaire de développement professionnel, il a pris connaissance de deux paradigmes : l'apprentissage et l'éducation. Le premier est que l'enseignant a la connaissance, il est en avant et il illumine sa classe de la connaissance : le cours magistral classique. Il y a aussi l'approche plus éducative, par compétence, où l'enseignant va construire avec l'élève par-dessus ce qu'il avait déjà acquis. À cette fin, il faut comprendre ce que l'élève comprend. Par exemple, en calcul différentiel, si l'étudiant a d'importantes lacunes face aux règles algébriques du secondaire, il ne sert à rien de lui enseigner les techniques de dérivées et les limites. L'étudiant va avoir en tête deux pièces de casse-tête qui ne s'imbriquent pas. Il est donc lui-même passé dans sa manière d'enseigner, de la manière traditionnelle à la manière de la réforme. Albert a aussi, dans un des premiers séminaires, appris qu'il y a plusieurs manières d'enseigner et qu'il importe d'être à l'aise avec sa manière d'enseigner. L'enseignement magistral, d'amuser une classe pendant deux heures juste en leur parlant, n'était pas nécessairement ce avec qui il était toujours à l'aise. Il trouve normal que les étudiants aient du temps pour travailler par eux-mêmes et pour réfléchir. Cette idée qu'il n'a pas à se conformer l'a encouragé à en faire plus, et lui a confirmé qu'il pouvait changer les choses. Il a confiance en ses capacités et confiance que d'emmener des changements fait partie de son travail.

Il a aussi compris qu'il était libre du contenu et de la forme de l'enseignement en tant qu'enseignant au cégep. Lorsqu'il était étudiant au cégep, Albert ne s'était pas rendu compte de tout ce qui se passait à l'extérieur de la classe. Par exemple, en calcul intégral, il est possible de débuter le cours avec les sommes finies, sommes de Riemann, ou encore de commencer en faisant un travail seulement algébrique et de faire les sommes de Riemann seulement en faisant les séries. L'ordre peut être changé et l'enseignant a beaucoup de liberté. Le plan-cadre du ministère et de l'institution n'est pas très contraignant. Il suffit donc de s'assurer que les cours avec le même sigle s'équivalent. L'enseignant est plus libre par la suite.

Motivation

Au début, Albert a accepté le contrat d’enseignant seulement parce qu’il devait se trouver un emploi. Mais finalement, le contact avec les gens l’a beaucoup motivé. En effet, après plusieurs années aux études graduées où peu d’étudiants avaient la même spécialité que lui et où son directeur de recherche, avec qui il aurait pu parler, n’était pas vraiment disponible, c’était motivant d’avoir des contacts humains d’une manière régulière. La solitude est une partie de ce qui a rendu Albert très démotivé au doctorat.

Au baccalauréat, c’était la recherche de la compréhension profonde et totale qui motivait Albert. Au cégep, il n’était pas un très bon étudiant et comme il ne savait ni à quoi ça allait lui servir et ni pourquoi ça devrait l’intéressé, il n’était pas motivé. Il visait seulement avoir une note au-dessus de la moyenne, ce qu’il accomplissait sans trop d’effort. Albert considère qu’il était près de la masse au cégep comme il ne comprenait pas tout et n’avait pas toujours été très attentif dans les cours. En ce qui concerne son expérience à l’école secondaire, il ne se considère pas près de la masse comme il avait beaucoup de facilité sans mettre d’effort.

En ce qui concerne les étudiants à qui Albert enseigne, il trouve que c’est très difficile de les motiver. En effet, c’est rare que la simple motivation d’avoir une bonne note soit suffisante. Dans le cas où le but de l’étudiant est de passer à l’étape suivante, d’oublier ce qu’il a appris pour avoir son diplôme et de faire autre chose qu’il espère ne nécessitera pas ce qu’il a appris, il sait qu’il a juste besoin de 60 % et c’est très dur de le motiver et de le faire performer. Il faut quand même que l’étudiant ait un désir de lui-même d’aller plus loin. En tant qu’enseignant, Albert ne peut pas être motivé à la place des étudiants. Les enseignants ont beau vouloir que les étudiants réussissent, qu’eux soient motivés, ça ne veut pas dire que les étudiants vont faire le travail.

Vera's Stories

The Master's Program

While doing her bachelor's degree in mathematics, Vera saw a poster advertising a master's degree in mathematics education. She was admitted to the master's program on the basis of the strength of her previous degree in science and on the condition that she maintain her grades in the undergraduate courses she had left to take. She then pursued the master's program concurrently with the bachelor's program. She graduated from the master's program first and from the bachelor's program second.

The master's program made her think about mathematics and how she perceived it. The program also made her think more deeply about how she wanted to teach mathematics and how other people might be looking at it. She realized that teaching mathematics does not have to be a "one size fits all" scenario. Mathematics can be taught in a variety of ways, even in a single course or to a single population. The program taught her to look at different ways of projecting or presenting mathematics.

The experiences she lived through her master's program led her to look at how mathematics and mathematics education classes were being presented to her as a student. She did so with an interest in being able to do the same thing or something different when she would have the opportunity to lead, or to stand in front of, a classroom. Vera loves a good presentation and she collects good explanations of things. A good explanation in a measure theory class or a differential equation class can be a good model for a good explanation in differential calculus, for example. It is something she collects and hangs on to for future use or reference.

The master's program also influenced Vera's perception of mathematics and its teaching. One particular course got her to think about why people do not like maths. Why do they not like maths and what can she do about it? Before she was in that program, mathematics was something she did and liked; she did not think about why she liked it, or why somebody else (should) like it. She believes that if one does like something, one is more likely to do better at it, and that it is valuable to be able to do mathematics—ever more valuable in our world today than ever before. She teaches the same calculus that has been taught for a long time, but the world is increasingly a more mathematical one. Being able to say that you can shake hands with mathematics, or at least not run away from it, is increasingly useful in today's world. That chunk of life in between her first and second time in university gave her a bit more of an appreciation for the uses of mathematics.

Insight on the Learning Process

Vera was a mathematics tutor for many years. During this time, she looked at how people learn and the roadblocks across which they come. This experience came in handy when she started learning again upon her return to cegep and university for the second time. Not only did she try what worked with others, and determine whether it worked for her, but she also reflected on her learning experiences. She was aware of how she learned and of the tricks she came up with to help herself.

Those experiences are an important basis on which she now relies when she teaches in her cegep classrooms. For example, as a tutor, she learned that the more strange or stupid you make something sound, the better you retain it. Some people work with rhythms, music, pictures, or visual cues. Therefore, in her classroom, she gives her students any word trick she can come up with. For example, she uses the following words to describe the rule for finding the derivative of a quotient: “the bottom times the derivative of the top minus the top times the derivative of the bottom all over the bottom square do not forget to square the bottom.” She says it really fast, over and over; it almost becomes a song. She also puts on the board the same rule, but writes it as $\frac{f}{g} = \frac{gf'-g'f}{g^2}$. Some may remember that better. Unfortunately, Vera already had students who have learned $\frac{g}{f}$ instead of $\frac{f}{g}$. And the quotient rule, as she formulates it, does not work that well!

Her experience in tutoring and her experience returning to cegep and university gave her insight into what may or may not work for her own and her students’ learning.

Attention to What Students Know

For Vera, teaching does not happen until you acknowledge where students are at. You cannot teach somebody calculus if they have little understanding of algebra. You can only teach by building on top of where students are at. She remembers a mathematics professor at university who dismissed students' questions by answering that they "should know that." Maybe that is true. But how can they move forward if they do not? Therefore, Vera tries to be attentive to what students (do not) know.

Study Plans

Before the semester starts, Vera goes through the textbook and takes note of the problems she wants to suggest students to solve. She then creates a tentative schedule of suggested problems: each week is associated with a list of problems related to the topics to be covered that same week. This is a way of suggesting problems to students that she borrowed from her mathematics courses in university. The list includes mostly rote problems and a few conceptual problems.

Vera tells her students at the beginning of the semester that, now that they are in cegep, they are responsible for studying, to do their homework and to determine how much homework they need to do. She gives them the list of problems and they get to decide how many and which ones to solve. There are some students who do none and some who try them all. The idea is that they are in control of how many rote problems they need to do to be able to do rote problems on the tests. She gives them control over their own study plan, their own learning habits, in the hope that they figure out what they need to do to succeed.

Vera also comes up with electronic assignments for additional practice and minimal marks. It is her responsibility to make sure these assignments are relevant to the course and of an adequate level of difficulty. It is the students' responsibility to decide when to do them, knowing Vera has set a firm due date for each set of problems. Something similar happens in class. Vera's responsibility is to give them the opportunity to learn the material in a classroom. It is up to them if they come to class and what they do if they come. Vera presents them opportunities to practice in class. They can take these or not.

Visual Cues

As Vera encountered students whose first language is not the one in which she teaches, she saw the importance of including visual cues in her teaching as much as possible, any kind of picture that can solidify the ideas she is working on. For instance, she prefers to start a new topic with a picture rather than to start with words. In a classroom, the students have to digest the words, even those written on the board. They have to understand them. This is hard especially for those whose first language is not the one in which she teaches, who have to translate the words in their head. The words are necessary to solidify the knowledge but a picture is often the best way to first get to the students.

Expand Their Idea of Mathematics

When Vera came back to school, it was because she wanted to do mathematics and study it for itself. She also focused more on the teaching she received as she moved through her journey in university. She was never interested in applications of mathematics but her time away from school gave her more of an appreciation for how mathematics can be used. This led her to want to expand her students' ideas about how mathematics can be useful. Often, Vera finds that their idea of mathematics is what they have seen in the classroom, and it has never been taken outside of the class. They know they can calculate change or tip in a restaurant but they do not really think of that as mathematics, or even an application of the concept of percentage they learned in grade 8.

To try to take the mathematics out of the classroom – for instance, in differential calculus – Vera asks her students if they know anything about rates. They often respond that they know nothing about that. She then asks them if they have ever been in a car. They then talk about the speedometer on their car, the ideas of average and instantaneous speed, and how policemen calculate speed with a radar. And, all of a sudden, the mathematics is outside of the classroom. Vera hopes students find mathematics to have a wider scope than they thought it to have before they went through her classroom, just like her life experiences outside of school allowed her to do.

Teaching as a Tool to Understand Better

Vera found that she never understood something better than when she explained it to someone else. Therefore, she encourages students to tutor their peers. They have a peer-tutoring program in her institution. When she promotes it, she tells students that the best way to improve their understanding is to try to explain things to somebody else. She tells them that using words to express what they understand solidifies their understanding. It's happened to her that she had certain ideas in her head and thought she understood them completely but when she expressed them with words or pictures or diagrams or examples, she noticed new things and got new understandings. Teaching adds to her understanding and she encourages her students to experience it.

Getting More Comfortable in the Job

Vera puts in a lot of work to make her courses run smoothly – a lot more work than anyone could see just by sitting at the back of her classroom. There is a lot of preparation, at least for her, before and after a class. In this sense, the work of a teacher is much harder than she expected. Obviously, not every teacher does the same preparatory work, but Vera needs to do a lot to relieve stress and be comfortable.

Before Vera started to teach in cegep, she was worried about standing in front of and talking to forty people. She had never been a natural public speaker. Consequently, she was worried about having full sentences to say to a group of people waiting to hear important things. To deal with that, Vera wrote extremely detailed lesson plans that included everything she wanted to do and say so she would not have to worry about that when she was at the front of the classroom. Being scrupulously prepared for a lesson alleviated the stress. She does not believe her notes are perfect but what she has, before she stands in front of the students, is something to say. After each class, she annotates the lesson plans to make them better if she gets to teach the same course a second time.

At the beginning of her career, Vera even rehearsed her lessons. She wanted to make sure she did not sound like she was reading off a teleprompter so she practised until she felt she seemed more natural and she was more comfortable doing it. Three years into the profession, she no longer rehearses, as there are not enough hours in the day! Overall, she is more confident and less stressed. Sometimes she makes mistakes on the board and she is less worried about that happening than she used to be. She uses such mistakes as teaching opportunities as much as she possibly can.

All things considered, the profession of teaching in cegep is working out better for Vera than she thought it would. When she started, she had not been sure she would do well and she dealt with that self-doubt and has overcome much of it. Vera now feels more confident about being a teacher.

Assessing Assessment Decisions

For Vera, assessing students is a challenging part of the work of a teacher. Over the years, she has talked to all the other mathematics teachers in her institution to see what they do to assess students, what works, and what does not. She then looked at what might or might not work for her. Something that often came up in her discussions with her colleagues is the idea of weekly assessments in the form of a quiz.

After trying it in her own classroom, Vera has decided against using it because she realized that students were losing marks instead of learning and understanding. It also took up a lot of class time, time that Vera could use to help them learn, and students kept complaining that they did not have enough time to finish the quizzes. According to Vera, it makes sense they are not yet efficient at using the material because their grasp of it is not yet fluid. It is material they just learned, and they are being tested on it by the end of that same week. Vera thought that maybe students would be more consistent in their studying habits if she gave them weekly assessments but that did not happen. If it did, she might still be doing them, but the quizzes became something students dreaded and from which they were definitely not learning. This encouraged Vera to find an alternative.

Vera decided to give exercises to do in class. To get the marks, students have to write a good answer, using their notes, their friends, and her help. They work through it together. She sees these in-class exercises as an opportunity to start to understand the material if students had not yet started doing so. They have 15 to 20 minutes right then and there to work on the mathematics in class, and Vera can answer their questions on the spot. On the other hand, when she gave quizzes ad students did not know how to do something, then Vera would just take away a bunch of marks from them without teaching them anything. She would rather have the class be a place in which to learn and understand the material, rather than a place in which to look at her do mathematics and lose marks.

Vera's desires to create a classroom environment where students can do and learn mathematics are not unfounded. During her master's degree in mathematics education, she looked at research on why a lot of people do not like mathematics and many sources said that people like mathematics right up to the moment when they feel they do not understand it anymore. Vera's experiences with teaching in university and tutoring also showed her that many students' difficulty with and dislike of mathematics came from their lack of understanding. At that moment, suddenly, mathematics becomes a barrier that's difficult to overcome. For example, when she tutored, Vera often heard sentences such as "I used to be good at mathematics, now I do not like it anymore," when students were confronted with concepts such as logarithms. She also taught a course in university where students were people returning to school. She did a survey and students said that understanding the mathematics would make it more enjoyable and easier. To that end, she tries to create a course where students can work with the mathematics and hopefully learn and understand. Vera found that weekly quizzes prevented her from creating such an atmosphere.

Interestingly, Vera is not able to explain why weekly quizzes work so well for other teachers and not for her. She wonders if maybe other teachers are better at encouraging their students to work diligently during the week and being ready for a quiz at the end of the week. Perhaps they prepare the students differently during the week.

Colleagues as Examples

Vera learns about being a teacher through being a teacher. For example, when she first started teaching in cegep, she was not sure how to find the right pace and how much material students can handle in a lesson. To that end, she asked a colleague if she could come and sit in their classroom, just to get an idea of presentation, style, pace, and questions students might ask. It was helpful to have an example. Now, she does not always get these right, but she adjusts when necessary.

The department in which Vera works is welcoming and is a lovely place in which to work. Even though the mathematics teachers' offices are not all in the same area, Vera ends up bumping into someone sooner or later and ask questions if she has any. Everybody has been helpful throughout the years. She did not run into anyone who was unwilling to help.

Numbers in a Problem

Vera learned that she should pay attention to the numbers she uses in a problem, especially when she solves it in front of the classroom. For example, putting twice the same number in a given problem can turn out to be confusing. It happened that finding the derivative of $(3x+4)^3$ got confusing for the students. Indeed, there are two factors of 3 in the derivative, $3(3x+4)*3$, and there was sometimes confusion about which "3" Vera was referring to while she was solving the problem. She therefore learned it would be better to work on $(5x+4)^3$ to avoid confusion that is unrelated to the topic at hand.

Variability in Performance

Vera learns as time passes what variability in student performance is normal and what is unusual for a given course. Indeed, she taught a Calculus I class which she expected to be quite representative of every Calculus I class. The students were quick to understand, which allowed Vera to go through concepts quickly and address interesting topics such as proof, “what if” questions, and some of the hardest examples and problems. She taught another Calculus I class the following semester and the students were much weaker. Part of it is because it was an “off semester.” Indeed, in a given program, there is a regular path for all students to follow, where they would all, for example, take Calculus I in the fall semester. However, the course is still offered in the winter, the “off semester,” for students who failed the class at their first attempt or for students who did not start their program in the fall. Therefore, courses given in an “off semester” include students who may struggle more with mathematics, which would explain the difference in their performance. As far as her teaching, Vera ended up doing more routine examples with the students in the “off semester” to reinforce the concepts and in that way adjusted to the population.

In the following semester, Vera ended up teaching a Calculus I class again and expected the students to be of a level similar to that of the students in her first experience, since this was not an “off semester.” However, after she gave them the first test, she realized that the class was much weaker than the class in her first experience. Therefore, she thinks that from now on she will do more routine examples and practice the basic concepts more with these students. She expects she to get better at knowing what she can expect from the average student in a given course when she has more experience being a teacher.

Length and Level of Assessment

The first time Vera teaches any course, she assumes that her instinct would be to make the exams too hard and too long because she would be motivated to make sure she was thorough and assessed every part of the material. Knowing this, she writes a first draft of an exam and cuts out part of it right away. Hopefully, making these changes will allow her to hit the level where the students are at.

She gets some insight into the students' level when they do in-class exercises. She observes how long it takes them to do it (this is usually much longer than what she expects). Then, she looks at what they have done and tries to include that wisdom when she writes exams.

However, even if she gets the level or length of an assessment right, students may still struggle. Indeed, she just graded the exam for her Calculus II students and the results were not what she expected, even if she aimed for the exam to be fair – easy, even. She took out a lot to make it shorter. She feels many students struggled with the basics, which would have been a struggle in any Calculus II exam.

Trials in Online Assessments

At the institution in which Vera teaches, most students have to complete online assessments. These total a small portion of their final mark. Each teacher decides how many attempts the students have to get the right answer and the mark associated to it. Some teachers give the students an unlimited number of attempts. Vera finds that this choice simply encourages them to keep on guessing. She believes that if students have not gotten the correct answer within a certain number of attempts, it is because they do not know how to do it and they should be reaching out for help either in class or during her office hours. She tells this to her students.

In the past, Vera tried giving students five attempts, but she found it was too few. One challenge of the online assessments is that students have to write their answer in a way that the software can understand, which may take a few attempts in and of itself. Therefore, with five attempts, the first three could be spent on entering the wrong symbols or the wrong syntax, which leaves little room for a mathematical error. Vera once tried to give students ten attempts but there were still students complaining that they used up all their attempts on getting the symbols right. Vera settled on 20 attempts and, so far, this seems to be working.

Why do more mathematics?

According to Vera, as a teacher, she needs to know more than the material she has to teach. This is why she believes her degree in mathematics is useful and necessary for her to be a cegep teacher. Indeed, students could ask “why?” regarding a given result or ask a hard question and as the teacher, Vera needs to be able to answer. Another type of question Vera could get from a student is “what are we doing this for?”; this can be answered with the broader understanding she gained from her degree in mathematics. Vera believes she gained a better understanding of topics she teaches, such as derivatives or integrals, when she saw them applied in a statistics course at university.

Vera completed a bachelor in mathematics but she did not complete a master in mathematics. Does she think there is anything in that gap, between the bachelor in mathematics and the master in mathematics, that would make her a better teacher? No, she does not think so. She thinks there are enough mathematics in the courses she took to provide the broader understanding she believes she needs as a teacher.

Now that Vera has learned a whole lot of mathematics in university, the challenge for her as a teacher is not the mathematics. Her need, as a student, was to understand the mathematics. Now, her need as a teacher is to get the material off the page, to figure out an explanation, and to try to get the mathematics across to others and to make it interesting for the students. Something as boring as the topic of quadratic functions can be fun depending on how it is approached. This is where the challenge is and what is interesting to her.

A whole new course, a whole new world

Vera has taught more than ten different courses in the first three years of her teaching career. She's covered a lot of topics! When she teaches a course for the first time, the first source she uses in her preparation is a folder, shared by the department teachers, where they keep accumulated materials. There is such a folder for each course of the department. It contains exams and review materials. There is also a competency document, which is essentially the content document for each course.

Among the courses Vera has taught, some were aimed at students in a career program. Consequently, some of the material she had to teach was new to her. When Vera finds that there are gaps in her mathematical knowledge, she goes out of her way to fill it. For example, she had to learn some applications of mathematics in contexts she never studied in university. Fortunately, her office is filled with books she can use to learn new applications and explanations of any topics she may be asked to teach.

Luckily, when she had to learn new things about applications of mathematics, she had enough experience as a teacher to be able to learn the material, and then turn it around to teach it back to the class in a short time frame. This was difficult to do when she first started to teach but got easier as she gained more experience. This is one thing Vera wished she would have done in her training: she wished there were courses where she would have been presented with a topic and then asked to present it in a short time frame. This would have been a great experience to prepare her for something she had never learned about in the teaching of mathematics. Fortunately, Vera was comfortable with the material of the first classes she had when she started to teach. There was a lot of anxiety and nerve involved in the beginning so it was reassuring that she could at least rely on her comfort with the topic.

Vera sometimes had to familiarize herself with topics that she had not worked with for a long time. For instance, this semester, she is teaching Calculus II; it has been some time since she had last tested a series using the limit comparison test. Therefore, she sat down and did a lot of examples. She made sure she had good notes and reflected on the best ways to explain and present the topic.

Big First Experience Teaching

Vera's first teaching contract started three weeks into the semester. One of the first things she had to do was write a test for her students. It was a peculiar situation as she had just met them and was not sure how, and what, they had been taught up to that point. She spoke with the department coordinator and the teacher who had been teaching them to get a better idea. Nevertheless, Vera recalls that the students did not do as well as she thought they would on the exam. Indeed, a third of the class failed. At first, she was not sure whether this was because of the test she wrote. Maybe she assessed on the wrong material or she was not asking questions in a way they understood. Vera spoke about it to the coordinator, who told her that it is possible for a third of a class to fail, even in a class where the teacher does everything the right way. Therefore, Vera changed her expectations of the grades students get in general.

Different Times, Different Motivations

When Vera came back to school as a mature student, it was a much more enjoyable experience. She had a great experience the first time around but she does not think she was old and mature enough to appreciate the gift that learning was. When she went back to school, it really was a gift to her and she was motivated. Because of this, Vera expected students in cegep classes to be more mature and motivated than they ended up being.

Vera finds that students are not mature enough to look for a challenge. When she gives them challenging questions, the kind of challenge she loved as a university student, it never goes as well as she had hoped it would because students are mostly looking for their marks. They are concerned about what is going to be on the test, how they are going to get through it, and still be able to get through their other classes' assignments. According to Vera, many students have not even reached the maturity level to understand that they may need what they are learning now later on in another course, in university, or in their future profession. They are focused on the fact that they need the mark to get into the program that they want, without really thinking about the knowledge they would need once they get into the program.

This is why Vera does not often ask challenging questions that are outside of the curriculum, even if they are interesting. Some students like such challenges, but this is hazardous because it means taking time away from the things that are important to the students. Even if such challenges could be interesting to them, they still have to meet the requirements of cegep and get the good marks to get into a university program. She understands that, but that does not preclude that they will get a better mark if they can solve a more challenging problem.

According to Vera, the way students care about their marks is, although short-term, often enough motivation to do the work or at least pass the test. However, it is not good quality motivation because it does not motivate students to actually understand. For example, the in-class exercises for her Calculus I class are in a computer lab. She tells students that they can use whatever they like to solve the problems she gives them and they can ask her questions. A group of students simply solved the question by using an online mathematics software and then wrote down the answer the software gave them. Vera assumed that having resources would be helpful for the students but in this case, they just copied it down without taking any learning from it. Indeed, when Vera asked the same derivative on the test, those students wrote the same result they had previously obtained through the online software. This confirmed to her that they did not care about finding out how to solve the problem. They only wanted the mark, even if it was worth less than 1% of their final mark. When she graded the exercise, she gave them the benefit of the doubt and gave them full marks, but on the test, they were expected to justify their answer.

The Roadmap and the Backup Plan

Vera believes her role as a teacher is closely tied to the fact that cegep corresponds to the two years between high school and university. Vera tries to give students opportunities to be independent learners while giving some support. She does not leave them out in a sink or swim situation similar to what happens in university. In cegep, they do still need support, but they must take on some of the responsibility. Therefore, she tries to give them opportunities to be responsible, but still provide some support. She does not check homework and she does not take attendance. They have electronic assignments they are responsible for getting done by a certain due date. They can find that date online so she does not remind them. However, each assignment is less than 1% of their grade. These assignments require independence, but missing one or two does not spell disaster.

Along the same line of thought, Vera tries to teach first and foremost in such a way that students can understand the material, but she still gives them a backup plan to succeed. Indeed, in her experience as a student, Vera found that if she understood the material, she would find it easy to pass the course. Therefore, understanding the material is a way to make passing the course easy. If you understand what is going on in a question, then you will have an easier time getting through it. More often than not, students have not assimilated the connection between understanding and success quite yet. Vera would like them to assimilate it and tries to push for that: if you learn the mathematics, then success on the test will follow. However, because it is not her role to put them in a sink or swim situation just yet, she also gives them the roadmap, the backup plan with precise instructions for what they should be doing. They find it easy when she has given them that roadmap and it tends to appeal to those who have struggled with mathematics. For example, she will tell them that when they see an integral that looks like a product of powers of sin, cos, tan or sec, it is probably a good idea to at least try to address it with a trigonometric integral. It does not mean that students understand the method, but at least they can address the problem and try to solve it. Vera has seen that students can succeed by practising and memorizing, but working hard with the understanding piece is, for sure, a recipe for success.

The roadmap is, however, not enough to solve all questions Vera asks her students. For example, Vera aims to prepare them for university by giving them questions that require them to do a little bit of thinking and to do more than what they are presented in class. She calls these ‘understanding questions,’ where you cannot just *apply* the material, but have to understand it to succeed. The goal is to give them challenges that they can approach. Therefore, Vera’s tests have to reflect a bit more than what students have seen in class. For example, she once asked them a question about a limit in the context of a word problem. It was about the limit as v approaches c of $M = \frac{M_0}{\sqrt{1-\frac{v}{c}}}$, where c is the speed of light, v the velocity of an object, M_0 the mass at rest, and M the mass at larger velocity. This tells us that mass approaches infinity when v approaches c. She first asked students to calculate the limit. In most of the limits they had worked with, they had the independent variable approach infinity or some given number a. Here, they need to work with a limit where the independent variable v approaches some unspecified constant c; she told her students that c was a constant, but that they were not to write “2” because it is not “2” – it is c. This limit is therefore a little bit different to calculate from those they have seen so far. Not all the students got that the mass approaches infinity, but Vera thinks they should have because this is an easy limit. She also asked them to interpret their answer. Not a single student commented on the fact that it is odd that the mass becomes infinite. In the review class, she had talked about a similar situation and she was surprised no one connected the example in class with the problem in the exam. This means to her that she has to talk a bit more in class next time about what things mean and about what they are doing. Vera has a lot of material to cover and, in light of the students' answers in the exams, she believes she did not spend enough time on contexts in class. She will find ways of doing so next time. She has therefore learned that students struggle with contexts, interpretations, and questions that are slightly different than what was covered in class. She wants to work on this in the future.

Michèle's Stories

Une famille pas comme les autres

Michèle entend parler du cégep depuis qu'elle est très jeune. En effet, plus d'un membre de son entourage y enseignait les mathématiques. Dans son entourage, c'était clair que le meilleur moment de la vie scolaire se passait au cégep. C'était la raison pour laquelle plus d'un membre de son entourage y enseignait. Quand Michèle est entrée au cégep, elle s'est dit « enfin ! ». Elle allait enfin expérimenter ce dont elle entendait parler depuis si longtemps et démystifier les mathématiques, comme la dérivée, dont elle entendait parler depuis si longtemps, sans savoir ce que c'était. En ce sens, Michèle trouve difficile de prendre sa propre expérience au cégep comme exemplaire d'un étudiant moyen. En effet, elle savait, de par son entourage, beaucoup trop à quoi s'attendre. Elle n'a pas eu de souci d'adaptation à son entrée au cégep comme certains de ses étudiants qui trouvent la transition de l'école secondaire au cégep difficile.

Or, les mathématiques ont toujours été très présentes dans la vie de Michèle. Sans bénéficier de cours de mathématiques à proprement parler, elle se rappelle toujours avoir fait des mathématiques avec son entourage. Michèle se souvient d'un voyage en voiture où elle a demandé à un membre de son entourage de compter le plus longtemps possible. Plus tard, ils proposaient des énigmes ou de courts problèmes qui la faisaient réfléchir. Michèle croit que ces expériences l'ont aidé à avoir de la facilité en mathématiques. Après tout, être bon en mathématiques, c'est une question de pratique. Conséquemment, elle pense parfois que les étudiants qui ont de la difficulté ont seulement besoin de plus de temps et de pratique.

L'entourage de Michèle a aussi eu un grand impact sur la manière dont elle enseigne. Par exemple, lorsqu'elle faisait ses devoirs en compagnie d'un membre de son entourage, il insistait énormément sur l'écriture mathématique. Ainsi, dans un problème où on doit additionner plusieurs termes, il n'est pas valide d'enchainer les opérations et de les entourer d'égalité : $20 + 5 = 25 + 4 = 29$. Elle ne se souvient pas d'avoir eu d'enseignant à l'école qui avait insisté là-dessus. Elle croit vraiment que sa tendance à insister énormément sur la notation à titre d'enseignante provient de son entourage.

De grands changements d'un ordre à un autre

Michèle se souvient d'un témoignage d'une enseignante du cégep qui disait que les étudiants entrent au cégep en tant qu'adolescents et sortent en tant qu'adultes. Elle trouve que c'est une belle image, car il y a là un aspect très particulier en lien avec le public à qui elle enseigne. Au début, les étudiants ne savent pas trop à quoi s'attendre. Ils ont fini le secondaire et il s'agit de la première fois qu'ils font face à plus de responsabilités. Ils doivent faire des choix et s'affirmer sur ce qu'ils aiment faire ou non. C'est définitivement un grand changement dans leur vie.

En ce sens, de manière générale, l'expérience de Michèle à l'université lui est plus utile pour comprendre la réalité de ses étudiants que son expérience au cégep. En effet, la période d'adaptation à l'université a été importante pour Michèle, en ce qui concerne la charge de travail et le niveau de difficulté des cours. C'est aussi à l'université qu'elle a eu ses premières difficultés importantes en mathématiques et qu'elle a vécu son premier sentiment d'échec. Elle avait l'impression, à un certain moment, qu'elle ne pouvait pas en faire plus pour être meilleure. C'était insécurisant. Quand tu apprends, tu es en position de vulnérabilité. Avoir vécu des difficultés se reflète dans sa façon d'enseigner.

Quand Michèle était auxiliaire d'enseignement à l'université, elle utilisait ces expériences pour guider son travail en classe, spécifiquement en abordant les difficultés qu'elle avait eues auparavant dans le même cours et comment gérer un sentiment d'échec. Elle ne peut pas faire la même chose quand elle enseigne au cégep puisqu'elle n'a pas eu de difficulté au cégep. Elle ne peut pas s'appuyer sur son expérience pour prédire ce qui sera difficile pour ses étudiants. Par contre, elle sait que ses difficultés d'adaptation et la gestion de l'échec à l'université sont des expériences qui peuvent survenir au cégep, pour certains étudiants, alors elle peut comprendre ce qu'ils vivent.

Les mathématiques avancées et plus loin encore

Lors de ses études universitaires en mathématiques, Michèle a abordé des mathématiques qui vont au-delà de ce qui est vu au cégep et sa connaissance des concepts abordés au cégep est plus solide, car elle a eu l'occasion de les étudier en profondeur. En effet, elle maitrise ce qui est sous-jacent aux concepts. Ça lui permet d'avoir une vue d'ensemble sur un sujet, même si elle n'explique pas tout à ses étudiants. Par exemple, Michèle trouve aidant de connaitre la vraie définition de la continuité afin de l'expliquer dans le cours de calcul différentiel au cégep. Cela lui permet aussi de voir des liens entre les concepts qui ne sont pas explicités dans les manuels du collégial, mais qui peuvent parfois aider les étudiants à comprendre la matière.

Les études universitaires ont aussi outillé Michèle à comprendre de nouveaux concepts mathématiques rapidement. Par exemple, elle a récemment dû enseigner la méthode du Simplex en remplacement d'un autre enseignant. Elle n'avait jamais appris cette méthode auparavant. Par contre, son expérience et ses acquis en mathématiques avancées lui ont permis de rapidement comprendre la méthode et son fonctionnement.

Selon elle, cette capacité à comprendre rapidement, ainsi qu'une bonne préparation à relever des défis provenant des cours de mathématiques très chargés, lui ont permis de trouver faciles les cours de pédagogie qu'elle a faites durant son programme court en pédagogie. En effet, les mécanismes cérébraux qu'elle a développés pour faire des mathématiques se traduisent ailleurs. En ce sens, Michèle sait que l'algèbre de base qu'elle enseigne au cégep ne servira que très rarement aux étudiants dans un milieu de travail. Il est très rare, effectivement, que les étudiants auront besoin d'isoler x dans leur profession. Par contre, les mécanismes cérébraux nécessaires pour effectuer ces manipulations algébriques se traduisent dans d'autres situations. Ce n'est pas pour rien que ceux qui ont étudié en mathématiques, ils sont bons dans plusieurs choses et ils peuvent travailler dans plusieurs domaines par la suite.

L'enseignement universitaire comme exemple à ne pas suivre

Michèle s'inspire de ce qu'elle a vécu en tant qu'étudiante pour parfaire son enseignement. Par exemple, à l'université, Michèle exprime que les professeurs expliquent peu. Ils n'explicitent pas ni leur raisonnement ni leurs objectifs. Ils n'enseignent pas non plus les applications, ne mentionnent pas à quoi sert la matière, et ne font pas de liens entre les cours. Aux yeux de Michèle, les professeurs assument que comme les étudiants ont choisi d'étudier en mathématiques, ils aiment ça et ce n'est donc pas nécessaire de les motiver ou de donner une motivation à la matière. Les étudiants feront aussi tous les liens entre les différents cours eux-mêmes. Michèle a senti que la culture universitaire était, d'emblée, seul le fait de choisir les mathématiques exemptait du besoin de savoir à quoi la matière sert ou comment elle s'applique. Choisir les mathématiques signifie que tu fais des mathématiques pour faire des mathématiques. Il y avait des gens pour qui cela semblait être le cas, mais pas pour Michèle. Cela l'aurait aidée de voir des exemples et des applications.

Ainsi, Michèle souhaite faire les choses différemment. Elle met l'ordre du jour au tableau à tous les cours et elle débute toujours ses cours avec un exemple concret pour donner une valeur à ce que les étudiants s'apprêtent à apprendre. Michèle considère qu'elle doit faire les liens entre les différents cours et montrer les applications, car elle est l'experte dans sa classe. Elle croit qu'il ne faut pas tenir pour acquis que les étudiants feront tous les liens d'eux-mêmes. Par exemple, beaucoup d'étudiants qui sont capables de dériver dans son cours ne sont plus en mesure de dériver dans leur cours de physique. Il y a un problème quelque part et c'est le rôle de Michèle de s'y pencher.

D'un autre côté, elle trouve que les professeurs universitaires ne sont pas les meilleurs pédagogues. Pour certains, la recherche est une priorité et non l'enseignement. Parfois, ils enseignent de la même manière, mais les étudiants devant eux ont changé. Pour sa part, Michèle tient à s'adapter à ses étudiants. Ainsi, en début de session, elle a beaucoup de difficulté à prendre de l'avance dans sa préparation, car elle ne connait pas ses étudiants. Habituellement, elle est prête une semaine à l'avance. Michèle se projette en classe lorsqu'elle se prépare et elle doit savoir à qui elle s'adresse pour bien choisir les problèmes avec un niveau de difficulté adéquat. De plus, elle veut proposer des problèmes intéressants pour eux. Ainsi, elle leur demande en début de la session quels sont leurs champs d'intérêt et plus la session avance, plus elle apprend à les connaitre. Par exemple, elle est allée chercher des problèmes sur une série télévisée comme un de ses étudiants l'adorait. Elle avait aussi une étudiante qui adorait l'équitation, alors elle faisait un problème avec des chevaux.

Sur l'impact de l'enseignant dans la classe

Les enseignants que Michèle a eus à travers les années l'ont beaucoup marquée. Parfois positivement, parfois négativement. C'était dans leur manière d'enseigner, d'agir, de présenter les mathématiques et d'être. L'enseignant a une grande influence sur l'atmosphère de la classe et Michèle est très attentive à cette réalité. Quand elle était étudiante, si elle aimait l'enseignant, elle allait aimer le cours. Une bonne atmosphère en classe l'encourageait à aimer travailler à l'extérieur du cours comme si elle se replongeait dans l'atmosphère de la classe lorsqu'elle travaillait sur ce cours. Elle se souvient particulièrement de la professeure de son deuxième cours d'analyse qui était très encadrante et avait une attitude très maternelle envers les étudiants. Elle en garde d'excellents souvenirs. C'est dans ce cours que Michèle a vraiment compris et apprécié cette branche des mathématiques. Michèle se décrit aussi comme très maternelle et encadrante comme enseignante.

Ainsi, dans sa classe, Michèle essaie d'être un modèle pour ses étudiants et de trouver une manière de les accrocher. Elle sait à quel point elle peut influencer. Elle ne sait pas qui elle va marquer ni quand ni comment. Les classes sont populeuses et elle ne peut pas connaitre les besoins de chaque étudiant. Elle ne sait pas si elle va avoir un impact en montrant que ce qu'elle enseigne peut-être utile, ou juste avec la façon dont elle agit avec ses étudiants. Elle essaie de rester dans un état d'esprit où elle peut constamment avoir un impact positif. Par exemple, elle met des collants sur les examens des étudiants qui ont eu une certaine note et certains étudiants expriment combien ils sont heureux d'avoir eu ce collant. Un mot d'encouragement peut avoir un impact important chez un étudiant. Elle essaie aussi de multiplier ses façons de faire en classe, pour rejoindre le plus d'étudiants possible. Elle utilise des diaporamas, des feuilles résumées, des échéanciers et des jeux parfois compétitifs, parfois non. En fait, elle multiplie les façons de faire en vue de rejoindre le plus grand nombre d'étudiants.

Les temps changent, les points de vue aussi

De plus en plus, Michèle réalise que son point de vue a évolué depuis qu'elle est devenue enseignante. Évidemment, le fait que son rôle ait changé a influencé son point de vue. Maintenant, elle sait qu'elle doit conduire les étudiants du point A au point B, elle a une vue globale du matériel qui doit être couvert, ce qui n'était pas le cas quand elle était étudiante dans un cours. Elle sait aussi que si elle doit annuler un cours, elle devrait faire une réorganisation importante. Quand elle était étudiante, elle était contente si un cours était annulé !

Mais ultimement, elle ne veut pas perdre le point de vue de l'étudiant et oublier que derrière chaque copie à corriger, il y a un étudiant qui veut réussir, qui a mis beaucoup ou pas d'efforts. Michèle essaie de se souvenir de ce qu'elle vivait comme étudiante, mais elle trouve qu'elle perd rapidement ce point de vue, spécialement lorsqu'elle se retrouve face à une montagne de copies à corriger. Elle réalise aussi qu'elle se doit, en quelque sorte, de le perdre. Ça lui est arrivé de devoir arrêter de corriger parce qu'elle devenait trop émotive face aux étudiants qui avaient des difficultés. Elle prend vraiment son travail à cœur.

Lorsqu'elle est retournée aux études pour un certificat en enseignement postsecondaire, elle a pu se remettre brièvement dans la position d'une étudiante. À ce moment-là, elle disait d'ailleurs à ses étudiants qu'elle les comprenait, qu'elle aussi avait un travail à remettre la semaine suivante. Elle espère qu'ils se sentent compris.

Formation pédagogique et didactique : impact dans la classe

Michèle a complété un certificat à l'université sur la pédagogie de l'enseignement postsecondaire. Elle a enseigné pendant déjà deux ans et comme elle n'était pas certaine d'avoir du travail à la session suivante, elle a décidé de s'inscrire. Elle a complété le certificat à temps partiel. L'obtention de ce certificat a eu un grand impact sur sa manière d'enseigner. Ses cours de pédagogie lui ont permis tout d'abord d'acquérir un vocabulaire pour parler de ce qu'elle faisait déjà ou voulait faire dans le futur. En ce sens, les cours qu'elle a suivis ont aussi confirmé que certaines stratégies pédagogiques auxquelles elle réfléchissait déjà de manière intuitive étaient pertinentes et elle a ressenti une nouvelle motivation pour les mettre en œuvre. Par exemple, elle donne des jeux à ses étudiants, dont certains sont issus des suggestions de ses professeurs au certificat.

Michèle met aussi à profit le matériel pédagogique qu'elle a créé dans le cadre du certificat. Elle l'utilise dans sa classe et ses collègues empruntent également son matériel. Tout ce qu'elle a créé concerne le cours de calcul différentiel, car il s'agit de celui qu'elle a donné le plus fréquemment. Maintenant, elle a hâte de transformer le matériel en vue d'enseigner d'autres cours et de continuer à innover.

Suite au certificat obtenu, elle continue de s'informer sur les nouvelles idées en pédagogie en particulier via les réseaux sociaux. Elle a un désir d'essayer de nouvelles choses. Et comme un professeur au certificat avait dit, quel est le risque devant une classe d'essayer des activités ? Le pire pourrait arriver c'est que ce cours-là n'aura pas fonctionné ! Elle y reviendra. Mais au moins, elle aura essayé. Michèle préfère maintenant se perfectionner en pédagogie, car elle voit tout de suite un bénéfice dans son enseignement, à l'inverse d'un perfectionnement en mathématiques.

Durant sa maitrise en mathématiques, Michèle a également suivi un cours qui a influencé ses stratégies pédagogiques. Elle avait choisi de suivre un cours de didactique du calcul différentiel et intégral. Elle utilise en classe des questions que le professeur avait suggérées et où les notions sont abordées de manière différente de ce qui est normalement fait au cégep. C'est aussi dans ce cours qu'elle a appris à travailler avec un logiciel de géométrie dynamique et elle l'utilise depuis.

Ouverture d'esprit

Michèle se décrit comme quelqu'un de passionné par l'enseignement et habité d'un désir d'innover. Elle considère que c'est à son entourage, comme elle a côtoyé plus d'un enseignant passionné et innovateur, qu'elle doit cette passion et son désir d'innover.

Ces attitudes lui ont permis de réaliser le certificat, qui s'adresse aux enseignants postsecondaires de toutes les disciplines, avec un esprit ouvert vis-à-vis tout ce qui était discuté. Son objectif était toujours d'adapter les méthodes pédagogiques présentées à sa classe de mathématique, plutôt que de rejeter ce qui est habituellement connecté à une autre discipline sous le seul prétexte qu'elle ne l'a jamais vu dans une classe de mathématiques. Par exemple, suite à ce certificat, elle a commencé à demander à ses étudiants de faire une analyse de fonctions accompagnée d'une situation précise et d'interpréter les résultats. C'était une nouvelle façon de faire pour elle, qu'elle n'avait jamais expérimentée non plus comme étudiante. Elle s'est inspirée des autres matières et a trouvé une façon intéressante de l'intégrer aux mathématiques.

Faire ou ne pas faire ce que le certificat prescrit

Malgré le grand impact du certificat en pédagogie sur son enseignement, Michèle ne suit pas toujours à la lettre ce qui est conseillé de faire dans les cours de pédagogie qu'elle a suivis. Par exemple, on lui a dit qu'il ne devrait pas y avoir trop d'évaluations certificatives. Il serait en fait préférable d'inclure des évaluations formatives, de manière à ne pas trop stresser les étudiants. Ceux-ci apprennent apparemment mieux de cette façon. Par contre, Michèle avait l'habitude de donner un mini-test aux étudiants chaque semaine. Avant de décider de transformer ces évaluations certificatives en évaluations formatives, elle a voulu connaitre l'opinion des étudiants sur ce sujet en leur demandant de répondre à quelques questions.

Certains étudiants disent que si les mini-tests devenaient formatifs, ils ne feraient aucun effort ce qui n'encourage pas Michèle à modifier sa manière de faire. Elle veut qu'ils essaient de résoudre les problèmes d'une manière sérieuse. Les étudiants disent aussi qu'à la fin de la session, ils aiment ça, car ils ont alors l'opportunité de pratiquer la matière en se préparant pour le mini-test et ils sont à jour dans la matière. Ça devient une routine. Aussi, ils connaissent la manière dont Michèle corrige ce qui les prépare pour les tests qui ont une pondération plus importante. Michèle se voit un peu comme un entraineur. Et, comme entraineur dans tout sport, il importe d'accompagner l'athlète et de le préparer à la compétition. De cette manière, une fois à l'examen, les étudiants savent un peu plus à quoi s'attendre, comment réagir et quoi faire.

Michèle ne donne par contre pas une grande pondération à ces mini-tests, qui valent environ 1 % de la session chacun et la moins bonne note est effacée. Elle donne aussi aux étudiants autant de temps que nécessaire pour les compléter, ce qui diminue le stress considérablement. Finalement, Michèle apprend donc ce qui fonctionne bien pour elle comme enseignante et ne fait pas à la lettre tout ce qui est conseillé au certificat.

Quand les contextes prennent toute la place

Dans son enseignement, Michèle s'inspire parfois de ce que ses collègues font. Par exemple, elle a commencé récemment à faire des examens thématiques, où chaque question contribue à une histoire qui s'étend tout au long de l'examen, ou encore des exemples thématiques qu'elle présente en classe. Elle positionne parfois les problèmes dans un contexte connu des étudiants, comme des émissions populaires par exemple. Michèle trouve que l'atmosphère est plus détendue et les étudiants aiment ça. Par contre, elle s'est rendu compte que les contextes peuvent parfois prendre trop de place et nuire à l'apprentissage. C'est arrivé lorsqu'elle a voulu introduire l'idée de dérivée dans un contexte où un superhéros bien connu voulait sauver le monde et on cherchait sa vitesse à un moment en particulier. Quelques étudiants lui ont dit que le contexte n'était pas clair et que cela les avait empêchés de comprendre le concept. Elle est donc retournée à un exemple plus classique avec une voiture. Elle parle aussi parfois d'un sprinteur et d'un coureur de marathon, ce qui est aussi assez universel. Donc maintenant, pour des concepts clés, elle essaie de prendre des contextes plus simples que les étudiants connaissent déjà pour ne pas obstruer le concept. Dès qu'ils l'auront compris, il sera possible d'ajouter un contexte nouveau. C'est important de montrer les différentes applications des concepts, mais il faut choisir les applications pour que la compréhension du contexte seul ne soit pas trop complexe. Finalement, Michèle apprend à bien utiliser des contextes et des applications dans son enseignement.

Innovations au cœur de la vie d'enseignante

À la fin de sa maitrise en mathématiques, deux institutions ont offert un emploi à temps plein à Michèle. C'est son désir d'innover qui a influencé son choix final. En effet, elle aurait pu aller travailler dans le même établissement qu'un des membres de son entourage. Mais comme cette personne lui avait parlé de certains collègues qui étaient très récalcitrants au changement, elle a choisi l'autre institution même si travailler aux côtés du membre de son entourage aurait été une expérience exceptionnelle. Michèle tenait à s'entourer d'enseignants passionnés, qui n'étaient pas attachés à la méthode traditionnelle et qui, comme elle, sont motivés par l'idée de s'améliorer constamment. Elle sentait que ce serait plus probable à l'institution qu'elle a choisie. Elle ne regrette pas son choix et croit vraiment qu'elle est aujourd'hui une meilleure enseignante suite à ce premier choix d'institution, malgré qu'elle aurait eu une plus grande sécurité d'emploi si elle avait choisi autrement. Depuis, elle a dû trouver un emploi dans une troisième institution, car il n'y avait pas assez de travail au lieu qu'elle avait choisi.

Évidemment, ce ne sont pas tous les enseignants des institutions où Michèle travaille qui sont ouverts aux nouvelles idées et surtout pas à n'importe quelles idées. Par exemple, en ce qui concerne les évaluations, Michèle a réfléchi à des alternatives à la manière dont les étudiants sont évalués généralement. Michèle aimerait repenser d'autres aspects de l'évaluation, mais si les autres enseignants ne sont pas prêts à faire des changements aussi drastiques, elle ne peut pas changer seule sa manière de faire pour le moment. Il y a des règles institutionnelles à suivre et tous les enseignants doivent évaluer un même cours de manière équivalente.

Elle a entamé cette réflexion sur l'évaluation à son arrivée au certificat en enseignement postsecondaire quand elle a réalisé que son attitude envers l'école avait changé. Elle était vraiment là pour apprendre, pas seulement pour avoir de bonnes notes. Quand elle était étudiante, avant le certificat, sa préoccupation principale était de savoir si c'était à l'examen. Elle était en mode académique, souhaitait obtenir des bourses alors elle devait avoir des résultats compétitifs. Elle ne mettait pas beaucoup d'attention à savoir ce à quoi ça allait servir dans le futur, mais elle se rend compte aujourd'hui de la possible utilité. Par exemple, elle n'aimait pas l'anglais au cégep, mais aujourd'hui elle aimerait être meilleure en anglais. Michèle tente donc que ce recul influence son enseignement et l'évaluation de ses étudiants. Elle a d'ailleurs cessé de donner les moyennes d'examens aux étudiants. Elle veut qu'ils le fassent pour eux et qu'ils réfléchissent au fait que ce cours pourrait être utile la suite de leur programme ou même plus tard dans leur vie, et non seulement pour l'examen. Mais il est difficile de modifier une pratique en place en mathématiques depuis si longtemps, tant pour les étudiants que pour les enseignants.

Dans le même ordre d'idées, cette session-ci, Michèle a essuyé un refus de la part des enseignants qui travaille avec elle sur un même cours. Elle voulait présenter une évaluation de nature récapitulative à faire à la maison. Son but était de mettre les étudiants dans un contexte représentatif de la vraie vie, c'est-à-dire de résoudre des problèmes en ayant accès à toutes les ressources possibles et avec plus de temps qu'un examen en classe. Elle se souvient, quand elle était étudiante, qu'il lui arrivait de trouver la réponse à un problème d'examen le soir après l'examen ou même quelques jours plus tard, et de la frustration ressentie. Elle souhaite donc voir ce que les étudiants peuvent réaliser avec plus de temps et moins de stress. Par contre, les autres enseignants ont trop peur du plagiat alors ils tiendront un examen traditionnel récapitulatif en classe. Michèle est d'avis qu'en donnant un problème à plusieurs solutions, elle évaluerait vraiment les compétences des étudiants et il n'y aurait pas de plagiat. Elle a l'impression que la pédagogie évolue dans cette direction et qu'il s'agit de la vieille méthode de tout évaluer en examen et que les étudiants sachent tout par cœur. Par contre, Michèle sait qu'elle ne peut pas le faire toute seule. Donc, cette session-ci, tout le groupe d'enseignants avec qui elle travaille expérimente avec l'évaluation récapitulative en classe, à l'opposé de ce que Michèle avait proposé. Elle prend ses arguments en notes afin qu'à la fin de la session, ils en reparlent et qu'elle fasse valoir ses points.

Dans les trois dernières années, Michèle s'est beaucoup affirmée et elle espère continuer. Elle a une idée plus précise de ce qui est important et de ce qui l'est moins en ce qui concerne l'évaluation. Ses opinions sont plus tranchées et elle est capable de les justifier. C'est l'expérience qui rentre. Maintenant, elle constate qu'il y a des enseignants avec qui elle est d'accord ou pas, et elle est capable de nommer pourquoi. Et ça lui arrive encore en réunion, de quitter frustrée, car elle est incapable de mettre des mots sur ses idées sur le moment. Avec du recul, elle est capable d'exprimer son désaccord.

Corriger sa correction

Michèle exprime avoir perfectionné sa manière de corriger avec le temps. Au départ, sa correction était approximative, car personne ne lui avait jamais montré comment faire. Elle a corrigé des examens comme auxiliaire à l'enseignement à l'université comme première expérience de correction. Pour obtenir des indications, elle était allée voir la professeure qui donnait le cours et elle lui avait seulement dit de se faire un barème, sans plus!

À force de pratique durant les premières expériences d'enseignante au cégep de Michèle, sa manière de corriger s'est beaucoup précisée. Elle a réalisé qu'il faut que ce soit juste pour tout le monde et elle a développé des manières d'y arriver. Ses exigences se sont précisées à travers du temps. Aussi, la manière dont elle prépare ses étudiants est devenue plus cohérente avec ses exigences qu'elle explicite. Michèle veut les évaluer le plus honnêtement possible et cela implique qu'ils sachent ce qui est attendu d'eux. Les mini-tests hebdomadaires servent justement à ça. Elle essaie toujours que ses critères d'évaluation soient transparents pour que les étudiants se préparent à ce qui s'en vient. Michèle définit la pondération selon le temps qu'elle aura passé sur chaque sujet. Disons qu'elle a fait 20 heures de théorie et qu'elle a passé 5 heures sur un sujet, elle sait qu'il y aura 25 % de la pondération de l'examen là-dessus environ et elle le mentionne à ses étudiants. Elle souhaite faire preuve de transparence en précisant, entre autres, les éléments qui seront évalués et éviter les évaluations surprises qu'elle n'aimait pas quand elle était étudiante.

Malgré cela, Michèle a récemment été face à une situation où elle a dû se questionner en profondeur sur ce qu'elle voulait vraiment évaluer suite à un examen. Elle a donné un examen où une question a été résolue par un seul étudiant. Même les étudiants les plus forts ne l'avaient pas résolu. Dans cette question, elle a misé sur une connexion entre des éléments qui sont matière à examen, mais qui n'a pas été explicitée aux étudiants. La question demandait de trouver l'équation d'une droite tangente avec de la trigonométrie, elle a donc connecté les idées de tangente et de trigonométrie. Pour résoudre le problème, les étudiants devaient dériver une expression trigonométrique puis qu'ils l'évaluent en un point. Évaluer avec de la trigonométrie est complexe pour les étudiants. Normalement, ils auraient dû être capables, mais certains ne savaient pas comment trouver l'équation d'une droite. Finalement, elle a conclu que les notes ne représentaient pas vraiment ce que les étudiants comprenaient sur la dérivation. Elle a alors éliminé la question et calculé son examen sur 90 au lieu de sur 100. C'était la première fois qu'elle modifiait un examen de cette façon. Elle en a discuté longuement avec Albert pour se convaincre que c'était la bonne chose à faire. Elle est maintenant plus attentive aux connexions qu'elle peut faire entre deux éléments de matière dans les questions d'examens et s'assure que les étudiants ont pu l'expérimenter d'abord.

Travail (d'équipe) forcé

Michèle trouve que le temps l'a grandement aidée à prendre du recul sur ses expériences d'étudiante et elle essaie d'en faire profiter ses étudiants. Par exemple, comme ses étudiants, elle détestait le travail d'équipe au cégep. Avec du recul, elle reconnait que des compétences à travailler en équipe sont utiles tant pour comprendre les mathématiques que pour les interactions dans la vie.

Au baccalauréat et à la maitrise, le travail d'équipe est ce que Michèle a le plus aimé. Elle a de très bons souvenirs de l'esprit d'équipe se formant suite à un devoir difficile et du plaisir de pouvoir s'y attaquer avec d'autres. Elle dirait même que c'est ce qui lui a parfois permis de réussir. Également, elle constate que réfléchir et expliquer ses raisonnements à voix haute avec d'autres personnes est très formateur et permet de clarifier ses idées et c'est un signe de compréhension d'être capable de l'expliquer à d'autres personnes.

En ce sens, Michèle oblige ses étudiants à travailler en équipe. Si quelqu'un est seul, elle va les présenter à une équipe. Quand elle voit que quelqu'un est mis de côté au sein d'une équipe, elle va intervenir. Elle est convaincue que c'est formateur même s'ils n'aiment pas ça. Cependant, elle est consciente qu'un travail d'équipe peut être réalisé de manière inégale par chaque membre de l'équipe, ce qui peut devenir frustrant pour les étudiants. Ainsi, elle le fait seulement pour des activités qui ne sont pas certificatives.

Méthode de travail

Quand elle est devenue auxiliaire d'enseignement à l'université, Michèle a voulu aider les étudiants en mathématiques en leur parlant de son expérience récente comme étudiante. Elle se souvenait des difficultés qu'elle avait eues et elle avait assez de recul pour y réfléchir clairement. Elle pouvait s'y appuyer.

Par exemple, elle a appris en faisant beaucoup de mathématiques à l'université qu'il peut être judicieux d'écrire la définition des objets dans un problème ou encore de dresser la liste des outils disponibles pour résoudre un problème donné. Ce sont des trucs qu'elle a développés à travers les années, mais aucun professeur ne lui a explicitement dits. Elle croit que certains d'entre eux possèdent cette façon de faire, et d'autres qui pourraient être utiles aux étudiants, mais il n'y a pas vraiment de partage.

Michèle utilise aussi ses propres expériences d'étudiante en matière d'organisation, car elle a expérimenté plusieurs méthodes et elle a réalisé en devenant enseignante que l'aspect organisationnel est une difficulté pour les nouveaux étudiants du cégep. Par exemple, quand elle était étudiante, Michèle avait l'habitude de préparer des feuilles résumées où elle écrivait tout ce qu'elle devait connaitre par cœur pour un examen. Elle crée donc une telle feuille pour ses étudiants. Elle inscrit aussi toutes les informations nécessaires au cours en ligne : les diaporamas, les solutionnaires ainsi qu'un échéancier mis à jour à après chaque rencontre. Elle classe aussi les exercices qu'elle donne par sujet, en invitant les étudiants à faire la liste d'exercices qui correspond aux sujets à propos desquels ils ont de la difficulté. C'est sa façon de les aider à se préparer. Elle ne peut pas faire plus en matière d'organisation et il appartient aux étudiants, par la suite, d'aller chercher des outils s'ils ont de la difficulté.

Michèle réfléchit aussi à haute voix lorsqu'elle enseigne pour leur montrer ce qui se passe dans sa tête et ce qui devrait se passer dans la leur. Par la suite, ils doivent le faire eux-mêmes, pour que les neurones se préparent et connectent. Par la pratique, les connexions se font plus facilement.

Difficultés des étudiants en mathématiques

Il est normal que les étudiants ne sachent pas vraiment comment surmonter leurs difficultés. Michèle a personnellement compris les difficultés qu'elle avait au cégep plusieurs années après les avoir vécus. Il y a encore des concepts que Michèle saisit, ou voit d'une nouvelle façon, au moment où elle se prépare à les enseigner. Tout de même, avec l'expérience, Michèle a développé des trucs pour aider les étudiants avec leurs difficultés. Elle essaie tout d'abord de les ramener à quelque chose de concret qu'ils maitrisent bien. La dérivation des fonctions composées est une première difficulté. Pour y remédier, elle leur demande d'abord s'ils remplaçaient le x dans l'expression par 1, quelle serait la dernière opération qu'ils feraient sur la calculatrice. Pour l'expression $((x^2 - 5)^4 + 6)^6$, ce serait l'exposant 6, alors c'est ce qu'il faut dériver en premier. Après, l'exposant s'en va, il faut dériver ce qui reste. Alors quelle serait la dernière opération qu'ils feraient sur la calculatrice, et ainsi de suite. Michèle leur dit aussi, avec humour, que c'est comme si on déshabillait les fonctions, ce qu'on enlèverait en premier est ce qu'il faut dériver en premier, et normalement les étudiants s'en souviennent comme c'est une idée cocasse.

Les étudiants ont aussi de la difficulté avec la notation de Leibniz $\frac{dy}{dx}$. Comme elle est introduite après qu'ils aient travaillé avec la notation «$'$», ils vont parfois traduire l'expression $(x^2 + 6)'$ par $(x^2 + 6)\frac{dy}{dx}$, avec l'idée que le symbole de dérivation vient toujours après l'expression à dériver. Alors pour les aider, Michèle les a ramenés au langage courant. Elle leur a dit que comme on lit de gauche à droite, on va dire « on fait la dérivée de quelque chose », on va mettre le symbole de dérivée avant. Quand on utilisait «$'$» on le mettait après, car on le disait après, « f prime ». Ils mémorisent ainsi plus facilement.

Applications

Michèle a constaté qu'il est difficile pour elle, et aussi pour les autres enseignants de mathématiques au cégep, d'inventer des problèmes de mathématiques appliquées. En réunion de 4 enseignants, ils ont eu besoin de l'après-midi complet pour inventer 3 problèmes. Michèle croit qu'ils devraient avoir plus d'habiletés dans leur profession. Elle constate qu'elle ne possède pas une bonne connaissance de la modélisation et des applications scientifiques et cela lui manque dans son travail. Elle aurait aimé suivre un parcours universitaire où elle en aurait appris plus au sujet des mathématiques appliquées.

Précarité : d'un cégep à l'autre

Michèle a enseigné dans 4 cégeps différents en 4 ans. Elle demeure une enseignante précaire qui sait rarement plus de quelques semaines à l'avance où elle travaillera et quels cours elle donnera. Ce n'est cependant pas une surprise. Elle savait en effet à quoi s'attendre après avoir vu un membre de son entourage poser sa candidature dans plusieurs établissements et devoir changer de lieu de travail à plusieurs reprises. Même si ce mode de vie n'est pas facile, Michèle a beaucoup grandi dans cette expérience.

Michèle a choisi d'aller faire le certificat en enseignement postsecondaire, car elle ne croyait pas avoir de travail. Ce choix lui a beaucoup apporté dans son enseignement. Aussi, comme Michèle devait parfois travailler dans plusieurs établissements en même temps et assurer une charge d'enseignement plus grande que normale, elle a développé de l'aisance à improviser devant la classe, car elle ne pouvait pas toujours tout préparer. Elle n'a maintenant aucun problème à demander à ses étudiants d'inventer un nouvel exemple qu'elle doit résoudre sur le vif. Elle s'est rendu compte que ça marchait bien ! Elle continue de se préparer, quelquefois trop si elle dispose du temps, mais elle a vite pris de l'assurance à enseigner dans des contextes difficiles, par nécessité. Si elle se trompe, ce n'est pas grave et elle mise aussi sur l'honnêteté et la transparence dans ces moments-là. Elle a déjà dit à des étudiants dans une classe où elle remplaçait à la dernière minute que c'était la première fois qu'elle expliquait un certain concept, mais de ne pas s'inquiéter, qu'ils vont le comprendre ensemble. Selon Michèle, si comme enseignante elle ne sait pas quelque chose, elle doit le dire aux étudiants et y revenir plutôt que de dire n'importe quoi. Elle a tiré de son expérience cette façon de faire lorsqu'elle savait ce qu'elle allait enseigner à la dernière minute. Donc elle essaie et ajuste au besoin selon la situation. Dans ces situations-là, elle ne peut pas tout contrôler. Elle n'a plus le temps de se pratiquer. Selon Michèle, la carrière d'enseignant, surtout au début, est basée sur de l'essai-erreur, sur tous les plans. Elle tente des choses, voit si elle aime ça et si c'est bien reçu par les étudiants. Par exemple, elle a essayé d'enseigner avec des notes trouées et elle n'a pas aimé ça. C'est ennuyant, c'est toujours la même chose. Mais c'est certain que la précarité de Michèle est arrivée au moment où, comme elle n'avait pas beaucoup d'expérience, chaque préparation exige plus de temps.

Il est déjà arrivé que Michèle constate que sa précarité a influencé son cours d'une manière négative. En effet, elle a enseigné le cours d'algèbre linéaire en soirée la session dernière, pendant qu'elle enseignait à temps plein de jour, en plus de suivre un cours à l'université. Elle avait donc moins de temps pour se préparer et conséquemment moins de plaisir à enseigner. Elle est certaine que les étudiants ont aussi eu moins de plaisir.

Finalement, sa précarité l'a forcée à s'adapter dans chaque établissement et département selon les préférences et règlements de chaque milieu. Par exemple, les asymptotes obliques sont abordées dans un établissement, mais pas ailleurs. Également, un établissement a une règle implicite et non écrite sur la présence obligatoire de preuves en évaluation. Il revient à Michèle de trouver ce type d'information, qu'elle découvre par le biais d'amis ou de collègues.

Évaluation de son enseignement

Michèle demande à ses étudiants de l'évaluer en fin de session pour avoir leurs commentaires. C'est une évaluation qu'elle fait d'elle-même, en plus de celle menée par le cégep, parce qu'elle aime avoir les commentaires. Elle présente aussi les résultats compilés en classe, pour que les étudiants voient que ce qu'ils n'aiment pas, certains apprécient. C'est un professeur d'un cours sur la gestion de classe à l'université qui avait proposé de faire ça. Il l'avait aussi fait avec eux et elle avait considéré que c'était une bonne idée.

Cette évaluation appuie Michèle dans certaines décisions. Par exemple, elle doit choisir avant le début de la session si elle divise ses cours en trois séances par semaine, deux qui durent deux heures et une qui dure une heure, ou bien 2 séances, dont une de trois heures, et une autre de deux heures. En tant qu'étudiante, Michèle adorait avoir des cours qui duraient une heure. Ça passe vite et elle pouvait apprendre quelque chose de difficile sans être fatiguée. Trois heures de suite, c'est fatigant, même avec une pause au milieu. Elle a tout de même demandé l'opinion des étudiants et ils préfèrent aussi avoir 3 séances alors c'est ce qu'elle fait. Michèle s'est aussi questionnée sur le nombre d'exercices qu'elle donnait. Certains étudiants lui ont dit qu'elle donnait trop d'exercices, et d'autres, pas assez. Elle croit donc en donner un nombre suffisant.

Étienne's Stories

Nouvelle compréhension

Maintenant qu'il est enseignant, Étienne comprend beaucoup mieux les mathématiques de niveau collégial. Ses études au cégep auraient été beaucoup plus faciles s'il avait compris tout ce qu'il comprend maintenant au moment où il était étudiant ! Mais il n'avait pas les mêmes habitudes à ce moment-là. En tant qu'enseignant, chaque fois qu'il a une question ou une incertitude face au matériel, il s'assure d'effectuer le travail nécessaire pour y remédier afin d'être capable de répondre à toutes les questions que ses étudiants pourraient poser. Quand il était étudiant, et il croit que la plupart des étudiants se comportent de cette façon, s'il y avait un élément qu'il ne comprenait pas, il passait à autre chose ou encore se contentait d'appliquer sans trop comprendre. Il apprenait les formules pour ensuite les oublier, tandis que maintenant, il les comprend, sait d'où elles viennent et ce à quoi elles servent précisément. Il s'en souvient donc facilement. Par exemple, en calcul différentiel, il n'avait pas adéquatement fait les liens entre la dérivée et la pente de la tangente, de sorte qu'il n'avait pas bien compris l'idée de variation en x et en y, et donc la formule de dérivée qui utilise la limite $\lim_{h \to 0} \frac{f(x+h)-f(x)}{h}$. Maintenant, la formule est porteuse de sens à ses yeux. Compter en binaire ou en base 8, ce qu'il n'avait jamais vraiment compris à l'université, il l'a compris lors de son stage.

Étienne dirait aussi qu'à la suite de ses études universitaires, il a une meilleure idée des mathématiques. Il a poussé son cerveau à réfléchir et maintenant qu'il est enseignant, il est content d'avoir poussé. En enseignant les mathématiques au collégial, il se rend compte que c'est plus facile que ce l'était avant. En terminant son programme collégial, il croyait qu'il était déjà prêt pour y enseigner. Il réalise que finalement, il faut se développer aussi après le cégep en vue d'y enseigner convenablement.

Pour épauler les étudiants à réellement comprendre la matière, par exemple la formule de dérivée, mais aussi d'autres concepts, il utilise la visualisation. Personnellement, Étienne a toujours eu plus de facilité à comprendre et à apprécier des choses qu'il peut visualiser, comme les problèmes qui se situent en dimension n. Pour introduire la dérivée, il utilise un logiciel de géométrie dynamique. C'est à l'université qu'il a appris l'existence d'un logiciel de géométrie dynamique, et son utilisation. Étienne enseigne ainsi les variations en x et y en bougeant les curseurs, et en montrant le lien entre la pente de la tangente et les variations. Il est convaincu que ceux qui écoutent comprennent bien : ils visualisent d'abord, puis saisissent d'où provient la formule.

Pour Étienne, aimer les mathématiques est étroitement lié à leur compréhension. Par exemple, les séries de MacLaurin ou les théorèmes de convergence, il ne les a jamais aimés lorsqu'il était étudiant, en partie parce qu'il ne comprenait très bien de quoi il s'agissait. Il devra les réviser et les réapprendre très bientôt pour l'enseigner. Il espère mieux les comprendre et donc les apprécier un peu plus. Cela concerne aussi les tests d'hypothèse. Au cégep, il n'appliquait que la méthode. Il ne comprenait pas vraiment ce qu'il faisait et pourquoi. En y revenant récemment avec son œil plus expérimenté, il a finalement compris les étapes qu'il faisait sans réfléchir auparavant. Enseigner les mathématiques lui apporte une vision plus positive de certains concepts, par une compréhension nouvellement acquise.

Enseigner au cégep

Étienne voulait être enseignant depuis l'âge de 16 ans. Lorsqu'il était élève au secondaire, il voulait être enseignant au secondaire. Quand il a débuté ses études au cégep, il voulait être enseignant au cégep. C'est surtout la clientèle et les mathématiques qu'on y fait qui l'ont fait décider pour le cégep.

En ce qui concerne la clientèle, les étudiants au cégep sont libres d'être présents au cours ou non. Il y a une règle dans son cégep qui stipule qu'après 3 absences, les étudiants sont hors du cours. Étienne ne tient pas compte de cette règle qui n'existait pas quand il était étudiant. Il vérifie les présences au premier cours de la session, pour s'assurer que la liste est bonne, mais c'est tout. Étienne pense que si les étudiants ne veulent pas être présents, c'est leur choix. Ils ont 18 ans, ils peuvent faire ce qu'ils veulent. Conséquemment, les étudiants qui sont dans la classe d'Étienne souhaitent y être, contrairement au secondaire où les élèves sont obligés d'y être.

D'un autre côté, la matière du cégep est un bon compromis de mathématiques assez avancées et intéressantes, sans être trop abstraites comme celles enseignées à l'université. La possibilité de les visualiser et d'aborder des problèmes concrets sont deux atouts pour rendre les mathématiques intéressantes pour Étienne.

Cours d'économie

Étienne a suivi un cours optionnel d'économie au baccalauréat et il ne le trouve pas aidant dans les moments où il propose des problèmes reliés à l'économie dans les cours de calcul différentiel ou intégral. En effet, à l'université, comme le cours s'adressait à une grande variété d'étudiants provenant d'une multitude de programmes, le professeur ne parlait jamais de dérivées ou d'intégrales, car certains étudiants n'avaient jamais vu ces concepts. Il doit donc apprendre les applications en économie comme s'il n'avait jamais suivi de cours.

Motivation

Quand il était jeune, Étienne aimait résoudre des énigmes, des *sudokus*, des problèmes qui le faisaient réfléchir. C'est ce qui l'a conduit aux mathématiques. Durant son baccalauréat, c'est dans le cours sur la résolution de problème, sans aucun doute son cours préféré à l'université, qu'il a retrouvé le même genre de travail mathématique. En effet, la résolution passait par de la réflexion, et non par l'utilisation d'un théorème précis. Même sans la bonne solution, le professeur pouvait accorder une note parfaite pour les raisonnements et la réflexion. Étienne aimait qu'il existe plusieurs chemins pour se rendre à la bonne réponse et c'est toujours ce qu'il a toujours préféré en mathématiques et ce qui démarquait les problèmes qui l'ont marqué au travers des années. C'est ce qu'il pouvait résoudre en réfléchissant plutôt qu'en invoquant sa mémoire. Il se souvient de problèmes au primaire que son enseignant donnait en disant qu'il était difficile et du sentiment de joie quand il réussissait et qu'il était le seul. Au secondaire, il se souvient d'un problème avec un tuyau d'arrosage. Il fallait utiliser les formules connues, mais aussi réfléchir beaucoup. Il fallait rouler le tuyau d'arrosage en ayant le diamètre du boyau et trouver combien de tours à faire. Il se souvient avoir eu une idée, s'être dit que ce serait trop complexe et que finalement, c'était la solution. Il était fier d'y avoir pensé et aussi frustré de ne pas l'avoir fait. Il aime cette idée d'appliquer les formules, mais il faut penser à comment le faire. Il se souvient aussi d'un examen en algèbre linéaire où il ne se souvenait pas de la formule qui détermine la distance entre deux points dans le plan cartésien. En faisant un dessin, il a pu la retrouver. De manière générale, Étienne était moins motivé dans les autres cours du baccalauréat lorsque la matière était très abstraite et théorique, comme travailler dans la dimension *n*, où il était presque impossible de retrouver les théorèmes ou les formules avec un dessin. Pas facile de dessiner en dimension *n* !

Étienne adorerait donner l'opportunité à ses étudiants de faire un cours similaire avec de la résolution de problèmes pour les motiver à faire des mathématiques. Comme lui, ils n'aiment pas ce qui est trop théorique ou abstrait et ça leur permettrait donc aussi, comme lui, de développer leur raisonnement logique et leur capacité à persévérer. Par contre, puisqu'il n'a pas appris de nouvelles théories dans ce cours, il ne pense pas que ça pourrait être utilisé au cégep pour enseigner le calcul différentiel et intégral. Il sait aussi que si certains étudiants ne pratiquent pas les techniques, ils ne réussiront pas le cours alors Étienne se doit d'utiliser le temps alloué au cours à les faire pratiquer et non pour leur faire faire des problèmes du type que lui apprécie. Étienne réalise qu'ils doivent être capables de dériver et d'intégrer pour leurs futurs emplois, il en fait donc sa priorité. De plus, ce ne sont pas tous les étudiants qui aiment les mathématiques et qui apprécieraient ce genre de problèmes. Comme enseignant, Étienne ne vise pas à changer leur vision des mathématiques ou encore de leur faire développer un désir de faire des mathématiques en dehors de l'école. Cela aurait été possible dans un cours de résolution de problèmes, mais les cours enseignés au cégep ne comportent pas des cours qui créent ce désir.

Tout de même pour rehausser la motivation de ses étudiants, Étienne ajoute à ses cours des éléments moins abstraits et moins théoriques pour motiver les étudiants. Ce sont des éléments qui ne seront pas à l'examen et pour lesquels ils n'ont pas à prendre de notes. Il leur a par exemple montré hier la suite de Fibonnacci, le nombre d'or, le rectangle d'or, la spirale d'or, tout en présentant des photos en vue de souligner les liens dans la nature. Ils ont aimé ces 30 minutes. Étienne leur a aussi demandé de résoudre l'intégrale de $sec^2(tan(x))$ avec un changement de variable. On pose $u = tan$ ou $u = sec$ et, à la fin, on arrive à deux résultats différents,

$tan^2(x)/2 + Cte$, $sec^2(x)/2 + C$. Il leur a montré, avec un logiciel de géométrie dynamique, ce qui se passait et pourquoi il y avait deux réponses différentes. Il trouve intéressant et stimulant de leur montrer, mais il ne leur demandera pas d'expliquer une telle chose à l'examen. Au prochain cours, il leur présentera le paradoxe de Zénon, Achille et la tortue. Étienne a parlé de ces activités à un collègue qui donne le même cours que lui. Celui-ci a décidé de ne pas les faire dans son propre cours. Même si Étienne se fie souvent à ce que ses collègues font, car il est un nouvel enseignant, il est convaincu de son choix. Il aime présenter des faits intéressants, quitte à laisser tomber un peu de matière et permettre aux étudiants d'apprécier les mathématiques. Pour intéresser les étudiants, pour les motiver, il faut leur montrer ce qui est captivant aussi, pas seulement les calculs. Quand il aura plus d'expérience comme enseignant, il garde en tête l'idée de développer un cours de résolution de problèmes. Il a hâte de les faire réfléchir au lieu d'appliquer !

Jeux

Quand Étienne a commencé à enseigner au cégep, il a vu beaucoup d'enseignants utiliser des jeux dans leurs cours. Ces enseignants disent que ça fonctionne très bien. Avant d'en créer lui-même, Étienne a décidé d'en emprunter à ses collègues et de les essayer dans sa classe, avec hésitation. Il se questionne sur la pertinence d'utiliser des jeux dans une classe collégiale et si cela intéressera les étudiants. Si Étienne enseignait au secondaire, il ferait des jeux en classe fréquemment, c'est certain ! Mais il croit que lorsqu'il était étudiant au cégep, si un de ses enseignants avait sorti un jeu, il se serait trouvé trop vieux pour cette activité. Il n'aurait pas apprécié du tout. Puisque son expérience d'étudiant est en contradiction avec ce que les autres enseignants font, il ne sait pas trop quoi conclure. Donc pour l'instant, Étienne enseigne principalement en cours magistral, propose des exercices aux étudiants afin de leur permettre tout de même d'être actifs.

Matériel pédagogique

Quand il a commencé à enseigner, Étienne voulait utiliser un diaporama dans sa classe et faire prendre des notes écrites aux étudiants. Il a l'impression que les étudiants n'écoutent pas en classe et qu'écrire les garderait attentifs au déroulement du cours. Or, Étienne a réalisé rapidement que c'était parfois inutile. Par exemple, pendant que les étudiants copient toutes les définitions, théorèmes et exercices, ils n'écoutent pas. Ils ne font que copier, sans comprendre. Étienne a donc choisi d'utiliser des notes trouées afin que les étudiants n'aient pas à recopier toute l'information. Quand il y a un passage qu'Étienne tient absolument à ce que les étudiants écoutent ou un exemple à résoudre absolument, il demande de l'écrire ou encore attend d'avoir l'attention de tous pour en parler. Il utilise son instinct pour déterminer ce qui sera manquant ou non dans les notes, ce qui sera dit seulement à voix haute.

Étienne remet aussi à ses étudiants une feuille de route pour chaque bloc. Elle inclut les dates d'examens, la description hebdomadaire ou quotidienne du cours ainsi que les lectures et exercices associés. Il aime donner cette feuille pour que les étudiants sachent où ils s'en vont. C'est une enseignante de chimie qui utilisait cette façon de faire avec laquelle il est très à l'aise. Il cochait chaque section quand c'était fait, habitude qu'il a gardée en tant qu'enseignant. Maintenant, il l'annote tout au long de la session afin de mieux suivre le déroulement de son cours et d'ajuster au besoin pour la prochaine fois qu'il enseignera un même cours. La première version s'inspire de ce que ses collègues ont fait, la version subséquente inclut l'expérience qu'il obtient en enseignant le cours lui-même.

S'ajuster aux différents programmes préuniversitaires

Étienne enseigne de manière similaire aux étudiants de tous les programmes. Cependant, il met l'accent sur différents concepts dépendamment de son auditoire. Par exemple, la factorisation de polynôme de degré 2 fait partie de la matière qui devrait être acquise au secondaire. En particulier, les étudiants voient la méthode « produit-somme ». Dans le cas général du polynôme $x^2 + ax + b$, la méthode « produit-somme » dicte qu'il faut trouver deux nombres dont le produit est b et dont la somme est a. Par exemple, face au polynôme $x^2 - 2x - 15$, la méthode « produit-somme » dirige à trouver deux nombres dont le produit est -15 et dont la somme est -2. Dans ce cas-ci on trouverait les nombres -5 et 3, pour trouver la factorisation $(x - 5)(x + 3)$. Dans les classes d'Étienne, la plupart du temps, les étudiants du parcours science nature se souviennent de la méthode, mais pas ceux en sciences humaines. Ainsi, pour ce groupe, Étienne exécute chacune des étapes dans les résolutions afin de bien expliciter les méthodes. Par contre, pour un sujet comme la trigonométrie, il constate que tous les groupes ont de la difficulté ! Ainsi, il modifie son enseignement pour aller lentement avec tous.

Étienne ajuste également les exemples donnés en classe selon les aspirations professionnelles des étudiants. Par exemple, dans un cours de statistiques pour un groupe du programme de sciences humaines, Étienne a effectué un sondage, à leur première rencontre, pour connaitre les aspirations universitaires des étudiants. Il a découvert que la majorité de la classe souhaitaient étudier en psychologie ! Alors, quand il choisissait les exercices et les exemples, il consultait le site Internet de Statistiques Canada en vue de trouver des statistiques en lien avec la psychologie, et ainsi offrir des problèmes qui étaient dans les intérêts des étudiants de la classe.

Évidemment, il ajuste ce qu'il enseigne au plan-cadre de chaque programme. Par exemple, la dérivation logarithmique ne fait pas partie du plan-cadre de sciences humaines. Aussi, Étienne laisse de côté les exemples qui se rapportent à la chimie ou à la physique, au profit de ceux qui discutent d'économie. Si nécessaire, Étienne ajoutera des problèmes appliqués en physique parce que la vitesse, l'accélération et la distance sont communes pour les étudiants familiers avec le transport. Aussi, lorsqu'Étienne était en secondaire 5, tous les étudiants devaient choisir deux de ces trois options : chimie, physique ou histoire. Tous les étudiants qui voulaient s'inscrire en sciences au cégep devaient choisir chimie et physique. Tous ceux qui ne voulaient pas s'inscrire en sciences choisissaient histoire et physique. Étienne croit donc, sans être certain, que ceux qui optent pour les sciences humaines aiment mieux la physique que la chimie. Donc il présente des exemples appliqués en physique quand ceux appliqués en sciences humaines se font rares.

Son rôle

Aux yeux d'Étienne, son rôle envers les étudiants, en tant qu'enseignant de mathématiques au cégep, est de les aider à réussir le cours qu'il leur enseigne. En d'autres mots, c'est de les emmener à comprendre la matière, de bien vulgariser les notions pour eux, de faire des exemples pour qu'ils sachent quoi faire une fois à l'examen et de les encourager à faire leurs exercices. Dans un cours de psychologie qu'Étienne a suivi dans son certificat en enseignement supérieur, on lui avait dit qu'il pourrait peut-être, pour certains étudiants, être une figure paternelle. Qu'ils pourraient venir le voir s'ils ont des problèmes, mais ça ne lui est jamais arrivé. Il doute donc que ça arrive un jour, et que ça fasse partie de son travail. Il n'a pas non plus l'impression que ça fait partie de son rôle d'enseignant de les guider dans leur choix de carrière. Il y a une seule étudiante qui est venue le voir pour lui parler de l'université. Elle voulait aller en psychologie. Elle lui a dit qu'elle avait demandé à ses autres enseignants, qui sont plus âgés qu'Étienne, et qu'ils lui ont dit d'aller à la bibliothèque bien que toutes les informations sur les programmes universitaires soient maintenant en ligne. Elle est donc venue le voir comme il est plus jeune et donc plus au fait de ce qui se passe dans les universités aujourd'hui. De prime abord, Étienne, avec son baccalauréat en mathématiques, ne pouvait pas vraiment l'aider. Par contre, un membre de son entourage a fait ses études en psychoéducation et une amie a fait un baccalauréat en psychologie alors il a quand même une idée du travail que demande ce genre d'études. Étienne lui a donc dit qu'il fallait beaucoup étudier dans ce programme, car un très petit nombre d'étudiants est admis au doctorat, un diplôme nécessaire pour pratiquer la psychologie. Étienne ne décrit donc pas son rôle comme étant paternel, autoritaire ou supérieur, son rôle est d'enseigner et de les aider à comprendre. Il ne se prend pas pour leur père encore, peut-être lorsqu'il aura 45 ans ! Il n'est pas le genre d'enseignant à dire quoi faire et à s'imposer. Après tout, il a seulement quelques années de plus qu'eux.

Les surprises

Depuis son arrivée au cégep à titre d'enseignant, Étienne a eu quelques surprises même si la profession correspond à ses attentes de manière générale. Il y a certains aspects auxquels il ne s'attendait pas comme le fait qu'il a plus d'échecs qu'il ne le pensait. Récemment, le quart de la classe d'Étienne a échoué à un examen et un autre enseignant a remarqué que ce n'était pas beaucoup, et ce, à la grande surprise d'Étienne qui trouve que le quart, c'est beaucoup ! Étienne avait l'impression, quand il était au cégep, que personne n'échouait. Il se demande si l'emplacement géographique a une influence sur le taux d'échec. Quand il était étudiant, c'était dans un plus petit cégep. Peut-être que les étudiants s'entraidaient plus ? Peut-être que les enseignants étaient moins sévères ? Cela est difficile à évaluer, comme il réussissait très bien. Il faudrait y retourner avec son regard d'enseignant. Il pourrait alors constater s'il y a une différence. C'est peut-être la quantité d'étudiants, et donc nécessairement plus d'étudiants en difficulté ou qui ne font pas d'efforts.

L'attitude de certains enseignants envers certains étudiants a aussi été un élément de surprise pour Étienne. Il a découvert que certains enseignants tiennent des propos péjoratifs envers certains cours moins bien réussis ou envers des groupes d'étudiants qui ont généralement un taux d'échec plus élevé, comme les cours de mise à niveau du secondaire. Aux yeux d'Étienne, il est clair que ces cours sont moins intéressants que les cours de base, tels que calcul différentiel et intégral et algèbre linéaire. Mais pour lui, il y a toujours un moyen de rendre le cours intéressant ! Par contre, Étienne estime que l'attitude qui est véhiculée dans le département autour de ces cours est désobligeante, considérant les commentaires négatifs et la grande difficulté à trouver des enseignants pour les donner.

Ses attentes basées sur ce qu'il faisait comme étudiant

Étienne se rend compte quotidiennement que son point de vue a changé, sur les mathématiques et sur les études, depuis qu'il est enseignant. Il réalise qu'il conseille des choses à ses étudiants qu'il n'aurait lui-même jamais faits à leur place. Même s'il a évolué à travers ses années d'études et sa première année d'enseignement, il sait que ses conseils sont pertinents et il comprend tout de même ses étudiants qui ne suivent pas ses conseils. Il était l'un d'eux il n'y a pas si longtemps.

Par exemple, il dit à ses étudiants de s'y prendre à l'avance pour compléter leurs exercices et apprendre les formules par cœur, mais lui-même était toujours à la dernière minute quand il était étudiant. Il se souvient des cours d'algèbre avancée à l'université, où étaient abordées les théories des groupes, des anneaux et des corps. Étienne essayait d'apprendre tous les théorèmes la veille de l'examen. Il a beau chialer contre les étudiants qui le font, mais il le faisait souvent à l'université ! Il leur mentionne aussi de ne pas utiliser le solutionnaire trop souvent, mais il l'utilisait toujours quand il étudiait à l'université. Il se souvient encore du cours de géométrie qu'il a suivi à l'université où le premier examen demandait de faire des constructions géométriques avec seulement une règle et un compas. Étienne ne savait pas comment réaliser les constructions dans les exercices alors il allait consulter le solutionnaire. En voyant la solution, il la trouvait facile, mais il ne faisait pas vraiment les constructions au complet. Ainsi, il n'a pas eu une bonne note à l'examen. Même s'il avait l'impression de comprendre la matière, en classe et à la lecture du solutionnaire, il ne comprenait que la solution, pas les idées sous-jacentes. D'ailleurs, Étienne a appris que ce n'est pas parce qu'il a le sentiment d'avoir compris ce qu'un enseignant fait en classe que son travail est terminé. Il manque l'étape de l'assimilation, nécessaire à la capacité à résoudre les problèmes. C'est en faisant les exercices, sans abuser du solutionnaire, qu'il devient possible de répéter un type de démarche. C'est ce qu'il essaie d'expliquer à ses étudiants.

En tant qu'enseignant, Étienne met l'accent plus sur la compréhension que sur l'exactitude des calculs même si ce n'était pas son habitude en tant qu'étudiant. Par exemple, en ce qui concerne l'application de l'algorithme de l'élimination de Gauss-Jordan, il est très facile de faire une erreur de calcul compte tenu du nombre d'opérations nécessaires. Aussi, Étienne souligne aux étudiants que s'ils ont bien compris l'algorithme, il n'est pas nécessaire de chercher où se situe l'erreur de calcul, même si, quand il était étudiant, il voulait à tout prix trouver cette erreur.

Dans le même ordre d'idées, lorsqu'Étienne donne du temps en classe pour faire des exercices, certains étudiants ne travaillent pas. Il ne juge pas ce comportement. Car même si c'est à leur avantage d'utiliser ce temps pour s'exercer et que c'est de cette manière que se fait l'apprentissage, Étienne agissait de manière similaire quand il était étudiant. Il travaillait en dehors des cours. Il n'était pas le meilleur étudiant en classe, mais en arrivant à la maison, il faisait ses exercices et comprenait. Il n'est pas non plus le genre d'enseignant à leur dire quoi faire et à s'imposer. Il a seulement quelques années de plus qu'eux, après tout.

Étienne constate que sa perception des cours a changé. Il a maintenant une vue d'ensemble qu'il n'a jamais eu en tant qu'étudiant. Comme il survole tout le manuel du cours lorsqu'il se prépare, il a une vue d'ensemble inégalée. Il voit d'où on part et où on va, quelle la matière sera clé dans le reste du cours et dans les cours suivants et les objectifs précis de chaque cours. C'est vraiment un point de vue différent que lorsqu'il était étudiant où il ne connaissait pas les objectifs et quels problèmes étaient plus pertinents. Il essaie d'aider les étudiants à bien cerner la visée du cours en l'inscrivant sur le dessus du document de révision qu'il donne avant un examen. Toutes les fois, il leur dit de lire les objectifs à la veille de l'examen et qu'ils se demandent s'ils pourraient atteindre tous les objectifs. Il est déjà arrivé que personne n'ait réussi la question en lien avec l'objectif 1 de la liste et Étienne a souligné qu'avec la lecture des objectifs, ils auraient pu réussir la question ! Mais Étienne est aussi convaincu qu'il aurait agi de la même façon à leur place.

Finalement, Étienne croit que s'il avait su à quel point tous ces conseils étaient pertinents, il les aurait suivis !

Être « fait » pour les mathématiques

Étienne est d'avis qu'afin de bien réussir dans un cours de mathématique, il faut mettre des efforts et avoir une bonne connaissance des préalables. Par exemple, il était au centre d'aide hier et un étudiant lui a demandé de l'aider à intégrer $sec(tan(x))$. L'étudiant ne connaissait pas ses formules de base alors il lui était impossible de résoudre ce problème. Cette personne n'est pas incapable, mais elle n'a pas mis assez d'effort et de temps à apprendre les formules. D'après Étienne, tout le monde a la capacité de comprendre les notions de base, il faut seulement y mettre les efforts.

Toutefois, lorsqu'il repense à son propre parcours universitaire, il estime qu'il n'aurait pas pu aller plus loin, et compléter la maitrise en mathématiques. Certes, il aurait pu mettre davantage d'efforts à l'université, mais il croit désormais qu'il y avait peut-être une limite et que certaines personnes possèdent une facilité que d'autres n'ont pas. Il pense tout de même que les premières notions enseignées aux élèves du primaire et du secondaire sont accessibles à tous, tout comme le calcul différentiel où il suffit d'appliquer les formules. Les difficultés débutent en calcul intégral qui, selon lui, demande plus de réflexion. Il a donc nuancé son point de vue, car il a pris connaissance de sa propre limite.

Prendre les étudiants par la main

Quand il était étudiant, il trouvait que certains enseignants prenaient les étudiants par la main en leur disant exactement quoi faire et en répétant souvent la même chose. Étienne trouvait ça tellement éreintant ! Il se disait : « voyons, laisse-moi vivre un peu ! » Mais en devenant enseignant, il s'est rendu compte qu'il n'a pas le choix. Il a beau répéter la même chose quatre fois en classe, certains ne comprendront pas ou ne s'en souviendront pas. Par exemple, concernant les listes d'exercices, il doit l'écrire au tableau et l'envoyer par courriel pour s'assurer que les étudiants s'en souviennent et le fassent. Il y a toutes les petites subtilités mathématiques aussi qu'ils ne comprendront pas par eux-mêmes si Étienne ne les mentionne pas à voix haute. Il doit non seulement le mentionner, mais aussi être explicite et l'écrire au tableau. Par exemple, quand il faut calculer l'aire entre deux courbes, par $f(x) - g(x)$, Étienne attend que tous ses étudiants aient fini de copier les notes, qu'ils aient relevé la tête, avant de dire que $f(x)$ doit être plus grande que $g(x)$. Ceux qui avaient compris la première fois, mais qu'Étienne le répète 2 ou 3 fois afin que tout le monde ait compris, se disent sûrement « OK, passe à autre chose ! Décroche ! », comme lui se serait dit face à un enseignant qui ferait la même chose.

Se fier à l'expérience des collègues

La plupart du temps, Étienne s'appuie sur l'expérience de ses collègues quand il a des décisions à prendre. Il est encore nouveau, il essaie donc de profiter de l'expérience des autres. Par exemple, s'il donne un cours pour la première fois, il prend le même livre que ceux qui le donnent en même temps que lui. La prochaine fois, peut-être, il fera son propre choix de manuel, car il aura une meilleure idée du déroulement du cours. Souvent, un autre enseignant aura déjà une liste d'exercices choisis pour donner aux étudiants et provenant du manuel choisi. Étienne utilise cette liste et l'ajuste selon ce qu'il a couvert en classe. Il regarde aussi d'anciens examens pour en créer un qui soit équivalent.

Concernant la séquence du cours, il a toujours utilisé celle des autres enseignants en se disant qu'il pourra la modifier plus tard. Pour chacune des sections et en lien avec le sujet à aborder, il s'inspire de plusieurs éléments. Il questionne parfois les autres enseignants qui donne le cours en même temps que lui. Il regarde ce qui est fait dans le manuel et ce qu'il peut trouver sur Internet. Il essaie aussi de s'inspirer de ses souvenirs alors qu'il était lui-même étudiant au cégep ou encore il se remémore son stage. Étienne peut aussi avoir accès à ce qui se fait dans d'autres institutions par plusieurs amis qui, comme lui, sont enseignants au collégial.

Parfois, face à une décision, Étienne se joindra à la majorité des enseignants même s'il n'est pas en accord. Par exemple, les autres enseignants demandent à leurs étudiants d'apprendre toutes les formules d'intégration par cœur. Personnellement, Étienne aimerait mieux leur donner à l'examen. Il sait que les étudiants apprennent les formules à la dernière minute, comme lui le faisait lui-même quand il était étudiant, pour ensuite les appliquer sans trop les comprendre et finalement l'oublier dès que l'examen est terminé. Mais pour l'instant, il agit comme les autres enseignants. Aussi, pour aider les étudiants à savoir s'ils ont compris la matière, Étienne aime donner des évaluations formatives ou des mini-tests avant le premier examen. Selon lui, cela donne un aperçu de l'examen aux étudiants et les aide à diriger leur préparation en vue de l'examen et réaliser ce qu'ils doivent améliorer. Par contre, avant de donner le premier examen cette session-ci, il n'y aura aucune autre évaluation. Le collègue avec qui il travaille ne voulait pas en faire. Comme c'était la première fois qu'Étienne donne le cours, il préfère regarder ce qu'un enseignant expérimenté fait d'abord. Il va voir à la fin de la session ce qu'il va faire pour la prochaine fois. Ainsi, Étienne va se conformer à ses collègues, même si c'est à l'encontre de ce dont il croit utile. Il va aussi suivre les indications de ses collègues même s'il ne connait pas la provenance de l'information. Par exemple, dans les cours de calcul différentiel et intégral, la règle implicite est que l'enseignant essaie d'introduire l'idée de preuve, l'aborde parfois en classe et demande possiblement une preuve dans l'examen. Par contre, Étienne ne sait pas d'où provient cette exigence. Il répète ce qu'il voit faire par ses collègues même si ce ne sont pas des règles qui sont écrites. Il ne sait pas d'où ses collègues prennent les informations. Mais ils en parlent entre eux et se disent qu'en calcul différentiel, les étudiants devraient être capables d'effectuer des preuves, car ils en auront dans le cours d'algèbre linéaire et géométrie vectorielle et dans leurs futures études dans la branche scientifique. Cependant, les étudiants en sciences humaines n'auront probablement pas à en faire à l'université, c'est donc moins intéressant. Quand il était étudiant au cégep, Étienne était vraiment « anti-preuve ». Il détestait en faire et il savait que dans le pire des cas, il y en aurait seulement une à l'examen. Mais comme ses collègues en font, il va le faire aussi.

En ce qui concerne les notes de cours, on lui a déjà donné des notes préparées pour l'aider à débuter son enseignement. Il avait en tête de les retoucher plus tard, quand il connaitrait mieux le cours et aurait une meilleure idée des concepts à accentuer et des difficultés des étudiants. Jusqu'à maintenant, il a repris quasiment les mêmes documents, car il avait trois préparations différentes à faire de sorte qu'il manquait de temps. Il espère le faire éventuellement.

Mathématiques avancées

Étienne refuse d’être un de ces enseignants qui vont trop loin dans les mathématiques ou dans le formalisme. Ainsi, il doit faire un effort conscient pour s’ancrer au cégep. Selon son expérience à l’université, il importe de tout prouver. Mais, au cégep, ce n’est pas toujours pertinent pour les étudiants. Il importe donc pour Étienne de délaisser ce besoin de tout prouver et de se questionner sur la nécessité d’aborder les preuves ou les raisons sous-jacentes à un résultat, tout comme ce qui est pertinent de seulement prendre pour acquis sans aucune sorte de justification. Étienne réfléchit longuement à ce dont les étudiants ont besoin pour prendre ces décisions. Par exemple, pour les étudiants qui étudient en sciences nature au cégep et qui se dirigent dans le domaine de la santé à l’université, les mathématiques ne sont probablement pas ce qu’ils aiment le plus ou la matière dans lequel ils seront le plus forts. Surtout, ils n’utiliseront probablement pas les concepts de mathématiques du cégep dans leur métier et encore moins les démonstrations. Selon Étienne, il est donc intéressant de présenter quelques démonstrations, mais pas toutes.

Il lui arrive parfois, lorsqu’il enseigne, de dépasser l’objectif prévu et d’enseigner quelque chose qui nécessite de faire une preuve. Dans ces moments-là, Étienne se ramène à quand il était étudiant. Pourquoi était-il là ? Par conséquent, pourquoi les étudiants sont-ils là ? Ils veulent comprendre, peut-être, mais surtout réussir le cours, c’est leur priorité. Il se souvient qu’il n’écoutait jamais, au cégep, quand son enseignant faisait des preuves sachant qu’il ne serait pas évalué là-dessus. Étienne croit que si ses étudiants veulent vraiment comprendre la provenance d’un résultat ou s’ils souhaitent aller plus loin, ils vont venir lui poser des questions. Il ne sert donc à rien d’aller dans l’abstrait ou le superflu et de risquer de rendre les étudiants confus, quand leur but est de réussir. Il restreint donc son enseignement et aborde des preuves seulement si l’établissement l’exige.

Or, Étienne n’est pas toujours capable de tout démontrer et de justifier ce qu’il enseigne. Par exemple, il se souvient avoir récemment introduit, en calcul intégral, une formule d’économie, sans preuve ni justification. Ce n’était pas nécessairement pertinent pour les étudiants d’avoir cette justification. Par contre, même si les étudiants avaient voulu plus de précisions, Étienne ne serait pas en mesure d’en donner. Il reconnait ne pas toujours posséder les compétences afin d’introduire des applications de manière rigoureuse, car ce ne sont pas des choses qu’il a abordées au baccalauréat.

Cours dans les programmes techniques

Étienne a été très étonné du nombre de cours de mathématiques enseignés dans le cadre des programmes techniques au cégep. Comme il est nouveau et qu'il ne connait pas ces cours, il hésite à les enseigner. Il se concentre sur ceux qu'il connait, c'est-à-dire les cours de base des programmes préuniversitaires ou encore les cours de rattrapage des mathématiques de niveau secondaire. Étienne a vu la session dernière un enseignant, qui a la même ancienneté que lui, donner un cours en technique où il a dû programmer, sur l'ordinateur, des trucs très élaborés qu'Étienne n'a pas la moindre idée comment faire, et encore moins comment le corriger ! Il croit que le moment où il va se sent à l'aise de le faire va venir. Heureusement, l'établissement où il enseigne ne l'oblige pas à le faire.

Lors de son certificat en enseignement collégial, Étienne a fait un stage. Il a été jumelé à une enseignante qui donnait un cours de mathématiques pour un programme technique. Le cours englobait beaucoup de contenu qu'il ne connaissait pas, environ la moitié de ce qui a été couvert. Étienne les apprenait en même temps que sa superviseure de stage les enseignait afin d'être capable de répondre aux questions des étudiants. Il ne s'en souvient malheureusement plus aujourd'hui et devrait tout réapprendre s'il devait l'enseigner. Il a aussi mené une séance en classe, une exigence du stage, où il a enseigné les tableaux booléens, les implications et les tables de vérité. Ce sont des concepts qu'il a dû réapprendre, mais qu'il connaissait à la suite de son baccalauréat. Ce cours a été l'occasion pour lui d'apprendre à compter en binaire ou en base 8, ce qu'il n'avait jamais vraiment compris auparavant. Il a donc vécu une belle expérience dans ce cours technique dans ses stages, mais il ne serait pas à l'aise de l'enseigner seul.

Vision des mathématiques

La perception qu'Étienne a des mathématiques a changé à chaque fois qu'il a changé d'ordre, du primaire au secondaire, du secondaire au cégep et du cégep à l'université. Par exemple, en arrivant au cégep dans le cours de calcul différentiel, tout à coup il est possible de diviser par zéro ou encore quand les racines carrées de nombre négatif, autrefois impossible, se transforme en quelque chose avec lequel travailler : les nombres complexes. Quand Étienne explorait les mathématiques plus en profondeur, il rencontrait une nouvelle réalité et voyait les mathématiques différemment.

Le diplôme de deuxième cycle a été la première occasion pour Étienne de se questionner sur la définition des mathématiques. Au baccalauréat, il appliquait et résolvait des problèmes, mais ne se posait pas vraiment de questions sur la nature de ce qu'il faisait. C'est une professeure du certificat en enseignement collégial qui l'a d'abord questionné à savoir si les mathématiques forment une science ou un outil, et si les mathématiques ont été découvertes ou créées. Étienne n'avait jamais pensé se poser une telle question auparavant et n'aurait pas répondu la même chose aujourd'hui sans avoir passé par le certificat. Après mûre réflexion, il a l'impression que les mathématiques sont créées, et qu'après les avoir créées, on découvre des choses supplémentaires avec ce que l'on a créé. Par exemple, Étienne a travaillé au baccalauréat sur la géométrie hyperbolique dans le plan complexe. En quelques mots, il s'agissait de prendre les axiomes d'Euclide, sauf un, et de créer une nouvelle réalité. Ensuite, il faut l'explorer pour en découvrir les caractéristiques, ce qui le pousse à croire que les mathématiques sont créées puis que les caractéristiques de ce qui a été créé sont à découvrir. En ce qui concerne la 2e question, Étienne croit que les mathématiques sont un outil. Ça sert à résoudre des problèmes de physique, de chimie ou de biologie, à comprendre des phénomènes qui sont tous reliés à une autre discipline. Sinon, les mathématiques c'est une discipline en soi en ce qui concerne les éléments de base, comme de l'algèbre toute simple ou des calculs. Il ne pense pas que ses étudiants aient une opinion sur ces questions. Après tout, lui-même ne s'est jamais posé la question avant ses études graduées. Il croit que cette question n'intéresse pas assez les étudiants. Pour qu'elle soit intéressante à explorer, il faut aimer les mathématiques. Il a l'impression que s'il leur pose la question actuellement, il recevra une réponse ressemblant à « je m'en fous un peu » de la part de la plupart de ses étudiants.

Cours pour les étudiants intéressés à l'enseignement collégial

Dans le cadre de son baccalauréat, Étienne a suivi un cours qui s'adressait aux étudiants de mathématiques qui s'intéressaient à l'enseignement postsecondaire. Dans ce cours, Étienne a entre autres étudié les intégrales et les dérivées afin de comprendre la matière couverte au postsecondaire de manière un peu plus poussée. Ils ont travaillé avec des logarithmes et leurs propriétés, et ce dans des problèmes complexes. Étienne a vraiment pu approfondir ses connaissances sur les logarithmes ainsi que de prouver toutes les propriétés, ce qu'il n'avait jamais eu la chance de faire auparavant, comme $\log_b b = 1$. C'est de la matière qu'il connaissait, mais il a pu l'approfondir. Ils ont aussi appris à travailler avec un logiciel de géométrie dynamique qu'Étienne utilise dans ses cours. Il a donc une meilleure compréhension de ce qu'il doit enseigner.

Toujours dans la cadre du même cours, Étienne a dû choisir un cours de technique et rencontrer un enseignant qui le donne. Par la suite, il a dû écrire un travail sur ce qu'est ce cours, son historique, ses objectifs ainsi que de préparer un mini-cours qui se terminait avec un examen donc il avait composé le solutionnaire.

Stage

Dans le cadre de son certificat en enseignement supérieur, Étienne a fait un stage dans un établissement collégial. En particulier, ce stage lui a permis d'en apprendre davantage sur l'existence des tâches administratives, comme le poste de coordonnateur du département, mais aussi sur les aspects administratifs du travail d'enseignant. Il a pris conscience de plusieurs aspects dont il ne se doutait pas, tel que la gestion de l'impression des documents, les accommodements pour les étudiants en difficulté et les réunions départementales et syndicales. Il a aussi appris l'existence des centres d'aide en mathématique. Il se souvient de la première fois qu'il est allé. Il était accompagné par un enseignant et un étudiant est arrivé avec une question sur un sujet dont Étienne ne se souvenait plus du tout ! En tant qu'étudiant au certificat et stagiaire, il ne faisait plus des mathématiques tous les jours. La question de l'étudiant concernait les propriétés des sommations et il devait répondre sous le regard de l'enseignant qui l'accompagnait. Ce fut une expérience très stressante.

Il a aussi pu prendre en charge quelques séances de cours, dans le programme de technique informatique. Il a reçu des commentaires de la part de sa superviseure de stage qui lui a fait remarquer qu'il regardait trop sa préparation de cours quand il enseigne. Elle disait que les étudiants seraient en confiance de le voir se détacher de ses notes de cours et que, de toute façon, il sait comment résoudre les problèmes qu'il fait en classe.

Dans son stage, l'enseignante avec qui Étienne travaillait lui a aussi fait composer une question d'examen et lui avait laissé corriger. Il a aussi corrigé une série de travaux pratiques dans un autre cours.

Sam’s Stories

Teaching in Continuing Education

Sam knew before he entered university that he wanted to be a cegep teacher. He also had this expectation that he would be the cool teacher, that he would get along really well with his students, and that they would find him approachable. Overall, Sam expected to be pretty good at his job. This all worked out for him. Even the ways in which he imagined he would teach, how he would lecture, or approach the job in general turned out to be close to reality. However, something he did not expect to do is teaching in continuing education, and so to the students who take night classes. Indeed, he was a daytime student when he attended cegep and was not even aware that continuing education existed before he applied for a teaching position in cegep. Teaching in the continuing education program did not completely clash with his image of what teaching cegep would be like, but he definitely noticed something peculiar about it. The culture is different, though he likes it a lot. The students are in general older than students who study during the day and tend to be more responsible. It is a group to which he connects well. The students are also, in general, weaker than the day students. Indeed, Sam has taught groups of students who come from the day program during a summer class; he perceives them to be stronger than the students in continuing education.

Teaching in continuing education impacts Sam's life as a teacher. For instance, he does not have an office, which means that he has to go out of his way to get support from, and ask questions to, other teachers. Nevertheless, other teachers are supportive when he does approach them. He received feedback about whether his exams were fair, whether they were reflective of the material that should be taught, or got feedback on his ideas. Sam used to talk only to the head of the mathematics department. She was friendly and approachable. She would also recommend other teachers to talk to who might be, for example, experts in certain areas of mathematics or in certain courses. Sam had to reach out, for example, about how to deal with a situation where students have to take a make-up test. There is no clear policy in place for such a case for night classes. Indeed, since he is a contract worker who is paid by the hour, he has to take time out of his day, which he is not paid for, to have the student write the test. There is also the question of whether the students' excuse for not being able to take the test is serious enough and whether or not Sam can pursue other alternatives such as not counting the test or averaging their grade in the end. Therefore, teaching night classes makes handling the policies a challenge; but there are people in the department who are willing to help if Sam reaches out to find the information.

Because Sam teaches in continuing education, there is no requirement for him to attend department meetings. In Sam's opinion, it is not conducive to the sense of belonging to a team of teachers when it is not mandatory to go to meetings. However, he thought it would be self-sabotaging not to go so he decided to attend anyway. That way, he was able to integrate himself more into the department and to understand who his colleagues are. It ended up helping his teaching in a lot of ways: he heard how other people approach situations and learned of some red flags about how some situations should not be approached. Sometimes, pedagogy gets discussed in the meetings, as does marking. Sam does not always agree with the majority of the teachers, but these meetings give him a frame of reference, especially for reinforcing what he thinks is intuitively right or wrong when it comes to his teaching.

Being a Student in University

Overall, Sam's experience in university has a bigger impact than his experience as a cegep student does on how he chooses to teach mathematics in cegep. For one, because he is at the bottom of the seniority list, Sam teaches night classes. Given that he only took day classes as a cegep student, he cannot draw upon his personal experience to guide his teaching.

Sam never experienced difficulties in mathematics in cegep. This prevents him from relating to his students' difficulties. Sam started with a leg up in cegep due to the fact that he was in an advanced mathematics class in high school that covered almost all the curriculum of Calculus I. In fact, he does not think he needed to study at any point in his education until his first year of university, when he experienced a massive spike in difficulty. The struggles he experienced when he arrived to university allow him to relate to his students more. These struggles also made him realize that it was not a weakness to ask for help. Before starting university, he had the impression that asking for help was a sign of weakness. In university, he became more willing to ask the instructor or the teaching assistants for help. Doing so helped a lot. Sam realized that asking for help is a good way to overcome obstacles in the areas of mathematics with which you have difficulty. This is a lesson he can pass on to his students.

Having difficulties made Sam give mathematics the time and attention it deserved, which made him discover and understand mathematics on a new level. Indeed, he found that in cegep, mathematics was taught to him deceptively as being an even split between step-by-step procedures to be memorized and occasional creative applications of those procedures, rather than something more abstract or axiomatic like what it was in university. He does not think he truly knew what mathematics was before university. For example, proof is an integral part of what he did in university. This is something in which he had not been trained earlier. Proof had been misrepresented as not even a salient feature of mathematics. Once he got to university, mathematics involved an entirely different way of thinking which was new to him and which made him appreciate mathematics more than he ever appreciated it before. Now, as a cegep teacher, Sam purposes to include some of abstract side of mathematics in his teaching to try to get students to appreciate the more interesting sides of mathematics. This is something he did not receive in cegep as a student but which he discovered in university and genuinely enjoyed.

Sam likes to pepper his class with interesting ideas. A good example is Gabriel's horn in his Calculus II class. It is as finite volume with infinite surface area. In class, he highlights how peculiar it is and asks students to ponder that. They discuss how odd this is and think about it mathematically. It is not, however, something Sam would evaluate them on. Something interesting on which students may be evaluated, in a secondary 4 class, is the proof of the equivalence of the Pythagorean theorem and the distance formula. This proof also requires creativity, which is hard to teach. And unfortunately, the skills that are rewarded in mathematics, such as the ones in art, are not always teachable.

This goal Sam has of showing interesting and sometimes abstract ideas to his students has forced him to seriously and explicitly ask himself what mathematics is, something he had not done before. To him, much of mathematics is like solving a riddle, where you are first given an axiomatic background to the riddles that you are constructing. Mathematics has indeed a lot of common ideas with riddle solving, like parsimony with information you provide. For example, in a well-structured riddle, you do not give more information than is needed. But you also do not give less information than is needed because then the riddle cannot be solved. Mathematics problems are constructed in the same way, with this implied mutual understanding that you are constructing a riddle about something everyone is supposed to know about. Maybe this sounds boring to some people. But to him, this is beautiful. Mathematics is a riddle and riddles are supposed to be fun and intellectually engaging and stimulating.

To sum up, Sam tries to reinvent what mathematics is to his students and to create meaning when it seems to be missing. He wants his students to approach it differently, in a more thoughtful and methodical way, that maybe gives them more appreciation for it, similar to how he started to approach it in university.

However, Sam does not think it is his job to be a mathematical evangelist, to make them love mathematics the way he does. Even if it were his job, he does not think he would be able to fully communicate his understanding or appreciation of mathematics because they would not be ready for it. They lack the sufficient mathematical background to do that, given how they were taught mathematics up to this point. His goal is to get them started on the path toward being ready for such understanding and appreciation.

If his role is not to make everyone love and enjoy mathematics in some incredibly profound way, then what is it? Part of it is to be transparent about the fact that mathematics in cegep is conceptually different from high school or university. It is also to get them through it but still in a way that takes it seriously. He does not go completely easy on them. He does not believe in "dumming" a course down because there are expectations that people will do badly at it. If the material is challenging, then there is a unique reward for being able to fully take in what is challenging about that material. That said, he does not think that students have to have a mathematician-level knowledge or appreciation of the material just to get by. His role is to please almost everybody; not just the students who are totally helpless. He aims to make the course accessible even to people who are not passionate about mathematics, but who are still willing to put in the work. Sam wants to do all this in a way that captures their attention, makes it worth their time, and makes it entertaining.

Mathematical Preparation for Teaching a Course

At the beginning of his career, when Sam taught a course that was difficult, such as Calculus II, he would prepare for unbelievably hard problems. He believed students might throw an extremely difficult question at him and he would have to show that he could do it on the spot. He was in a mindset where, in his role of teacher, he could not, in any way, show any weakness at all. With this idea that he would have to be able to do any problem, Sam would look for incredibly difficult problems on the internet and solve them, or at least map out how he would do them. It was such an overestimation of how much a student would need to get 100% in that course that doing it made him feel confident he knew the material enough to teach it. Today, Sam is probably more comfortable than most telling his students he is not sure what the answer to a specific question is and that he will think about it for next time.

Sam's take on proofs was different. He did not feel he had to know every proof of everything he taught to be confident that he mastered the material. For example, his favourite theorem is the Riemann rearrangement theorem. He does not know the proof of this theorem. He did look it up once, but said he dismissed it because it looked hard. This is one thing that he teaches to his students every year but only knows to be true because he trusts the community of mathematicians behind it.

Provide Extra Resources

Sam remembers that, in university, there were a number of courses he took where there was neither a textbook nor some official online resource for the course. In these cases, he feels too much was left to the individual ability and autonomy of the student to figure out the material. That is a symptom of teachers who do not put themselves at all in their students' shoes. Putting himself in his students' shoes is key for Sam. In general, students could use guidance and explanations that are sensitive to a variety of learning styles. He is sensitive to the fact that some students are learn differently from others. What is the role as a teacher, if it is not at least to provide help? Sam really thinks teachers should give alternative options to students for whom lecture is not enough or if they missed the class.

For example, Sam has had students who recognized that the material was a huge source of difficulty for them. It is not something at which they are naturally great. Mathematics does not always immediately resonate with them as it may resonate with other people, but they work hard to succeed. One particular student clearly did work hard and finished the course in the low 70s. That student asked Sam for problems from the textbook she could use to understand the material better. His idea is that if this student is going out of her way to ask for ways to improve, then his role is to put an equal amount of effort into providing these examples for her. Sam therefore put efforts into organizing the list and making sure the examples are well selected and that there are not going to be things they have not learned or that are well beyond the scope of the course.

Learning a Lot of Mathematics

Sam did not study mathematics in university for any purpose other than teaching it. One might think that he went through more mathematics than he needed if he all he wanted was to teach cegep-level mathematics. But he believes that without his time in university, his explanations to students would not have been deep. For him, learning beyond what he has to teach his students is tremendously helpful. It gives him more confidence to articulate concepts to his students. It allows him to project a strong mastery of the material, contributing to the teaching persona he projects in class. Sam has seen a study that showed a strong correlation between knowing a subject and being able to teach it. On that basis alone, he would say his degree was helpful.

Furthermore, doing a lot more mathematics has also taught him an extensive vocabulary to which students are not used. This distinguishes him from people who would not have studied mathematics as extensively. For example, he refers to things like commutativity in multiplication even though some students have probably not heard that word before. He will use words such as multiplicative identity or inverse and give a brief explanation of what that means. He is very careful with the expressions he uses, especially when teaching limits. Students will say thing like "plugging in infinity." He will say things like "we are making it arbitrarily large" or "arbitrarily close to this value." The use of the word "arbitrarily" in that context registers to him as mathematicians' language and it is not something of which the average person may think. He thinks it is important to go through definitions in a way that seem mathematically formal and dense to show that there is more to the concepts than an intuitive explanation.

For example, limits are often explained using intuitive definitions or geometric understanding that students will hold on to and rely on when a more formal definition might require more analysis. In terms of what they are being evaluated on, they are often able to memorize procedures and answer questions. However, a lot of concepts that are related to limits, such as series, are misunderstood by students in a formal sense and his own more formal training allows him to attain the necessary level, which he only got to after cegep. Now, the challenge is to filter his teaching through his higher education and teach what would be appropriate for the level of his students.

Sam also believes that without his time in university, his oratory skills would not have been good since this is when he created for himself what he calls his "teaching voice." Indeed, a few years ago, he decided that he did not want to be stumbling when lecturing in class. It might ignite an erosion of respect or be a sign that he did not have enough of a foundation of knowledge in the material. That motivated him to find a teacher's voice that would work for him. Something a bit more pretentious, but still mixed in with his personality. He worked on being taken seriously, show expertise while still being able to relate to his students, joke around, and be approachable. Following his first teaching experience, teaching a class in university, he received negative comments in the course evaluations regarding his personality. Since developing and finding his teaching voice, he is happy that he never received such comments again.

Applications

Sam feels that he lacks knowledge about mathematical applications. It bothers him not to know more. It would probably make him a slightly better teacher to be confident in his knowledge of mathematical applications. He likely would not teach any differently than he already does but it would make him more prepared for any question a student might ask. Sam would like to have a complete knowledge of this area that is a huge part of his life and of his teaching. When he has to teach some applications, Sam prepares extensively.

During his mathematics training in university, anything that involved an excessive number of applications did not resonate with him well. He took a course on partial differential equations, which is reasonably proof-heavy, but when there were parts that could be understood better by some reference to real-life applications or anything to do with physics, he struggled. Part of the problem is that the mathematician in him did not care. Sam has idealized views of mathematics and he does think it would be worth studying even if it had no applications at all or any functional real-life purpose. If pure mathematics were all that existed, it would be interesting and still worth learning. Sam feels he has blinded himself throughout the years, as a result of this mindset, to a lot of mathematics-related applications and the exact competencies students might need later on after graduating from cegep, both of which might have been useful to know as a teacher.

As such, even though he has been able to do a good job as a teacher while being relatively weak in the area of applications of mathematics, he wants to know more interesting applications of mathematics. Sam wants to make that portion of the course interesting and relevant to the students. He does not want it to be just about ticking off a box, like applications are often treated in class. Sam believes that applications are often covered lazily. Students are given any word problems where clearly nobody is going to use that mathematics procedure to solve this problem in real life.

Once, Sam learned from the textbook that he needs to give some type of flow or traffic problem to the students, with the broader goal in mind of giving them real life linear algebraic applications. Sam did not stop there. He wanted to see if people have actually used the application. He has found that people in Ghana used linear algebra to solve a traffic float problem. They used it to back up claims about certain intersections in the capital of the country being congested and traffic-inefficient. These claims were presented as evidence for policy changes such as adding traffic lights. This was a problem about the number of vehicles that can go through a certain stretch of road. Addressing such a problem introduces students to applications of systems of equations, a concept about which they have already learned. He told his students that some people have tried this for real and that it is truly helpful. This is a situation where it is interesting, for instance, to talk about problems which are restricted to a particular domain because of the circumstances of a real-life application. There cannot be negative numbers or a fractional number of vehicles going through a road.

Another type of applied problem Sam uses in the classroom is related to probability. Some probability examples he comes up with can be whimsical, funny, or relevant to students. For example, he finds interesting to give a Markov chain example. In the US, in the 1960s, the employment rate for women was about 40% because many women were not allowed to work. In class, he talked, first of all, about the fact that a lot of people consider their work to be a chore, and that for some the right to be able to work is considered hugely empowering. He talks about such issues even if it is not completely mathematics-related. It gives some motivating background to what he is about to teach. He gives the example that in a given decade, there is an employment rate for women that depends on whether a woman's mother had been employed. Women whose mothers work are more likely to be employed themselves, and women whose mother did not work typically continue the cycle. There are probabilities associated to each of these and it is possible to determine after some number generations the percentage of women that will be working. By giving an example like that, he found that women in his class who had not participated before were participating. While not all women are self-identified feminist and find feminist issues engaging, there was more engagement from everybody in the class, and especially from women. The choice of that example was partly because he thought it was interesting and it appeals to some of his interests. He also thought it might be relevant to his students' lives and give him things to talk about that are not explicitly mathematics-related but still emphasize the link between mathematics and reality.

Relearning Mathematics to Teach It

The first time Sam taught linear algebra, he had to relearn much the material because he had not done it in a long time. Learning it the second time was completely different, especially in how he looked at the abstract concepts such as vector spaces. Studying these concepts formally in university gave him a different foundation and a different perspective as to why it would be interesting or what might be important about it. Additionally, going through the process of teaching the material to himself gave him some frame of reference for teaching it to his students. He could repurpose ways that he would explain the material or make it interesting to himself and use them when he taught his students.

Students' Struggles

During his master's program in mathematics education, Sam got to study students' misconceptions in mathematics. These experiences transpire in his teaching as he can now predict some of his students' difficulties and hypothesize on the thinking behind these. Moreover, his experiences in the classroom in the past three years have taught him many things about difficulties students have, mistakes they make and the reasoning that got them there, and even more misconceptions they may have. Therefore, his teaching is predictive and based on past experiences with students. Sam can therefore show his students not only what to do, but also what not to do. For example, if students are *not* told that the integral of a product is not the product of the integral, $\int f(x)g(x)dx \neq \int f(x)dx * \int g(x)dx$, they might think it is true. Another thing that seems too good to be true is that $(x+y)^n = x^n + y^n$. So Sam explicitly tells his students these are not true. Talking about these is a bit self-serving, because Sam likes talking about statements, mathematical or otherwise, that appear to be true, but turn out to be false. Also, if students pursue these misconceptions, at least there is some accountability on their part because Sam told them not to. It tells them that if they were to listen to him in the future, it could be to their benefit.

Sam puts some true or false questions in his tests to address such misconceptions. For example, one question asked if an integral of the product of two functions is equal to the product of the integral of each function. To stop his students from thinking that, he reminds them in class that it is not true. To evaluate whether they have paid attention, he gives them questions about it on a test. Furthermore, this tactic has the benefit of reminding them not to make these mistakes later on in the test. One of the main goals of the course is for students to learn and that there be some transfer of knowledge from him to the students by the end of the semester. One way for this to happen is to have reminders or situations or memories that stand out in students' minds. If they remember certain things coming up on a test or making certain mistake somewhere, they may better remember them down the road. This is the reasoning behind the design of his questions.

On another note, by knowing what his students struggle with, Sam can teach them in a way that addresses these difficulties. For example, trigonometric substitution is something with which students struggle. It is different from the other methods used in Calculus II and it may seem unusual that the integral of functions that looks quite nice, like $\frac{1}{\sqrt{4-x^2}}$, can be inverse trigonometric functions: $\int \frac{1}{\sqrt{4-x^2}} = \arcsin\left(\frac{x}{2}\right) + C$. When teaching this method, Sam goes out of his way to go slowly, to identify visual cues, to explain strategies. He details why it is that he is performing a substitution to get something in a certain identity and why things cannot substitute in certain ways. He reasons with his students strategically about what needs to be done to allow them to develop some intuitive basis for why the method works and why to make certain choices. One thing he does is make a substitution that is wrong or even take their wrong idea for a substitution just to see where it goes. Students can then see that it does not work and think for themselves about why it did not work and what makes a problem solvable in one way and not others. Therefore, his teaching method is to expose them to this world of lies, have them root out possible misconceptions, and learn through these misconceptions.

Another example of a difficulty students have has to do with the chain rule $\frac{d}{dx}[f(g(x))] = f'\big(g(x)\big)g'(x)$ in Calculus I. The expression $f'(g(x))$ is unclear to many students. They think that it means plug g into f, then derive it, which would be written as $(f(g(x)))'$, and not the other way around: derive f and then plug g into the resulting function, $f'\big(g(x)\big)$. Sam tries to pre-empt this mistake by saying up front that it does not mean what they may think it means. He remembers that, as a student, this was not clarified for him. However, he still "understood" it through imitation and by seeing multiple examples of what was expected of him. This always worked out for him so he did not question whether there was anything more to the procedure. He only truly understood it much later, which is why he tries to explain it properly to his students.

Sam does believe that the way the chain rule was taught to him taught him a valuable lesson that he can now use in his teaching. He learned that what might be meaningful to a mathematician might not be meaningful to a mathematics student. This can happen even if the mathematical symbolism and vocabulary used are rigorous, even if there is nothing wrong with the way statements are made; a statement might still be ambiguous or make no sense at all to a student. Even if there is a canonical way of presenting something in a mathematics classroom, there might be possible misunderstandings associated to it. Therefore, Sam can teach some concepts the way it is typically taught, with the way that mathematical convention works, the way we write certain things as a community with the usual mathematical nomenclature, and there might still be certain ambiguities for students. He therefore has to attend to those ambiguities and misconceptions, even when he teaches in the most conventional way.

Another misconception Sam discovered is that students do not seem to understand how literally or strictly a rule or formula needs to be applied. For example, the first part of the fundamental theorem of calculus states that $\frac{dF(x)}{dx} = \frac{d}{dx}\left[\int_a^x f(t)dt\right] = f(x)$. It is meant to be taken literally. It only works if the upper limit of integration is x, it does not work if it is any other thing, and the bottom needs to be a constant. However, when he gives a problem where the upper limit is x^2, students might apply the theorem directly and get $f(x^2)$. It feels to him as if students struggle with the limitations the theorem gives them as well as with the power it gives them. They struggle with how wide or narrow the set of instances in which a formula applies is and what to do to expand that set properly. This misconception led Sam to question his idea of what mathematics is, to find ways to address that misconception proficiently. Indeed, if students cannot even apply theorems such as the first part of the fundamental theorem of calculus, they may have a misunderstanding of what mathematics is and how it is supposed to work. He now uses the metaphor that mathematics is very lawyerly. When a case is adjudicated in a courtroom, there are orthodox sets of laws that have to be referred to and interpreted strictly, often in a mechanized way and without much room for interpretation. In Sam's eyes, mathematics is like that, with more of an element of beauty to it. Hopefully, this helps students understand that they need to apply rules strictly as they would civil laws.

Sam finds that students also struggle with a basic level of mathematical rigour. Students often give a simple example when asked to a prove a general statement, even if they know for a fact that that would not be accepted in a real-life situation. It suggests a serious misconception about what it means to prove a general mathematical statement.

The Master's Degree

Sam remembers thinking, at the end of his cegep degree, that since he knew all cegep-level mathematics, he could teach it. He realizes now that he was nowhere near as prepared as he was after he went through the master's degree in mathematics education. A lot of classes helped crystallize his understanding of mathematical concepts about which he had already learned. Even relearning abstract, logical things like learning about Peano's arithmetic, was genuinely helpful. Relearning cegep-level mathematics courses from an analytical perspective, more rigorously and without the mathematical hand-waving that might be taught in cegep-level mathematics courses, was hugely helpful. For example, infinite series are one of his favourite topics; the way they are taught at the cegep level leads students to get the misconception that an infinite series is literally a sum obtained by adding infinitely many numbers rather than a limit of a sequence of partial sums. Familiarizing himself again with things that he had already learned or of which he already had a strong functional understanding, and reinforcing his understanding, was helpful.

Now that he has gone through university, he tells students that the mathematics they learn may be slightly above what they need. They have to push themselves a bit to truly solidify knowledge they have and actually need for their future. That is why schools do not teach students only the very basics of each concept. They get more and more challenging examples to push their limits and push themselves, and have better knowledge retention over time.

In addition to what the master's program brought Sam mathematically, there was also what it brought him pedagogically. Anything that allowed discussion with and feedback from other potential teachers, such as talking about what actually works with students and misconceptions students have, was helpful. This helped him actually get into students' skin and predict their mistakes. Identifying the thinking behind their mistakes once they made them was hugely helpful, and that is a skill he largely credits—90% of it—to the master program, with the other 10% to his innate abilities.

Assessment of Understanding

Sam remembers not fully understanding the material he was taught as a cegep student. Still, he was able to successfully solve problems and earn good grades. Indeed, Sam has gone through situations as a student where time constraints forced him to decide what he would and would not learn and understand. However, even when he did not have the time, he would still go through the motions, execute whatever procedures were required of him, and succeed. Sam could figure out how to mimic procedures he learned in class without having any deeper understanding. So Sam knows that some people succeed in mathematics by performing within that scheme of glorified instruction-following that often prevails in the mathematics classroom. He struggles to see how he can assess whether students actually understand the material he teaches; after all, he experienced first-hand how one can succeed without understanding.

Sam does not know how he could have assessed his own understanding when he was in cegep. Looking back to his understanding is an interesting metacognitive experience; it was hard to tell what he had difficulty with before mastering it. He is able to look back, now that he understands things better, and identify what he had issues with. Thus, he does not know if, and how, his students are successfully assessing their understanding. However, one event suggests to him that students do have some notion of what can help them test their understanding. Early on in his career, some students asked him for a list of textbooks problems. He originally neglected to give it to them because he was either not fond of the textbook or he just did not incorporate it that much into his teaching. Now he has a list ready.

When thinking about students' understanding, Sam recalls a story of a talking bird—not a parrot, but a bird that could talk. The bird had been taught some basic mathematics, mostly through what seemed like memorization. However, at one point, the bird answered a question for which the answer was "zero" but it answered "none." That displays an understanding of the conceptual link between those "zero" and "none" words. He would say that students' understanding is kind of similar. If they are able to repeat things back to him, maybe in different words or in a different way, this usually indicates that they may not have a perfect understanding but do have more understanding than they did originally. However, Sam finds it difficult to get such information in an exam in the way exams are traditionally done in mathematics. Indeed, it is a challenge for him to draw the distinction between a question that is similar to what was done in class and therefore does not test understanding and a question that is similar but tests understanding. Indeed, in the first type, students could just mimic the procedure and get it right even if they may or may not understand what is going on. To be sure students understand, Sam would need to have a discussion with them or at least more information than what usually appears in a regular mathematics evaluation.

Sam would love to have more flexibility in how he can assess his students, to hopefully attend to their understanding. This flexibility would also allow him to attend to how different kinds of students can show and express understanding. Once, Sam had a student who was extremely active in class, asked insightful questions, and answered questions correctly most of the time. In other words, she showed mathematical knowledge in the classroom. And yet, when it came to quizzes and tests, she was average at best. On that occasion, Sam wished he could give grades for participation or through another method where being neuro-atypical and having an understanding that does not always shine through in regular evaluations could be acknowledged. Sam knows this is done in other disciplines. He even knows of a professor at the university he went to for his graduate studies who assesses people orally in mathematics courses. Therefore, it is possible to put in place assessments that could be considered unconventional, even in mathematics where the norm is to assess through written work. But Sam would be too uncomfortable going that far outside the norm. Not only has he not tried unconventional methods of assessment, he has not thought of asking the institution at which he teaches if this would be allowed. He does not know if there is a rule he would violate by doing that. He knows of some rules in the mathematics department, such as the rule that sets the weight for the final exams and the rule that students cannot pass the course if they only did the final.

That said, even without institutional norms, Sam does not generally feel comfortable to deviate far outside mathematics teaching conventions; severe deviations are extremely uncommon in mathematics. Therefore, he thinks there could be something small, such as an extra 5%, where each student gets at least their average grade, some students could get a higher grade. A student might get a higher grade if Sam knows they are promising or if they demonstrate understanding through insightful questions or by answering conceptual questions. He is aware that it would be naïve of him to think that he knows perfectly well what is going on in every student's mind. However, he is convinced there is additional understanding that shines through his students' work, either verbally in class or on a test, that is not accounted for in their grade of traditional assessments. He just wants to find a way to acknowledge that. That is the flexibility he would like to have but does not know of a practical way to make work.

Teaching the Conventional Way

The conventional ways of teaching mathematics have been instilled in Sam throughout his school life. Therefore, the core of his teaching is conventional, though he adds things onto that core. Sam does so by modelling his teaching on what he was used to as a student and adds in his personality. In this sense, he uses his experience as a student as a workable foundation on which an acceptable cegep-level curriculum can be built. When he thinks about the existing curriculum with a critical stance, he is not sure he agrees with it. But he finds it is hard to be too critical of how the curriculum is structured given that he was able to pass through the system and be good at mathematics.

Sam keeps conventional mathematics teaching as the core of his own teaching for two reasons. First, if he taught in a very different way, it might be difficult for the students to adapt. Indeed, he gets into their mathematical lives quite late and they have been subjected to traditional ways of teaching since elementary school. Sam also knows his place in the system. He knows there are certain expectations imposed on him by cegep teaching conventions and demands of a particular curriculum that requires him to teach certain things. In this sense, he filters his mathematical self through the expectations to which he has to live up.

Relation to Students

Sam felt that some people had a strong influence on him during his time in university. Some of them were not mathematicians, but role models in his university life. One particular person, a fellow student, encouraged him to just keep going. Sam learned that even at the lowest point, you do not have to give up and there can still be hope. This is something that comes out in his teaching in subtle ways. Sam does not just give up on his students if they fail the first test. He is highly sensitive to the fact that some students learn differently from others. He tries to always believe in his students and give them second chances and the benefit of the doubt.

However, that tendency backfired on one occasion. Even though he is convinced that what happened then was an exception, it encouraged Sam to have a healthy dose of skepticism in all situations. Most students are invested in the course and respectful of him. However, it would have been helpful for Sam to know that sometimes students who appear to be in a bad situation or appear to need a lot of help are in reality trying to extract favours or sympathy from him. Once, a student missed the majority of the classes and the majority of the tests, with seemingly valid excuses for all of it. By the end of the semester, the student was not even there to write the final exam and expected Sam to make the final exam 100% of his final grade, which is not even an option in the institution at which he works. Moreover, the student was outraged that Sam would not break rules for him, even though he barely showed up all semester. In general, Sam tries to go through life believing what people say. If they do need a lot of help, he tries to be sympathetic to them because he has energy and sympathy to give them. He is not heartless but he should have been clued in earlier that this person was manipulative. One thing he learned is not to go too far in any direction. He now tries to give people a chance, in a healthily skeptical way, knowing some students can be manipulative in asking a lot from a teacher and not really meeting them halfway. Sam now has a healthy skepticism in all situations.

Teaching in University

During his master's degree, Sam started to be involved in teaching. He marked some exams, ran some tutorial sessions, and taught a class for the first time. At first, he did not know how to approach teaching. He did not know how to prepare for a class. He wondered whether he should actually sit down, take a notebook, and write his lectures. Obviously, he should prepare *something*. But how much of it should be prepared? Should he prepare exactly what to say? Should he write out key words or full sentences? Should he decide what will be written on the board and have fully-solved examples ready? Should he have extra material prepared at all times? Those are all things that may be obvious now that Sam is used to teaching but were not obvious to him as a first-time teacher. He had to figure these out on his own.

Now, Sam tries to stay in a nebulous area between totally unprepared and over-rehearsed. In his lesson plan, he writes down in red anything that gets written on the board, blue is associated with key words he wants to give to himself that he might say out loud, and black is the colour of things he wants to emphasize in class. He does not write out whole sentences he is going to say so as not to be over-rehearsed. When he is at the front of his classroom, his lesson plan is on his desk but 99% of it is in his mind. He is not good at coming up with examples on the spot. He looks through his notes about an hour before class. Because mathematics is extremely logical and almost all ideas are a logical link in a chain, he finds it easy to remember things that he wants to say. Ideas flow logically from the things he said previously. Often, he is able to go through most of his lecture without consulting his notes. He needs to look at them for specific numbers in a problem. Because he overly prepares beforehand, he does not need his notes that much.

Overall, Sam finds that his experience being an instructor in university ended up being a good pilot for his teaching in cegep and a good opportunity for experimenting what would or would not work in class. He found that his experience teaching in university was good to train his lecturing skills, but not so much for interactions with students since there were few of these. Sam also remembers that the course he taught in university was being over-administered in a way that was truly helpful and formed good training wheels for a first-time teacher. There was a clear schedule for what had to be taught each week, a list of problems for the students to solve and exams were written by an experienced instructor. Sam thought he was reasonably well received by the students, even if they gave him critical comments in the course evaluation; this is expected for a first-time teacher.

Another difference between teaching in cegep and university is that cegep is in a nebulous area between high school and university where students are expected to be autonomous adults. Sam approaches teaching in cegep differently because of this. Students are expected to be on the journey to adulthood and Sam treats them in a way that is reflective of that: all the respect but not all the responsibility.

His and His Students' Interests

In general, Sam's teaching is geared towards fending off the criticism that his lecture is not useful. In that sense, he is constantly self-conscious about whether somebody will find it interesting or relevant to their life. He always thinks about what he would do if somebody were to ask him about how the material is relevant to their life or about a real-life example. For his authority as a teacher not to be discredited, he expects himself to be able to come up with an example students can at least look up on their own afterwards. In this sense, he always puts himself in his students' shoes.

These concerns come from Sam's belief that students' relationship with mathematics sometimes ameliorates when they learn about real-life examples, in particular examples with which they can relate using their own life experiences or common sense. For example, Sam mentions the price of offer and demands in Calculus I. He asks students to come up with an example of a good whose demand would change if its price went up by a lot. They think of things like necessary items, such as water. If the price of water spiked, people would need to buy it anyway. He then asks funny examples of things that people would want even more if the price went up. Students give cute examples like Apple products or shoes. If they can give an insightful answer or a funny answer, they derive some kind of meaning. He even had a problem similar to that on a final exam and some people opted for the funny answer even if they probably knew they would lose grades. But he gave them the marks. No one oversees the grading of the final anyway. And by a twist of logic, their answers could be good. He appreciates them engaging at all, even if it is just in a funny way. He therefore sees how real-life examples can improve students' relationship with mathematics.

On another note, the topics Sam talks about in his class, like mathematical misconceptions, paradoxes, or social issues, are a reflection of his own interests. They are topics about which he is comfortable talking. This creates more engaging lectures because he does not just fumble around with topics about which he does not feel comfortable talking. What he wants to talk about is therefore based on self-consciousness and even a bit of selfishness. Sam thinks this is not altogether a bad thing if it makes him more comfortable lecturing. He also likes to be entertaining and funny. This is a big part of his teaching. All in all, Sam genuinely wants to do a good job at being a teacher. He gets paid the same and would still advance the same in his career even if he were mediocre as a teacher. In truth, what he does as a teacher is just about his own satisfaction and his self-consciousness about how he is perceived by others.

Level of the Students

Finding the level his students are at is challenging for Sam. When he first started teaching at cegep, he taught to two different groups. One of them, a Calculus I class for science students, was especially strong, and the other, a secondary 5 class, was especially weak. He ended up with the idea that all secondary 5 students were that weak and all Calculus I science students were that strong. He realized, through subsequent teaching experiences, that those first students were not random samples. Their level was somewhat representative of those populations. However, he still has to teach the same thing many times to be able to figure out the level of an “average” student and to visualize a normal distribution of the level of the students.

With three years of experience under his belt, Sam knows more about how far he can push his students. He is improving at this. However, he still has a self-imposed policy of making a new course a bit easier the first time he teaches it because he wants to get a feel for how far he can push. It is impossible for him to know with certainty what students will find easy or not and how the course will be perceived before he teaches it. He therefore plays it safe the first time.

Finding the right level of difficulty for the questions in an exam is something with which Sam still struggles. As a result, some of his old tests are not even adequate as practice tests for his students because questions are sometimes too easy and other times too hard. Nevertheless, in each exam, Sam tries to include a harder question. This gives him an idea of how hard it is for them exactly. If it turns out that over half the class is able to get it without too much trouble, maybe it was not too hard and he overestimated what they might have difficulty with or how poorly he explained something.

Students' Prerequisite Knowledge

In Sam's view, all mathematical knowledge is based on deductions from previous knowledge. Therefore, it did not surprise him that students have difficulty dealing with and managing the amount of prerequisite knowledge required for some cegep mathematics classes. There is an understanding among students that things would not go well in a Calculus II class if they take it after being out of mathematics for a while and too much time passing since they completed Calculus I. Calculus I is a prerequisite for Calculus II and therefore some material covered in Calculus I is necessary in Calculus II. Sam tries to address the prerequisites to some extent but he cannot have a subclass of Calculus I within a Calculus II class.

At the beginning of his career, Sam had students ask him what they need to remember for a particular class all the time. When Sam realized how much that was a difficulty for his students, he started to address in class what he felt were the main mathematical results from previous classes. He started to lecture on these, review these, and include them in a document for his students. After that, students asked another set of questions: do they need to remember all of this right away, by when will they need to remember it, will it be provided to them on a cheat sheet, and can they bring a cheat sheet to exams? They think there is just quantitatively a lot they have to remember from their past—it seems to haunt them. They think they might get stuck on a problem, not through any fault of their own, not because they did not attend lectures, or because they have not been paying attention, but because of their deficiencies in remembering something from a previous mathematics class.

In an ideal world, it would not fall on him to review things from a previous course. It would certainly make things a lot more interesting because he thinks one of the least interesting parts of teaching is re-teaching things students have already learned. Many students remember things just fine, so they do not learn anything during his review. For students that do not remember the material, at best he is explaining something in a way that is unique compared to how they have learned it before; but this is not the purpose of the mathematics course he is teaching.