Teaching 21st Century Skills: An Integrative Literature Review

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A thesis

In the

Department

Of

Education

Presented in Partial Fulfillment of the Requirements

For the Degree of

Master of Arts (Educational Technology) at

Concordia University

Montréal, Québec, Canada

August 2020

CONCORDIA UNIVERSITY
School of Graduate Studies

This is to certify that the thesis prepared

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Entitled: Teaching 21st Century Skills: An Integrative Literature Review

and submitted in partial fulfillment of the requirements for the degree of

Educational Technology, MA

complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Abstract

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Research Problem: The purpose of this integrative literature review is to explore the scientific literature on 21st century skills, the education establishment's response to forecasted socioeconomic changes brought forth by automation technology. The review analyzes the literature to identify its predominant patterns and trends.

Research questions:

1. What terminology is most prominently used in the literature to refer to 21st century skills, competencies, and literacies?
2. Which 21st century skills, competencies and literacies are most prominent in the literature?
3. Which teaching strategies and educational technologies have been suggested to support the development of 21st century skills, competencies, and literacies?

Literature Review: The purpose of the literature review is to describe the emergence of 21st century skills and identify gaps that it presents. This preliminary review first examines the major international frameworks promoting 21st century skills that have been published by governments and non-profit organizations. The review then follows by examining the empirical literature on the topic, including two comparative analyses that compared the 21st century skills frameworks.

Methodology: The study uses an integrative literature review methodology, analyzing articles using content analysis. A sample of articles is collected, using replicable search parameters. These articles are then reviewed to confirm they meet the integration criteria. Included articles are then reviewed systematically to determine the terminology they used and the 21st century skills, teaching strategies and educational technology they identified.

Results and Conclusions: The study revealed several dominant and strong patterns in the literature. These patterns included the use of the term skill as the dominant terminology, and the prominence in the literature of skills such as communication, collaboration, problem-solving and critical thinking. The review also identified that the use of student-centred learning activities, learning activities based on designing products, as well as the integration of ICT devices, social media, communication, and web 2.0 tools in the learning environment represented strong patterns in the literature. The implications of this study serve to inform the practice of teachers seeking to integrate 21st century skills into their classrooms, by enabling them to focus their efforts on integrating the groups of skills, teaching strategies and educational technology tools that were identified as prominent in the literature. Furthermore, this study also serves to identify priorities for researchers wanting to operationalize the key concepts, strategies, and tools of 21st century skills and contribute to the accrual of empirical knowledge about them. The limitations of the study relate to the fact that the literature is continuously evolving and that new patterns may yet emerge from it. Future research should seek to operationalize terms that are used ambiguously throughout the literature. Furthermore, researchers should seek to create working definitions of individual skills to suggest ways to best develop them in students.

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Chapter 1: Introduction

Over the last few decades, technological developments in communications, finance and manufacturing technologies have disrupted the customary pathways through which individuals participate socioeconomically in their society. Mobile technology, for instance, has enabled a new form of industry labelled by some as the gig economy (Stefano, 2015), in which digital platforms connect individuals seeking to buy or sell goods and services (Taylor, Marsh, Nicol & Broadbent, 2017, p. 25). On the other hand, economics and labour organizations have expressed concerns regarding the potential for automation to displace workers in several industries (Frey & Osborne, 2013; Arntz, Gregory & Zierahn, 2016; McKinsey Global Institute [MGI], 2017; International Labour Organization [ILO], 2017; Taylor et al., 2017; PricewaterhouseCoopers [PwC], 2018; Autor & Salomons, 2018). This raises the possibility that today's youth will be faced with a job market that differs from the one they are currently being prepared for. Just so, the Waterloo Global Science Initiative – an organization which assembles experts to analyze a question – has suggested that, in addition to reading, writing and numeracy, "young adults will need to develop a set of skills and competencies that have largely been excluded from the education systems and curricula of the last century*"* (Brooks & Holmes, 2014, p. 10).

This chapter will provide a background for this study by describing trends that are forecasted to alter the economic landscape, as well as the various responses proposed to minimize the impacts of these trends.

A New Economic Reality

The following section characterizes the potential socioeconomic impacts of current and forthcoming technologies, as forecasted by economists and organizations in the field of work, the economy, and public policy. Notably, the section presents a new Industrial Revolution theorized

by economist Klaus Schwab (2016), founder and executive chairman of the World Economic Forum. Following this, the potential for job automation and worker displacement is explored to help portray the different job market it is anticipated to create.

A New Industrial Revolution

According to Klaus Schwab (2016), the many technological developments that have emerged in the last decades – and the socioeconomic shifts that followed – are part and cause of a global economic phenomena he calls the Fourth Industrial Revolution. This naming is in reference to the past industrial revolutions in history, where a few key technological developments led to revolutionary boosts in productivity, as well as important socioeconomic restructuration. Schwab (2016) supports his use of such historical language by pointing to three defining elements: the speed at which new technologies are created, the way in which they combine to create new applications, and the impact they can have on entire systems, such as creating "unprecedented paradigm shifts in economy, business, society and individually" (p. 3).

Schwab (2016) states that the Fourth Industrial Revolution "is characterized by a much more ubiquitous and mobile internet, by smaller and more powerful sensors that have become cheaper, and by artificial intelligence and machine learning" (p. 7). He also notes that this Industrial Revolution poses a key difference from past ones, in that the new technologies that are fuelling it are not domain specific. Rather, they are creating bridges "across the physical, digital and biological domains" (Schwab, 2016, p. 8), creating new disruptive applications for these technologies and accelerating the rate of change.

Job Automation and Worker Displacement

As in past industrial revolutions, the access to productivity-increasing technology is predicted to influence the job market. This has led many economists and organizations to reflect

on the issues around large-scale job automation and its effect on the access to work as well as its economic value and changing nature (Frey & Osborne, 2013; Arntz, Gregory & Zierahn, 2016; Executive Office of the President of the United States, 2016; MGI, 2017; ILO, 2017; Taylor et al., 2017; PwC, 2018; Autor & Salomons, 2018). A well-documented driving force behind these issues is the development of advanced applications for artificial intelligence and machine learning technologies.

Artificial intelligence and machine learning are technologies designed with the intent of executing tasks done by humans. Thus, as with the first Industrial Revolution – when steam-powered mechanization led to the mass displacement of farm workers – there is a significant risk for job automation to cause issues for today's and tomorrow's workers (Frey & Osborne, 2013; Arntz, Gregory & Zierahn, 2016; Executive Office of the President of the United States, 2016; McKinsey Global Institute [MGI], 2017; International Labour Organization [ILO], 2017; Taylor et al., 2017; PricewaterhouseCoopers [PwC], 2018; Autor & Salomons, 2018).

The extent to which job automation will affect the world's economies is a question that several economists and organizations have attempted to study and generate estimates for. However, the forecasts provided by these actors vary from study to study.

Economists Frey and Osborne (2013) of the Oxford Martin School published a study estimating "how exposed existing jobs are to recent developments in artificial intelligence and mobile robotics" (Frey & Osborne, 2018). It concluded that "about 47 percent of total US employment is at risk" (Frey & Osborne, 2013, p. 1) of computerization. On the other hand, a 2016 study, by Arntz, Gregory and Zierahn (2016) for the Organization for Economic Co-Operation and Development [OECD], disputed Frey and Osborne's (2013) results. It suggested that only 9 percent of US jobs were at a high risk of automation, as 70% of their tasks were

highly automatable (Arntz, Gregory & Zierahn, 2016, p. 14). The study included a statistical transfer to 21 OECD countries that yielded similar results.

Building on the two previously mentioned studies, the professional services group PricewaterhouseCoopers [PwC] published their own report, based instead on the technical feasibility of automation for individual tasks (PwC, 2018, p. 1). Its results were situated between those of Frey and Osborne (2013) and Arntz, Gregory & Zierahn (2016). They estimated that the percentage of jobs at high risk of automation ranged from "20-25% in some East Asian and Nordic economies with relatively high average education levels, to over 40% in Eastern European economies" (PwC, 2018, p. 2), where industrial production is a large sector of employment.

In contrast to these concerns, the propagation and increased performance of artificial intelligence and machine learning technologies is forecasted to also create jobs, notably in "areas such as the development and supervision of AI" (Executive Office of the President of the United States, 2016, p. 2). Even PricewaterhouseCoopers' report on job automation (2018), whose forecasts are not entirely optimistic, emphasizes that "any job losses from automation are likely to be broadly offset in the long run by new jobs created as a result of the larger and wealthier economy made possible by these new technologies" (p. 2).

Furthermore, a recent study by Autor and Salomons (2018), using a macroeconomic methodology, concluded that there was insufficient evidence to support claims that job automation will destroy more jobs than it will create. However, their findings did suggest that automation appears to have a depreciating effect on the market value of labour (Autor & Salomons, 2018); a worrying notion for future workers whose work hours are predicted to be worth less and less to their employers.

Ultimately, the extent to which job automation will make some jobs obsolete is unknowable with any certainty. As the previously mentioned studies demonstrated, estimates range from optimistic to pessimistic, but as Schwab (2016) reminds us, "history shows that the outcome is likely to be somewhere in the middle" (p. 36).

A Different Job Market

What can be predicted about the future of jobs is that the current and upcoming changes will lead them to fall under one of the three following categories: jobs that are likely to disappear, jobs that will remain, and "jobs that do not even exist yet" (Brooks & Holmes, 2014, p. 10).

What is known about the jobs in the first two categories suggests that the predicted changes in our economy will put some skills in higher demand while other skills will become less valuable as they increasingly compete with automation (PwC, 2018, p. 34). Jobs with the highest risk of automation include those with repetitive and predictable tasks, such as: cashiers, servers, fast-food preparation workers, or secretaries and administrative assistants. Jobs in the fields of transportation, storage and manufacturing are also among the most automatable (Whitehouse, Rojanasakul & Sam, 2017; PwC, 2018), along with jobs involving the collection and processing of data (MGI, 2017, n.p.). According to Bloomberg Businessweek (Whitehouse, Rojanasakul & Sam, 2017), as well as corroborating analysis from PricewaterhouseCoopers (2018, p. 18) and Klaus Schwab (2016, p. 40), jobs that are at a low risk of automation are those that involve non-routine thinking and decision-making, ethical consideration, and human-to-human interaction; these include jobs in the field of health, education, management, law, and law enforcement. Jobs based on creative and problem-solving skills, such as software engineers and craft artists, are also at low risk of automation (Whitehouse, Rojanasakul & Sam, 2017).

Schwab (2016) provides evidence suggesting that "new technologies will dramatically change the nature of work across all industries and occupations" (p. 35). It is arguable that even the jobs resisting the destructive effect of new technologies are unlikely to remain unchanged in terms of the qualifications they require from workers.

Responding to the Forecasts

Having portrayed the economic landscapes that are forecasted to take form in the upcoming future, the following section examines the approaches that have been proposed as solutions to the identified gaps. First, the perspective of economists and public policy experts is explored to identify the solutions it yields. Then, the educational perspective is adopted and the 21st century skills movement that emerged from it is presented.

The Economics and Public Policy Perspective

The evidence presented above suggests that changes to the economy will have a considerable effect on the labour market, which has the potential to be harmful to unprepared societies. It is questioned whether current systems of governance are equipped to respond effectively to these changes as "both at the national and global levels, the requisite institutional framework to govern the diffusion of innovation and mitigate the disruption is inadequate at best and, at worst, absent altogether" (Schwab, 2016, p. 9).

Many of the experts and organizations bringing attention to the issues associated with the Fourth Industrial Revolution have suggested paths towards better preparing societies for these changes. Proposed strategies include investing in the creation of new jobs (PwC, 2018, p. 34; Executive Office of the President of the United States, 2016, p. 3), developing systems to help workers transition between fields of work (Executive Office of the President of the United States, 2016, p. 3; MGI, 2017, n.p) and investing in safety nets such as income support for

displaced workers (MGI, 2017, n.p; PwC, 2018, p. 35). However, the majority of these groups point towards improvements in education and training as being the key strategy to effectively adapt societies to these changes (Frey & Osborne, 2013, p. 45; Executive Office of the President of the United States, 2016, p. 3; MGI, 2017, n.p; PwC, 2018, p. 34). The suggestions presented above are limited in scope and do not elaborate concrete solutions. For example, Frey and Osborne (2013) suggest that workers "will have to acquire creative and social skills" (p. 45) but they do not offer insight into how such skills could be learned. The Executive Office of the President of the United States, under the Obama presidency, published a report (2016) on this situation and suggested an increased focus on the quality of early childhood education, as well as adapting "education to the skills and nature of work as it changes"(p. 3). However, they did not propose concrete steps that could be taken towards that direction. In addition to highlighting the role of education and training in facilitating the retraining of displaced workers, PricewaterhouseCoopers (2018) also suggests investing in better education, which they define as one that increases the adaptability and skills of learners (p. 34). The recommendations made by McKinsey Global Institute (2017) are somewhat more developed, proposing the rethinking of education and training to "improve basic skills in the STEM fields of science, technology, engineering, and mathematics, and put a new emphasis on creativity, as well as on critical and systems thinking" (p. 19). They also highlight the importance of developing agility, resilience, and flexibility in future workers (MGI, 2017, p. 19). While economists are bringing these societal challenges to light, a similar conversation has been occurring within the education establishment for over a decade.

The 21st Century Skills Movement

For education practitioners and policymakers, the recognized need to adapt education systems to the changing requirements of work and society has been framed as the question of 21st century skills and competencies (Trilling & Fadel, 2009).

The movement for 21st century skills promotes the idea that, to thrive socioeconomically in the twenty-first century, students will need to develop "a new mix of skills" (Trilling & Fadel, 2009, p. 8) that are not typically emphasized in traditional curricula. Many groups and organizations that promote 21st century skills do so by publishing framework documents detailing their vision. These documents identify the skills that they consider critical for learners to acquire, as well as – in certain cases – propose teaching strategies and educational technologies that support their development.

Major contributors to the 21st century skills movement include private and governmental world-stage entities – such as the Organization for Economic Co-operation and Development [OECD] (Ananiadou & Claro, 2009), the United Nations Education, Scientific and Cultural Organization [UNESCO] (Scott, 2015), the World Economic Forum [WEF] (2015) and the Council of the European Union (2018) – as well as non-profit organizations and projects – such as the Partnership for 21st Century Learning [P21] (2015; 2019), Canadians for 21st Century Learning & Innovation [C21] (2012), International Society for Technology in Education [ISTE] (2016) and the Assessment and Teaching of 21st Century Skills [ATC21S] (Binkley et al., 2010) and the North Central Regional Education Laboratory [NCREL] in partnership with the Metiri Group, which have published the EnGauge framework for 21st century learning (2002).

Furthermore, several governments have been working to integrate some of the proposed 21st century skills practices into their compulsory education curricula. In Canada, for example, the provincial governments of Quebec (Quebec Ministry of Education and Higher Education,

2006a; 2016b; 2016c), Ontario (Ontario Ministry of Education, 2016), British Columbia (British Columbia Ministry of Education, 2018), Alberta (Alberta Education, 2011), and New Brunswick (New Brunswick Department of Education, 2010) have all begun integrating 21st century skills into their curricula in some fashion.

However, it remains unclear to which degree these proposals for educational change – and the various initiatives they have inspired – are informed and supported by empirical evidence. Furthermore, many of the ideas around 21st century skills were formed before economists and economics organizations had published their works and forecasts (Schwab, 2016; Frey & Osborne, 2013; Arntz, Gregory & Zierahn, 2016; PwC, 2018).

With rising concerns around the economic competitiveness of the young people that are expected to join the workforce in the upcoming decades, it is imperative to provide education policymakers with the information to best equip the future workforce of the societies they represent.

Research Questions

This thesis explores the literature on 21st century skills systematically to determine which skills, competencies, and literacies it recognizes as important. To better characterize the literature, the review identifies the dominant terminology that is used to refer to 21st century skills, competencies and literature. To better frame 21st century skills, the review of the literature also seeks to identify the teaching strategies and educational technologies which are suggested to support the development of these skills, competencies and literacies. In other words, this thesis explores the following research questions:

1. What terminology is most prominently used in the literature to refer to 21st century skills, competencies, and literacies?

2. Which 21st century skills, competencies and literacies are most prominent in the literature?
3. Which teaching strategies and educational technologies have been suggested to support the development of 21st century skills, competencies, and literacies?

Chapter 2: Literature Review

This chapter will characterize the current state of the literature regarding 21st century skills to frame it and highlight some of the gaps it manifests. More precisely, the review will examine the empirical literature on the topic to determine whether it supports the visions for 21st century skills that are promoted through the major frameworks.

Competing Terminology in the Literature

An examination of major 21st century skills frameworks, as well as some of the academic literature on this topic, shows that – in promoting their own versions of this movement – organizations and authors have been using terms interchangeably to refer to 21st century skills, competencies, and literacies. (Voogt & Roblin, 2012, p. 301).

A review of the major framework documents promoting 21st century skills reveals that terms such as "competencies" (OECD, 2005; C21, 2012; European Commission, 2017) and "skills" (Trilling & Fadel, 2009; WEF, 2015; P21, 2015; Brooks & Holmes, 2014; Binkley et al., 2010; NRCEL & Metiri Group, 2003) are used to refer to the same concept, sometimes even interchangeably within the same document (Ontario Ministry of Education, 2016; Ananiadou & Claro, 2009). The word "literacy" is used in some frameworks to refer to what "active, successful participants in this 21st century global society must be able to" do (National Council of Teachers of English [NCTE], 2013). Other organizations, such as the ISTE (2020) use the term "standards" to "describe the skills and knowledge [students] need to thrive, grow and contribute in a global, interconnected and constantly changing society" (n.p.).

The fact is that multiple terms are found in the literature that refer to the "knowledge, skills and expertise [that] students should master to succeed in work and life in the 21st century" (P21, 2015, p. 2). While this does not delegitimize the importance of integrating these skills,

competencies and literacies into curricula, it does reveal a gap in the literature worth investigating. Ultimately, "the operationalization of scientific notions is instrumental in enabling experimental evidence to bear on scientific propositions" (Machery, 2007, p. 1). In other words, the lack of a standard terminology used to refer to 21st century skills, competencies, and literacies imposes a limit on the ability of academic researchers to operationalize the shared concepts they study and generate concrete evidence to support them.

Competing Visions For 21st Century Skills

An important question in the broader conversation around 21st century skills regards the multitude of competing visions regarding how they should inform practice. The identification of which skills, competencies, and literacies that are the most important for policymakers to integrate into curricula is also a central question in this area of research.

At least two comparative analyses have addressed this question. Both systematically compared international frameworks for 21st century skills and concluded that they were "generally consistent with each other" (Dede, 2010, p. 11). One of these comparative analyses further concluded that "each framework has a different focus and areas of emphasis within the overarching competences" (Voogt & Roblin, 2012, p. 306). Indeed, while some frameworks call for a more holistic set of changes to educational practices (P21, 2015), others focus more on the role of technology in the development of 21st century skills (ISTE, 2016).

Complexifying the ecology of competing visions for 21st century skills is the degree to which empirical evidence is used to support claims. A simple search on Google Scholar for '21st Century Skills' yields just under 800,000 research articles that were published in the last 10 years, suggesting that there is significant scientific interest surrounding this topic. Yet, an examination of major 21st century skills framework documents – as well as Canadian curricular

documents including concepts related to 21st century skills – shows that very few of them support their proposals by referring to the existing body of peer-reviewed and empirical literature. The 21st century skills frameworks published by P21 (2015; 2019), C21 (2012), the European Commission (2017), and ISTE (2016), did not support their propositions using empirical evidence, nor did they disclose the methodologies employed to obtain their results. Moreover, the 21st century skills frameworks that did provide methodological information did so in a cursory fashion, stating their results were obtained through the analysis of undisclosed experts (OECD, 2005; Ananiadou & Claro, 2009). A third category of framework documents, which includes the ATC21S (Binkley et al., 2012), presented a methodology based on the analysis of other existing frameworks, several of which belong to the category of frameworks using a non-disclosed methodology. This evidence suggests significant potential for unvalidated ideas to be circulated amongst education stakeholders and proponents of 21st century skills.

Admittedly, undisclosed methodologies and lack of support through empirical evidence does not discredit the propositions found within these frameworks. Rather, it presents a gap in the literature, in the sense where the major conversations in this field could be influenced by ideas that are seemingly not evidenced-based. This gap is significant considering that the policymakers, who have been entrusted with contributing to the preparedness of societies, could be making decisions entirely based on disputable literature.

In addition to the lack of evidence used to support their claims, doubt has been expressed regarding the agenda of some of the organizations promoting 21st century skills. More specifically, critics have questioned the motives of some of the non-profit organizations within the 21st century skills movement. Several of these organizations are funded in large part by corporations and groups with potential interests in promoting educational technology (Ehrcke,

2013, p. 65). This creates a certain potential for bias, reinforcing the need to compare the various visions with the evidence that can be found in the empirical literature.

Implications of 21st Century Skills on Educational Practice

Critics have also argued that many of the proposed frameworks focus too strongly on the identification of skills, competencies, and literacies, rather than their development. Rotherham and Willingham (2010), for instance, argue that efforts would be better placed on studying how to successfully develop these skills (p. 19).

There is an entire branch of educational research interested in identifying effective teaching strategies. More specifically, some of this literature seeks to identify teaching strategies that specifically promote the development of 21st century skills, competencies, and literacies. Among the teaching strategies that are found in the 21st century skills literature are:

- student-driven learning activities, such as problem-based (Zapalska, McCarty, Young-McLear, & White, 2018, p. 294; Hixson, Ravitz, Whisman, 2012; Kimberly & Scott, 2016; Mughal & Shaikh, 2018), discovery (Chase & Klahr, 2017, p. 583) and inquiry-based learning (Bai & Song, 2018; Rahmat & Chanunan, 2018);
- new types of physical (Dos Santos & Benneworth, 2019) or web-based learning environments (Kong, Chan, Griffin, Hoppe, Huang, Kinshuk, Looi, Milrad, Norris, Nussbaum, Sharples, So, Soloway, & Yu, 2014; Khlaisang & Songkram, 2019); and
- technology-enabled learning activities such as digital storytelling (Thang & Najihah, 2017; Lin & Noor, 2019; Thang, Sim, Mahmud, Lin, Zabidi & Ismail, 2014), educational robotics (Soumela & Stavros, 2016) and digital games (Echao & Romero, 2017; Sardone & Devlin-Scherer, 2010; Romero, Usart, & Ott, 2014).

The listed teaching strategies appear, to an extent, to be aligned with the few methods that are referred to in several of the major frameworks (see Appendix 1). For instance, learner-centred methods such as inquiry, discovery and problem-based learning are proposed as effective in several major frameworks (C21, 2012; P21, 2019; Brooks & Holmes, 2014; British Columbia Ministry of Education, 2018; Trilling & Fadel, 2009). The use of technology-based tools, supportive technologies and technology-enabled learning environments are also promoted in several major 21st century skills framework documents (C21, 2012; British Columbia Ministry of Education, 2018; P21, 2019; WEF, 2015).

An examination of the peer-reviewed literature on the topic of effective teaching methods brings forward a few issues worthy of consideration. For instance, some of the research on the effectiveness of learning methods– such as problem-based learning and discovery learning – have been subject to controversy and critique. Problem-based learning [PBL] has indeed been the focus of several studies, but these have yielded conflicting results. Some studies have demonstrated benefits from the instructional method, such as increased student motivation (De Witte & Rogge, 2016). However, many researchers challenge its effectiveness and claim that "PBL has been largely oversold by its advocates" (Norman & Schmidt, 2000, p. 721). Other critics point out that common educational science does not suggest the teaching strategy should be effective on its own. Indeed, according to de Bruyckere, Kirshner and Hulshof (2016), the effectiveness of problem-based learning is limited by the fact that it requires learners to actively process information as they acquire it, rather than rely on previously developed information schema to build new knowledge. This suggests that problem-based learning would be particularly ineffective with novice learners as they would not have the prerequisite knowledge which makes learning through trial and error constructive. De Bruyckere et al. (2016) ultimately

suggest that "problem-based learning is very suitable for applying and honing existing skills and for making connections between concepts" (p. 57), but less so for learning new knowledge.

Moreover, the very ability of common experimental research methods to produce convincing evidence for the effectiveness of teaching strategies is subject to question (as cited in Oliver, 2011, p. 374). The reason being that many such studies rely on an experimental methodology to provide evidence. Such studies examine how one group, using an experimental methodology, measures on a certain learning metric compared to another group using a control methodology, sometimes referred to as the traditional classroom. The flaw that critics point out in such experiments is in assuming that, other than the different teaching strategies, both groups are comparable. Researchers Norman and Schmidt (2000) add that the environments in which experimental interventions are studied "are so complex and multifactorial, with so many unseen interacting forces, using outcomes so distant from the learning setting, that any predicted effects would inevitably be diffused by myriad unexplained variables" (p. 722). The authors (2000) also question the feasibility of blinding – a staple of good experimental research – when studying educational interventions, because it is impossible to avoid individual differences in teacher and learner participants (p. 724). Finally, Norman and Schmidt (2000) remind us that interventions such as problem-based learning are interpreted and implemented in varying ways, and that each variant involves multiple interventions which "each [have] a demonstrable effect - some positive, some negative" (p. 725). Although this does not undermine the results of experimental research of the effectiveness of teaching methods, it does limit the inferences which can be made from individual studies. Moreover, it reinforces the need to identify which teaching methods are most prominent in 21st century skills discourse to concentrate research efforts towards providing evidence for their use.

The Role of Technology in 21st Century Skills

Another conversation surrounding this topic investigates the role of technology, which "is almost always identified as a component of 21st century learning" (Ehrcke, 2013, p. 68). In their comparative analysis of international 21st century skills frameworks, Voogt and Roblin (2012) found that all frameworks look at technology as a justification for the integration of new skills into curricula. Technology, they say, "is also associated to a whole new set of [skills] about how to effectively use, manage, evaluate, and produce information across different types of media." (Voogt & Roblin, 2012, p. 308). On the other hand, the study also found that "most frameworks also emphasized the need for a comprehensive use of [technology] to enhance student learning and to promote the mastery of 21st century [tools]" (as cited in Voogt & Roblin, 2012, p. 310). Ultimately, technology, as related to the topic of 21st century skills, is interpreted in three ways:

- as an argument for the importance of developing 21st century skills, competencies, and literacies;
- as specific sets of skills to develop in learners; and
- as a tool for the development of 21st century skills, competencies, and literacies.

With that said, there is "a growing body of work [that] argues for the need for the development of a critical perspective on educational technology use" (Oliver, 2011, p. 373). It has been argued that unspoken ideological assumptions regarding technology, "especially technological determinism, may influence the thinking or discourse of educators concerning technology" (as cited in Webster, 2017, p. 25). Although technological determinism can be pessimistic or optimistic, the form which concerns critics most is when researchers are "so convinced of the benefits of technology in education that they are unwilling to think otherwise" (Selwyn, 2011, p. 713). According to Kirkwood (2014), technological optimists "tend to draw

attention to idealized characteristics and potential of the particular technology or tool they wish to promote" and "imply that the generalized benefits [...] can be achieved in a context-free manner simply through the adoption of that technology"(p. 208).

Ultimately, these critics do not raise doubt as to the usefulness of educational technology but rather encourage "adopting a critical position" when reading studies on educational technology whose "research conclusions are couched in materialistic and causal terms" (Oliver, 2011, p. 381). Considering the heavily documented presence of technology within the 21st century skills movement, it seems worthwhile to further explore the empirical literature to identify which educational technologies it is promoting.

Towards Research-Based Educational Practices

Interest in the identification of 21st century skills, competencies, and literacies – as well as their related teaching strategies and educational technologies – appears well-established. However, the literature on this topic remains in an exploratory stage rather than a stage of consensus and theory building. In addition, the scientific reliability of individual studies is under question by various critics. Furthermore, educational researchers have noted an undercurrent of panic in the educational establishment, which could be making practitioners "feverishly interested in anything new on the market that might help" (De Bruyckere et al., 2016, p. 2). In this climate, "new theories of education are introduced into schools every day (without labelling them as experiments) on the basis of their philosophical or common-sense plausibility but without genuine empirical support" (Christodoulou, 2014, p. 5).

This state of things reinforces the need for large-scale studies to review the existing literature on this topic to identify the skills, competencies and literacies, teaching strategies, and educational technologies which are evidence-based. After all, the best practices that are

promoted to education stakeholders “must be based on strong empirical data gained from experiments set up according to good research methodologies rather than legends, hypes and methodologically unsound research” (De Bruyckere et al., 2016, p. 199).

Chapter 3: Methodology

This section will provide details regarding the methodology that was used to answer the following research questions:

1. What terminology is most prominently used in the literature to refer to 21st century skills, competencies, and literacies?
2. Which 21st century skills, competencies and literacies are most prominent in the literature?
3. Which teaching strategies and educational technologies have been suggested to support the development of 21st century skills, competencies, and literacies?

The section begins by justifying the choice of methodology that was used. Following that, it provides explanations as to how the included literature was selected, how it was analyzed and lastly explains how the study assured credibility and trustworthiness.

Choice of a Research Methodology

The choice of a research methodology for this study was informed by two key factors: the nature of the literature on the topic of 21st century skills, and the gaps that were observed in it. A preliminary search in three education research databases yielded 7292 articles, the majority of which have been published in the last ten years, suggesting that '21st century skills, competencies and literacies' are indeed a new and emerging topic. An important gap identified in the literature is that empirical evidence is rarely used to support popular claims, especially within the reviewed framework documents. To account for this, the search was limited to peer-reviewed articles, yielding 3152 articles and demonstrating that there is also significant interest for this topic in the scientific community. These two factors suggested that a review of the broad literature could yield valuable information which could answer this study's research questions.

The large size of the literature required selecting a methodological process with which the literature could be analyzed systematically and consistently. As the research questions all involve identifying emerging trends in the empirical literature, a systematic literature review presented itself as an ideal choice. Systematic literature reviews are a better choice here than traditional literature reviews as, by focusing on specific characteristics that are coded from individual articles, systematic literature reviews provide an overview of the literature while also identifying emerging trends in regard to the characteristics of interest.

There are several systematic literature review methodologies to choose from, each of which is designed for specific bodies of literature. In this case, the integrative literature review methodology has presented itself as the tool of choice as they are "used to review new emerging topics that generate a growing body of literature that may include contradictions or a discrepancy between the literature and observations about the issue, which are not addressed in the literature" (Torraco, 2016, p. 404). While contradictions haven't exactly been demonstrated between the scientific literature and popular 21st century skills publications, the latter are rarely bolstered with evidence, presenting a discrepancy worth investigating. Indeed, it is important for policymakers to have access to reviews such as these, as they provide a synthesized portrait of the literature. With few reviews having yet been published, policymakers can only look to non-empirical, and thus potentially biased, publications or the policies of other governments. The strength of these justifications for the choice of methodology is corroborated by Richard Torraco who cites the absence of other literature reviews for dynamic topics such as this one, as well as the importance of the topic to practitioners in the field, as justifications for the use of integrative literature reviews (p. 411).

Selection of Literature to Include in the Review

When selecting which studies to include in the review of the literature, only peer-reviewed empirical research articles were considered. The following steps and search algorithm were used on Proquest's advanced search engine to identify literature for the review.

In the first step, articles were filtered to include the keywords *skill**, *skill set*, *competenc**, *competency based* or *literac** within a two-word distance from the keywords *21st century*, or *twenty-first century*. As 21st century skills, competencies and literacies is the main subject of this research, they were correspondingly used as a primary search filter.

In the second step, the following keywords were used: *K-12*, *elementary education*, *elementary school**, *middle school**, *high school**, *secondary education*, *primary education*, *intermediate grades*, *kindergarten*, *grade 1*, *grade 2*, *grade 3*, *grade 4*, *grade 5*, *grade 6*, *grade 7*, *grade 8*, *grade 9*, *grade 10*, *grade 11*, *grade 12*, *grade 13*, *elementary secondary education* or *grades 6*. These keywords were used to narrow the scope of the selected literature to one level of education. The outcomes of K-12 and higher education are different and accordingly both levels would likely seek to develop different 21st century skills in their students. K-12 was chosen as the target education level for this study as it is the least specialized level and is thus likely to yield the broadest set of skills, competencies and literacies. Furthermore, as K-12 education is compulsory in many states, it will reach the broadest population. This makes it the optimal level of education for practitioners and policymakers wanting to develop 21st century skills in their learners.

In the third step, the following keywords were used: *technology*, *information and communication*, *digital tool**, *comput**, *mobile*, *smartphone*, *smart phone*, *cellular*, *social media*, *social technology* or *social network*. These keywords were added to apply a light focus on

literature that could potentially be helpful in answering the third research question examining the uses of ICTs in 21st century education. Most keywords were chosen as they are technologies that were identified in the preliminary review of the 21st century movement's literature. The keywords social media, social technology and social network were added due to their suspected presence in the 21st century skills literature.

In step four, the last filter was applied to remove articles containing the following keywords: *staff development*, *professional development*, *teacher education*, *preservice teach**, *teacher qualifications*, *teacher preparation**, *effective teaching*, *teaching skills*, *teacher effectiveness*, *teacher competenc**, *teacher improvement*, *postsecondary education*, *college students*, *higher education*, *adult education*, *lifelong learning*, *professional education*, *vocational education*, *workplace learning*, *undergraduate students*, *graduate students*, *college instruction*, *colleges and universities*. This final filter was added to remove articles focusing on skills for teachers (current and pre-service), adult and lifelong learners, vocational students, and post-secondary students and teachers. Although teacher training should be an important concern for policymakers seeking to develop 21st century skills related practices, such literature would not serve to answer the research questions of this study.

All keywords were programmed to be searched for anywhere but in the full text (meaning the abstract, title, subject, etc.). The inclusion of an asterisk in some keywords ensured that alternative spelling of words would still get included.

As a last step, the search was limited to articles published after 2008 to limit the scope of selected literature to the last ten years. This was done to account for the fact that this literature is relatively young and growing at a considerable rate. As 21st century skill development seems to

involve ICT tools, it is also likely that over ten-year-old literature might not account for newer or more readily available educational technology.

The databases that were used for the research for literature are ERIC, Proquest Central Education and the Canadian Research Index. ERIC and Proquest Central Education were chosen as both large databases specialize in Education journals, with ERIC also including other peer-reviewed education resources such as conference proceedings, governmental publications and reports. Finally, the Canadian Research Index was included as its articles include those relating to social science.

The presented search algorithm yielded 184 peer reviewed articles. Of these articles, 21 were removed due to being doubled in the selection due to research database overlap. Furthermore, 26 more articles were removed for falling out of scope. Articles were deemed out of scope in cases where:

- Their subject focused on teachers, librarians, trainers and/or administrators,
- Their topics did not mention or relate to 21st century skills, competencies or literacies,
- Their context of analysis did not generalize, such as specific socio-cultural practices,
- The context of analysis relates to special education, higher education, or adult learning.

An additional 33 articles were removing for not disclosing an empirical methodology, these peer-reviewed articles included experience reports, theoretical documents, and opinion articles. Another 32 articles were rejected as they did not name any 21st century skills, competencies or literacies. Finally, 4 framework documents were added to the selection as they were cited three

or more times in the sample. The total number of articles kept in the final selection of the literature was 76.

How Data Was Collected

The selected literature was reviewed in detail to answer the study's research questions. The following information was recorded in a spreadsheet document as it was found in the articles:

- Skills, competencies, or literacies that were identified as being important to the 21st century student. When these skills, competencies or literacies were cited with a source, the source was recorded. When a description for the skills, competencies and literacies was given, this also was recorded. Finally, the descriptors used to refer to the identified skills, competencies and literacies were also recorded to answer the first research question.
- Teaching strategies that were suggested as beneficial to the development of 21st century skills, competencies and literacies. When the articles specified an educational context in the skills could be developed, this was also recorded. When details were provided for the suggested strategies, these were recorded as well.
- Educational technology tools that were suggested as being beneficial to the development of 21st century skills, competencies, and literacies. When details or justifications were provided, they were recorded as well.

The analysis began by testing the classification system to verify that it would yield the information that was sought. After testing ten articles for the presence of information fitting these categories, the classification system was confirmed, and the remaining articles were analyzed and coded. Articles were analyzed digitally using digital ink to highlight codes as they

were identified. After an initial coding, articles were analyzed a second time and confirmed codes were added to a spreadsheet document (see Appendix B).

How Data Was Analyzed

Once the data was compiled, it was analyzed using a qualitative content analysis approach borrowed from Grounded Theory research. This three-level process used open, axial and selective coding for the "identification of different categories, properties, and dimensions within and among the data" (Kolb, 2012, p. 84). This process was used on the reviewed literature to generate categories of 21st century skills, as well as the terms used to refer to them and suggested teaching strategies and educational technology tools that may help their development. In addition to generating a list of 21st century skill categories, the definitions used to describe them in the literature were compiled and synthesized to characterize the categories.

To determine the importance of these categories, in terms of the patterns they represent in the literature, the relative frequency with which each category was identified was calculated. For 21st century skill, teaching strategy and educational technology categories:

- categories representing over 25% of the sample were considered dominant patterns;
- categories representing 15-25% of the sample were considered strong patterns;
- categories representing 5-15% of the sample were considered noteworthy patterns; and
- categories representing under 5% of the sample were considered weak patterns.

When examining the terms that are used in the literature to refer to 21st century skills, the identification of a pattern's strength uses a different scale as the use of multiple terms to refer the same concept is not expected to occur often within the same article. As such, terms that were used in over 50% of instances were considered dominant patterns, terms that were used in 25-

50% of instances were strong patterns, patterns which were identified in 5-15% of instances were classified as noteworthy and terms used in less than 10% of articles represented weak patterns.

Finally, a general characterization of the state of the literature was made for each of the three research questions "using the insights acquired from a careful and critical analysis of the literature" (Torraco, 2016, p. 420). This synthesis was congruent with the integrative literature review methodology and was used to generate new questions for further research on the topic (Torraco, 2016).

Assuring Credibility and Trustworthiness

By disclosing the methodology and enabling others to replicate the study and verify its findings, the trustworthiness of the study is ensured. As all the data used in this study stems from published peer-reviewed research articles, the Manager of Compliance, who oversees the Research Ethics Committee at the University indicated that additional research ethics approval was not necessary.

Furthermore, faculty supervisors reviewed the data analysis as a means of providing some inter-rater services with the coding.

Chapter 4: Results

This section will present the results of the study. The section begins with a description of the research articles that were included and analyzed as part of this study. Following this, each of the three research questions is addressed and answered individually.

About the Sample

The following section provides descriptive information regarding the research articles that were included and analyzed as part of this integrative literature review. More specifically, the section describes the methodology used in the included studies, their year of publication, the journal in which these studies were published as well as their research context, in terms of the education level in which the studies were conducted.

Research Methodology of Included Articles

As stated in the previous chapter, the total body of literature that was included in the integrative literature review counted 76 articles. Of these articles, the largest proportion used a qualitative methodology, of which the most popular form was case studies. The sample also included a large proportion of mixed methods and quantitative experimental, or quasi-experimental, research designs. Table 1 summarizes the distribution of research methodologies in the sample.

Table 1. *The Number of Articles by Research Methodology*

Research Methodology	Number of Articles	Percentage of sample
Quantitative		
Experimental	12	15.8%
Survey	9	11.8%
Total Quantitative	**21**	**27.6%**
Qualitative		
Interview	4	5.3%
Ethnography	3	3.9%
Narrative Inquiry	1	1.3%
Case Study	21	27.6%
Critical Document Review	3	3.9%
Total Qualitative	**32**	**42.1%**
Mixed Methods	14	18.4%
Usability Test	2	2.6%
Systematic Review of Literature	3	3.9%
Framework Document	4	5.3%
TOTAL	**76**	**100%**

Year of Publication

To have a sense of the evolution of this literature over time, the publication years of the included articles were catalogued. From this, it is possible to glean that research articles on the topic of 21st century skills saw a slight increase in the years following 2009 but fell halfway through the decade. However, there seems to have been another spike in interest on the topic in the second half of the decade, leading to 69.7% of the articles included in this study being published during this period. Figure 1 summarizes these findings and visually presents the two spikes in publications on the topic.

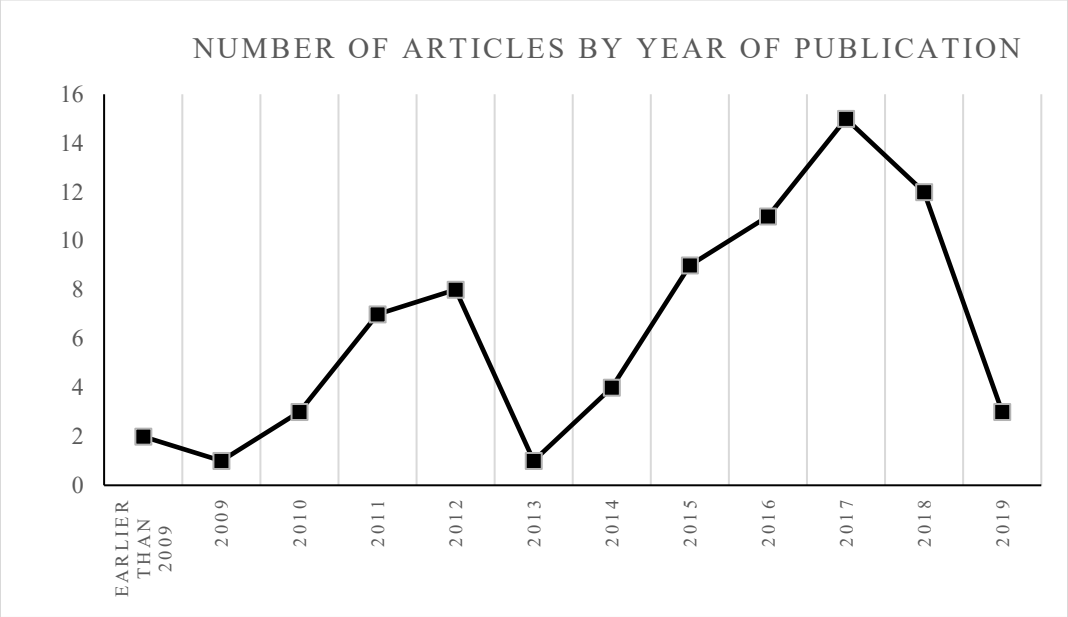

Figure 1. Number of articles by year of publication

Publication

To determine which publications have been exploring the topic of 21st century skills, the academic journal which included the articles that were published was tracked. Most journals of publications that were identified contributed to a single article in the sample, except for nine journals that published two of the articles included in the sample and one journal that published three. Table 2 summarizes the number of included articles that were published per journal.

Table 2. *The Number of Articles per Journal of Publication*

Journal of Publication	Number of Articles
Asia Pacific Journal of Education	3
Computers & Education	2
Computers in the Schools	2
Education Sciences	2
Journal of Learning Analytics	2
Journal of School Educational Technology	2
Middle School Journal	2
Technology, Pedagogy and Education	2
TechTrends: Linking Research and Practice to Improve Learning	2
Voices from the Middle	2
Art Education	1

Asia Pacific Education Review	1
Asia-Pacific Forum on Science Learning and Teaching	1
Australian and International Journal of Rural Education	1
Compare: A Journal of Comparative and International Education	1
Comunicar: Media Education Research Journal	1
Contemporary Educational Technology	1
Curriculum Journal	1
Design and Technology Education	1
Educational Researcher	1
Educational Sciences: Theory and Practice	1
Educational Technology, Research and Development	1
Educational Technology & Society	1
Electronic Journal of e-Learning	1
Electronic Journal of Science Education	1
English Education	1
European Journal of Education	1
Interdisciplinary Journal of E-Learning and Learning Objects	1
International Journal of Applied Educational Studies	1
International Journal of Distance Education Technologies	1
International Journal of Education in Mathematics, Science and Technology	1
International Journal of Game-Based Learning	1
International Journal of Instruction	1
International Journal of Research in Education and Science	1
International Journal of Science and Mathematics Education	1
International Research in Geographical and Environmental Education	1
Journal of Catholic Education	1
Journal of Computer Assisted Learning	1
Journal of Computers in Mathematics and Science Teaching	1
Journal of Curriculum and Teaching	1
Journal of Curriculum Studies	1
Journal of Educational Computing Research	1
Journal of Education in Science, Environment and Health	1
Journal of Language and Literacy Education	1
Journal of Psychoeducational Assessment	1
Journal of School Leadership	1
Kappa Delta Pi Record	1
Language Arts	1
Learning, Media and Technology	1
Mathematics Teaching in the Middle School	1
Reading Teacher	1
Research in Science & Technological Education	1
Research-publishing.net	1
Science and Children	1
Science and Technology Education	1
Science Teacher	1
Teaching English with Technology	1
Technology and Engineering Teacher	1
The International Journal of Information and Learning Technology	1
Turkish Online Journal of Educational Technology - TOJET	1
World Journal of Education	1
TOTAL	**72***

Note. Four articles from the sample were not included here as they are framework documents which were not published in an academic journal.

Education Levels Studied

The inclusion criteria for this integrative literature review was limited to only include articles examining 21st century skills in the context of K-12, or pre-university, education. Nonetheless, the education level that was studied or discussed in each article was tracked to gain a better sense of what education levels were noted in the empirical literature as pertinent to the development of 21st century skills. This revealed that, while the included literature did examine all pre-university levels, the majority (26 articles) of studies were done in the context of high school, or secondary, education. Table 3 summarizes the contexts in which the included research articles were done.

Table 3. *The Number of Articles by Studied Level of Education*

Studied Level of Education	Number of Articles	Percentage of sample
High school or secondary only	26	34.2 %
K to 12	13	17.1 %
Primary or elementary only	12	15.8 %
Middle school only	12	15.8 %
Unspecified level of education	10	13.2 %
Elementary and middle school	2	2.6 %
Pre-Collegiate	1	1.3 %
TOTAL	**76**	**100 %**

Answer to Rq1. What Terminology is Most Prominently Used in the Literature to Refer to 21st Century Skills, Competencies, and Literacies?

The following section serves to present the results to the first research question. The section begins by detailing the way in which the research data was analyzed and finishes by presenting the results and answering the question.

About This Analysis

Throughout the literature, multiple words or groups of words are used as descriptors to refer to the 509 21st century skills, competencies, and literacies that were identified in it. To determine which of these terms represents the most prevalent patterns in the terminology that is used to study 21st century skills, the terms that were identified in the literature were first listed and their frequency was counted. The frequency of use for each term was then divided by the total number of skills, competencies and literacies identified in the literature and multiplied by 100 to obtain the relative frequency of use for each term. This relative frequency was then used to determine the importance of each pattern in the literature and served to identify the dominant pattern.

A term that was used in over 50% of instances was considered a dominant pattern, while a term that was used in 25-50% of instances was considered a strong pattern. Finally, a term used in 10-25% of instances was considered as noteworthy and terms used in less than 10% of instances were seen to represent a weak pattern.

Patterns in the Terminology

Among the various expressions that were used to refer to 21st century skills, competencies and literacies, the dominant pattern is the use of the term “skill”, which was used in 64.8% of incidences. Another noteworthy pattern in the literature’s choice of terminology is the use of “competencies” or “competences”, which was used in 15.9% of cases. Table 4 lists the terms that were identified in the literature and describes their relative importance in the sample.

Several other descriptors were identified in the literature but did not comprise a noteworthy pattern. These included the descriptors “Literacies”, “Standard”, “Capacity”, “Learning disposition” and “Personal attribute”.

Table 4. *The Number of Skills, Competencies, and Literacies per Terminology Used*

Terminology used in literature	Number of Skills, Competencies, and Literacies	Number of articles	Relative Percentage of Skills, Competencies and Literacies
Skill	328	54	64.8 %
Competency or Competence	81	14	15.9 %
Skill and Competence, interchangeably	44	8	8.6 %
Literacy	23	10	4.5 %
No descriptor given	10	2	2.0 %
Standard	7	1	1.4 %
Capacity	5	2	1.0 %
Learning Disposition	5	1	1.0 %
Personal Attribute	3	1	0.6 %
Skill and Literacy, interchangeably	1	1	0.2 %
Literacy and Competency, interchangeably	1	1	0.2 %
Skill, Competency and Literacy, interchangeably	1	1	0.2 %
TOTAL	**509**	**96**	**100 %**

Moreover, several of the articles in the sample used terms interchangeably. This, however, is a rather weak pattern (combined 9.5 % of the sample) in the literature, with the most recurrent interchangeable use of terms being with the words “skill” and “competency” (8.6 % of the sample). Similarly, 15 articles in the sample opted for different terms depending on which individual skills they were referring to. One of those articles, Niemi, Niu, Vivitsou & Li (2018) used 5 different combinations of terms to refer to the fourteen 21st century skills that it identified. Another note is that two of the articles in the sample identified skills without using a specific term to refer to them. However, this represents a small proportion (2 %) of the sample.

Finally, the results of this study’s analysis suggest that the term “skill” represents the dominant pattern for terminology in the literature, when it comes to referring to the skills, competencies, and literacies that are forecasted to be beneficial to success in the 21st century.

Answer to Rq2. Which 21st Century Skills, Competencies, and Literacies Are Most Prominent in the Literature?

This section will present the results regarding the skills, competencies and literacies that were identified in the literature and then categorized into broader competency areas. First, these broader categories are presented to establish their relative importance in the literature. Then, the more important categories are further detailed using secondary categorization and the most important secondary categories are characterized more precisely. Finally, the section ends by answering the research question.

About This Analysis

The importance of each skill category in the literature is determined as a function of the relative frequency with which it was identified in the research articles that make up the sample. A category that represents over 25% of the identified skills, competencies and literacies was considered as a dominant pattern in the literature, while one that included 15 - 25% of identified skills was considered as a strong pattern. Finally, categories representing 5 - 15% of identified skills, competencies and literacies were considered as a noteworthy pattern and those representing under 5% were considered as a weak pattern.

The analysis of the sample identified 509 skills, competencies and literacies in the literature. These 509 cases were categorized into seven broad skill categories with an eighth category containing 10 skills which were ambiguously named or defined, or that did not match the seven broader categories.

None of the identified skill categories represented a dominant pattern in the literature while three categories emerged as strong patterns: “Communication and Collaboration” (23.4

%), "Problem-Solving and Critical Thinking" (18.5 %) and "Self-Management, Productivity and Accountability" (16.9 %). Four categories represented noteworthy patterns in the literature: "Creative thinking and Innovation" (14.1%), "Information and Media" (13.4 %) and "Technology Use" (7.1%). Finally, the categories "Social and Cultural" (4.7 %) and "Other", which contains ambiguous, ill-defined or uncategorizable skills, represent weak patterns (2.0 %). Table 5 presents the frequency and relative frequency for all 8 skill categories and summarizes their relative importance in the literature.

Table 5. *The frequency of SCL areas in the literature*

Skill/Competency/Literature Categories	Category Frequency	Relative Frequency	Importance of Pattern
Communication and Collaboration	119	23.4 %	Strong
Problem-Solving and Critical thinking	94	18.5 %	Strong
Self-Management, Productivity and Accountability	86	16.9 %	Strong
Creative thinking and Innovation	72	14.1 %	Noteworthy
Information and Media	68	13.4 %	Noteworthy
Technology Use	36	7.1 %	Noteworthy
Social and Cultural	24	4.7 %	Weak
Other	10	2.0 %	Weak
TOTAL	**509**	**100 %**	

Communication and Collaboration

The "Communication and Collaboration" skill category represents the strongest pattern in the literature sample with a relative frequency of 23.4 %. This category included all skills, competencies and literacies relating to one's capacity to work, help, negotiate, connect and exchange information and knowledge with others, particularly with peers but also with individuals from different cultural contexts.

Detailed examination of the skills, competencies and literacies that were classified into this category revealed that they could be further categorized into 11 subcategories. Sub-categorization was informed by the expressions used to refer to individual skills in the category

and, when applicable, the descriptions that accompanied them. Table 6 presents the subcategories which make up the broader "Communication and Collaboration" category.

Table 6. *Frequency of Communication and Collaboration subcategories*

Communication and Collaboration Sub-categories	Sub-category Frequency	Relative Frequency
Collaboration	36	30.3 %
Communication	34	28.6 %
Communication and Collaboration (combined)	11	9.2 %
Managing and Building Relationships	10	8.4 %
Collaborative learning	6	5.0 %
Collaborating with ICTs	5	4.2 %
Communicating Across Cultures and Communities	5	4.2 %
Collaborating Across Cultures and Communities	4	3.4 %
Effective Oral and Written Communication	4	3.4 %
Communicating in Mother Tongue	3	2.5 %
Communicating with ICTs	1	0.8 %
TOTAL	**119**	**100%**

Two subcategories emerged as dominant within the broader category: "Collaboration" (30.3 %) and "Communication" (28.6 %). In both cases, the skills that constitute these subcategories are, for the most part, identical in name to the sub-categories in which they were placed and tended to be identified in articles without a description or definition.

For instance, of the 36 skills sub-categorized as "Collaboration", 23 of them were solely identified in the literature as "Collaboration", while the remaining 13 included additional words such as "Effective", "Leadership", "Teamwork", "Cooperative", "Skilled" or "Complex". Moreover, of the 36 skills that were placed into this subcategory, only 5 were described in the articles that identified them. These descriptions included ideas such as iterative problem-solving with others (Scoular, Care & Awwal, 2017), coordinating with team members and mutually monitoring performance (Koh, Hong & Tan, 2018), and using help-giving and help-asking strategies (Niemi & Multisilta, 2016).

A similar pattern exists with the skills, competencies and literacies that were sub-categorized under "Communication", where 21 out of 34 skills were simply identified as "Communication", without any description provided, while the remaining 13 instances in this sub-category included modifiers such as "Skilled", "Complex", "Effective", and "Interactive". Of the 34 skills in this sub-category, 6 articles that identified them also provided a description. These descriptions include ideas of multimodal communication (Wolff & Mnguni, 2015; Chung, Yoo, Kim, Lee & Zeidler, 2016; International Society for Technology in Education [ISTE], 2016) and communication as an exchange of information or understanding (Wan Husin, Nor Fadzilah, Mohamad Arsad, Othman, Halim, Rasul, Osman & Iksan, 2016; Wolff & Mnguni, 2015).

Three additional noteworthy patterns emerged from the "Communication and Collaboration" category. The first of these noteworthy patterns is the consideration of "Communication" and "Collaboration" as a combined skill (9.3 % of the category), which manifests as a student's ability to interact effectively with others and work effectively in diverse teams (P21, 2019, p. 6-7). The second noteworthy pattern in the "Communication and Collaboration" category is the ability to "Manage and Build Relationships" which, when described in articles, is done so in terms of networking (Schmier, 2019) and management of others and one's own emotions, motivations and behaviours (NRCEL & the Metiri group, 2002). The last noteworthy pattern in this category is "Communication and Collaboration" as "Collaborative learning" (5.1 % of the category), or the ability to cooperate with others to solve problems and create new products or knowledge (NRCEL & the Metiri group, 2002).

Problem Solving and Critical Thinking

The "Problem Solving and Critical Thinking" category represents the second strongest pattern in the literature sample with a relative frequency of 18.5 %, or 94 skills, competencies and literacies identified in the sample. The skills that were included in this category are all those relating to the ability to collect, evaluate and critically analyze information, and apply this analysis to develop solutions to complex situations.

Detailed analysis of this category revealed that the skills, competencies and literacies that it contained could be further classified into 6 distinct sub-categories. Table 7 presents these subcategories in order of their importance in the sample.

Table 7. *Frequency of Problem Solving and Critical Thinking subcategories*

Problem Solving and Critical Thinking Sub-categories	Sub-category Frequency	Relative Frequency
Problem Solving	35	37.2 %
Critical Thinking	34	36.2 %
Problem Solving and Critical Thinking (combined)	8	8.5 %
Systemic Thinking	6	6.4 %
Computational Thinking	6	6.4 %
Undefined or Ambiguous Thinking skills	5	5.3 %
TOTAL	**94**	**100%**

In similar fashion to the "Communication and Collaboration" category, the "Problem Solving and Critical Thinking" category presents two dominant subcategories which together make up the broader category's name, meaning the "Problem Solving" (37.2 % of the category) and "Critical Thinking" (36.2 % of category) subcategories. Echoing the previous skill category once again, the skills, competencies and literacies that make up the two most important subcategories it contains are predominantly found in the literature without a description or definition.

Indeed, in the most important subcategory “Problem Solving” only 9 out of 26 instances (9.6 % of category) are stated with descriptions or modifiers to frame their interpretation. In these 9 instances, “Problem Solving” is presented as the ability to frame, analyze and solve problems (Wolff & Mnguni, 2015) and, in greater detail, as "the ability to question, hypothesize, analyze, evaluate, synthesize, strategize, plan, prioritize, implement, produce, and reflect" (Luterbach & Brown, 2011, p. 18).

The second most important subcategory is “Critical Thinking”. Of the 34 instances in which “Critical Thinking” skills were identified in the sample, only 4 identifications were accompanied with a description. In these cases, “Critical Thinking” was described as deep understanding and critical reflection (Trust & Maloy, 2017), the ability to form opinions, critically reflect on them and express them to others using argumentation (Van & Voogt, 2018), or simply as the “ability to think on [one’s] feet” (Nichols, 2016, p. 24). Other skills in this subcategory were stated using different wording than “Critical Thinking”, such as “Analyzing”, Synthesis”, “Reasoning” or “Decision-Making”.

Three other subcategories that were identified represent noteworthy patterns within this category. This includes the consideration of “Problem Solving and Critical Thinking” as a single combined skill (8.5 % of instances), defined in one instance as the ability to think effectively and solve problems (P21, 2019), “Systemic thinking” (6.4 %) or thinking and decision-making in interconnected systems (Wolff & Mnguni, 2015), and “Computational Thinking (6.4 %) or “solving problems in ways that leverage the power of technological methods to develop and test solutions” (ISTE, 2016, p. 2).

Finally, the subcategory "Undefined or Ambiguous Thinking Skills" (5.3 %) included skills, competencies and literacies that do not fit in the other sub-categories, such as "Higher-order" or "High-Level" thinking skills and "Argumentation".

Self-Management, Productivity and Accountability

The third category representing a strong pattern in the literature is "Self-Management, Productivity and Accountability". The skills, competencies and literacies that were grouped in this category were those relating to one's ability to direct their own effort and time and to do so in a manner which stimulates one's growth and learning, and increases one's capacity to complete difficult tasks. The category also included skills related to one's ability to react to different situations and to take risks while ensuring that results and expectations are met.

This skill category represented 16.9% of all identified skills, competencies and literacies, with 86 cases which were further categorized into 7 subcategories. Table 8 presents these subcategories along with their predominance within this category.

Within the "Self-Management, Productivity and Accountability" category, one grouping of skills emerged as a dominant pattern. The subcategory "Managing One's Growth and Learning" was found to represent 34.9 % of this category. The skills that were categorized as such included "Life and Career Skills", "Metacognition" – defined in one instance as knowing how to learn (Chalkiadaki, 2018) – "Autonomous learning", "Self-Management", "Self-Regulation", and "Self-Direction", or setting learning goals and striving to meet those goals (Wolff & Mnguni, 2015; NRCEL & the Metiri group, 2002).

Table 8. *Frequency of Self-Management, Productivity & Accountability subcategories*

Self-Management, Productivity and Accountability Sub-categories	Sub-category Frequency	Relative Frequency
Managing One's Growth and Learning	30	34.9 %
Managing Time and Projects to Deliver Results	20	23.3 %

Adaptability and Flexibility	15	17.4 %
Initiative and Entrepreneurship	11	12.8 %
Risk taking	4	4.7 %
Persistence	3	3.5 %
Sense of responsibility	3	3.5 %
TOTAL	**86**	**100%**

The category also presented strong patterns in the form of skills related to "Managing Time and Projects to Deliver Results" (23.3 % of category) and "Adaptability & Flexibility" (17.4 % of category). The first sub-category consists of skills such as "High Productivity", "Managing Goals and Time" and "Self-Organization". "Adaptability and Flexibility" skills naturally included "Adaptability" and "Flexibility" when facing change, but also included the notion of adapting to varied roles and environments.

In addition to the previously mentioned subcategories of skills, "Initiative and Entrepreneurship" (12.78 % of category) was a noteworthy pattern within the category. The category also included the "Sense of Responsibility" (4.7 % of category), "Risk-Taking" (3.5 % of category) and "Persistence" (3.5 % of category), but these were found to be weak patterns within the category.

Creative Thinking and Innovation

Among the noteworthy patterns identified in the literature are the 72 skills, competencies and literacies belonging to the "Creative Thinking and Innovation" category which correspond to 14.1% of identified skills. These included skills relating to one's ability and willingness to develop new ideas and knowledge and one's openness to other's ideas and knowledge.

Further sub-categorization of this skill category yielded 5 groups. Of these subcategories, "Creativity" (37.5% of category) and "Innovation" (25.0% of category) emerged as dominant. The only strong pattern in this category was "Inquiry and Knowledge-Creation", representing

15.3% of the group. Finally, the subcategories "Intellectual Curiosity" and "The ability to design products" represented noteworthy patterns within the "Creative Thinking and Innovation" category.

Information and Media

The presence of skills, competencies and literacies belonging to the category "Information & Media" was also identified as a noteworthy pattern. This category encompassed all skills related to the ability to produce and derive meaning in a variety of formats ranging from written texts to audio and video files.

This category contains 68 skills, competencies and literacies (13.4% of sample), of which most are referred to as literacies. In order of importance within the category, are "Information Literacies" (39.7 % of category), "Multi-media Literacies" (30.9 %), "The Ability to Produce Media" (10.3 % of category), "Digital-Age Literacy" (8.8 % of category), "Traditional Literacies" (5.9 % of category) and other "Undefined or Ambiguous Literacies" (4.4 % of category).

Technology Use

A weaker, yet noteworthy pattern in the literature, was the reference to 36 skills, competencies and literacies falling within the "Technology Use" category (7.1% of SCLs). Skills in this category included all those relating to the ability to operate digital tools effectively and safely. Skills, competencies and literacies in this category were further classified as "The Ability to Interact Effectively with Technology" (44.4% of category), "Technological Literacies" (36.1 % of category) and "Managing one's Digital Footprint" (19.4 % of category).

Social and Cultural

The "Social and Cultural" skill category represented a weak pattern. Skills that were placed in this category included those related to the respect of other individuals' backgrounds and the understanding of one's own. The category also included skills related to the management of one's responsibilities to others. The category only contains 24, or 4.7%, of identified skills. The category was further classified as "Social and Civil Responsibility and Participation" (45.8 % of category), "Inter-cultural Awareness and Understanding" (37.5 % of category) and "Critical Analysis and Participation in Culture" (16.7 % of category).

Other Skills, Competencies and Literacies

Finally, 10 of the skills (2.0 %) that were identified in the sample did not fit within any of the presented categories. These included three references to "Moral and Spiritual Skills", defined once as "the practice of religious knowledge and belief, positive attitude and moral values" (Wan Husin et al., 2016, p. 4). The other seven ambiguous skills in this category were undefined in the articles in which they were identified. These are "Classification", "Confidence with tools", "Control Release", "Emotional Intelligence", "Hand", "Operational Definition" and "Personalization".

Most prominent Skills, Competencies and Literacies

Considering the above analysis, it can be determined that no category of skills, competencies and literacies dominates the literature. Rather, multiple categories emerged as strong patterns and several more represented a noteworthy portion of the skills, competencies and literacies that were studied in the articles of the sample.

In order of prominence in the literature, the more important skill categories are "Communication and Collaboration" skills, "Problem-Solving and Critical Thinking" skills,

"Self-Management, Productivity and Accountability" skills, "Creative Thinking and Innovation" skills, "Information and Media" skills and skills related to "Technology Use".

Answer to Rq3. Which Teaching Strategies and Educational Technologies Have Been Suggested to Support the Development of 21st Century Skills, Competencies, and Literacies?

This section will present the results regarding the teaching strategies and educational technologies that were identified in the literature. To evaluate the importance of the patterns that were identified in the literature, teaching strategies and education technologies that presented similarities were grouped into categories. The section will begin by explaining how these categories were analyzed to determine their prominence in the literature on 21st century skills. Following this, the categories – of teaching strategies and educational technologies respectively – are presented and those that were identified as stronger patterns in the sample are further characterized using a second level of categorization.

About This Analysis

Analysis of the sample revealed 92 instances of teaching strategies and 80 instances of education technologies being suggested as effective in the development of 21st century skills. The importance of each teaching strategy and educational technology category was determined as a function of its relative frequency in the sample. Categories which were mentioned in over 25% of cases represented a dominant pattern in the literature, while those identified in 15 - 25% of instances were considered as a strong pattern. Finally, categories representing 5 - 15% of identified teaching methods or educational technologies were considered as a noteworthy pattern and those representing under 5% were considered as a weak pattern in the sample.

Teaching Strategies

The literature on 21st century skills included several instances were teaching strategies were suggested as effective in the development of 21st century skills. In the context of this review, teaching strategies encompassed any learning activity, pedagogical approach, learning environment or tool which could be assigned to a student to stimulate the development of one or several 21st century skills.

The sample of the literature that was analyzed contained 92 instances were specific teaching strategies were proposed as effective for the development of 21st century skills. These were sorted into 12 categories of which 2 stood out as representing strong patterns in the sample. Of the remaining 10 categories, only 4 were suggested in enough instances to represent noteworthy patterns. Table 9 summarizes the categories of suggested teaching strategies that were identified in the sample.

Table 9. *The frequency of teaching strategies suggested as effective in the literature.*

Teaching Strategies Categories	Category Frequency	Relative Frequency	Importance of Pattern
Student-driven learning activities	23	25.0 %	Strong
Design activities	21	22.8 %	Strong
Collaborative learning activities	8	8.7 %	Noteworthy
Digital Storytelling activities	7	7.6 %	Noteworthy
STEM/STEAM activities	7	7.6 %	Noteworthy
Innovative assessments	6	6.5 %	Noteworthy
Educational video games and simulations	4	4.3 %	Weak
Integration of new topics in learning	4	4.3 %	Weak
Integration of ICTs in learning	4	4.3 %	Weak
Use of real data and resources in learning	4	3.3 %	Weak
Other teaching methods	3	3.3 %	Weak
Researching activities	2	2.2 %	Weak
TOTAL	**92**	**100 %**	

In 25 % of instances where a teaching strategy was identified in the sample, it called for "Student-driven learning activities". In the majority of these cases, "Project-based learning" (43 % of category) was the activity that was recommended, but "Inquiry-based" (26 % of category)

and “Problem-based” (22 % of category) learning activities were also recurrently suggested as effective in the sample.

Learning activities that involve students designing a product were also often recommended in the literature (22.8% of the sample). The objective of the recommended design activity varies between cases. In order of prevalence in the sample, the product of the recommended design activities were media products – such as videos, audio, or art – and engineered solutions to challenges, interactive games, and information products – such as maps, reports or models.

Although not as prevalent as the previously mentioned teaching strategies, multiple other categories emerged from the literature. These include “Collaborative learning activities” (8.7 %) such as peer discussion groups, “Digital storytelling activities” (7.6 %), “STEM or STEAM activities” (7.6 %) and “Innovative assessment methods” (6.5%) such as game-based assessments (Scoular, Care & Awwal, 2017; Tan, Koh, Jonathan, & Yang, 2017).

Several other categories of teaching strategies were identified in the sample, such as the “use of real data and resources in learning” (3.3 %) and the use of “educational video games and simulations” (4.3 %). However, these categories represented weak patterns as few research articles expressed interest in them.

Also of note, is the fact that, while some articles which mentioned teaching strategies for 21st century skill development aimed to validate them empirically, most of the articles did not directly seek to validate their efficacy for 21st century skill development. Rather, most articles involved such teaching strategies without including them in the research questions they were seeking to answer.

Educational Technology

The sample of the literature that was reviewed included several research articles in which the use of certain educational technologies was suggested to promote the development of 21st century skills. In the context of this study, the understanding of educational technology was adapted from the definition of the Association for Educational Communications and Technology (2004). That is to say that educational technology was defined as any technological process or resource aimed at facilitating learning and improving performance.

The sample of the literature that was analyzed contained 80 instances where specific educational technologies were involved in a study or suggested as being effective tools in the development of 21st century skills. These 80 instances were categorized into 8 categories, of which none emerged as a dominant pattern. Three categories did reoccur enough times to be identified as strong patterns in the sample and four more educational technology categories were identified with enough frequency to be considered as noteworthy patterns in the literature sample. A final eighth category, with only two instances identified in the sample was classified as a weak pattern. Table 10 lists these categories along with their relative frequency in the sample.

In a fourth of all instances where educational technology was recommended in the literature on 21st century skills, it was “ICT devices for learning” (25.0%) that were identified. The category includes all cases recommending the use of specific technological devices by students in the learning environment. In order of relative importance, the following recommendations were included in this category: the use of mobile devices for learning, the use of ICTs in the classroom, “1-to-1 laptop programs”, “3D printing and modelling” tools, internet access for independent learning, “geo-positioning” tools and “Interactive whiteboards”.

Table 10. *The frequency of educational technology suggested as effective in the literature.*

Educational Technology Categories	Category Frequency	Relative Frequency	Importance of Pattern
ICT devices for learning	20	25.0 %	Strong
Social media, communication and collaborative tools	17	21.3 %	Strong
Digital production and publishing tools	16	20.0 %	Strong
Online learning environments	8	10.0 %	Noteworthy
Innovative assessment tools	7	8.8 %	Noteworthy
Video games and Simulations	6	7.5 %	Noteworthy
Instructional multimedia	4	5.0 %	Noteworthy
Supportive technology	2	2.5 %	Weak
TOTAL	**80**	**100 %**	

Another pattern in the sample was the recommendation of "Social media, communication and collaborative tools" (21.3 %). These most often referred to "Web 2.0 tools" (52.9 % of category) such as collaborative cloud-based tools like Google Apps for Education (Hartmann, Braae, Pedersen, & Khalid, 2017; Layton, Cady & Layton, 2017). Social media and other communication tools were also recommended as part of this educational technology category.

The third and last of the patterns in the literature is the category containing "Digital production and publishing tools" (20.0 %). Among this category were tools that can be used for video, audio and image editing emerged as the most highly recommended in the sample (43.8 % of category). Software belonging to Microsoft's Office suite was also referred to four times (25.0 % of category). Other than these, tools allowing web design, programming and video game design were also noted in the literature, albeit at a lesser frequency.

Additional categories of educational technology were identified in the literature. These categories were recommended less frequently yet represented noteworthy patterns in the sample. These include "online learning environments" (10.0 %), "innovative assessment tools" (8.8 %), "Video games and Simulations" (7.5 %) and "instructional multimedia" (5.0 %). Finally, the category "supportive technology" did not represent a noteworthy pattern (2.0 %).

Another noteworthy pattern regarding the mention of educational technology tools in the literature is that, while most studies that included them did so in the goal of promoting 21st century skill development, very few empirically evaluated the effect of these tools on skill development.

Recommended Teaching Methods and Educational Technologies

No individual category of teaching method or educational technology emerged as a strong pattern in the literature. Nonetheless, in both cases, several categories were identified with enough frequency in the literature sample to represent strong patterns. Teaching strategies that rely on student-driven learning or the design of products, especially in collaborative ways, were often suggested as beneficial to the development of 21st century skills. In regards to educational technologies in the context of 21st century skill development, the strongest patterns in the sample related to the use of ICT devices in the learning classroom, the use of social media and communication tools, and the use of digital production and publishing tools.

Chapter 5: Conclusions

This section of the thesis will discuss the conclusions stemming from the systematic review of the literature. This discussion will assess how the study's results can help bridge the gaps that were initially identified in this literature, as well as how, in contrast, it has highlighted new gaps. Following this, the implications of the study's findings are presented. Finally, the section will disclose some of the limitations of the study and make suggestions for future research on this topic.

Conclusions

Several gaps were identified in the literature on 21st century skills, which this study aimed to address. These gaps, as presented in Chapter 2, stem in part from the multiple visions competing and interacting within the 21st century skill ecology. To begin, multiple terms are used to refer to the concept of 21st century skills, competencies, and literacies, as was noted in the preliminary review of the literature. In addition to this, the significant number of varying approaches to the development of 21st century skills also presented as a gap in the literature, as it has led to a wide array of skills being recommended for youth to develop through their education. Another two gaps were also noted in the literature with regards to the identification of evidence-based best practices, in terms of teaching methods and educational technologies.

Competing terminology in literature

The systematic review of the sample identified 7 words being used to identify the concept of 21st century skills. Furthermore, the review confirmed that varied terminology is used interchangeably, and in some instances, within the same documents. This adds evidence to the notion that the literature has not yet entered its theory-generating phase, for which a generalized

consensus is a requirement. The systematic review of the sample did reveal, however, that a dominant pattern existed around the use of the term "skill", as it was used in over 60% of instances.

The identification of a dominant pattern in terminology could be a justification for research that aims to operationalize the term "skill". Research that seeks to understand the conceptual differences between terms such as "skills", "competencies" and "literacies" would also be pertinent. It could be argued that this would facilitate the gathering of scientific evidence regarding their impact on learner success. Based on these conclusions, education policymakers should seek to define the terminology they use in their curricula as well as in teacher training. This would help to ensure that their visions for 21st century skills are well framed and interpreted consistently by practitioners.

Visions for 21st Century Skills

Overall, the skills that emerged as most prominent in the academic literature are consistent with those largely promoted in the major 21st century skills frameworks. In terms of the frequency in which they were referred to in the literature, the most important skill category contained those related to "Communication and Collaboration". Skills that fall within this category were noted in all the major frameworks that were analyzed as part of the preliminary review of the literature (see Appendix 1). To a lesser extent, the second and third most often identified skill categories, "Problem Solving and Critical thinking" and "Self-Management, Productivity and Accountability", are also congruent with the recommendations found in most major frameworks. These findings suggest that there is an alignment between the skills that are recognized in the peer-reviewed literature and those promoted by the major frameworks.

The skill categories that emerged as most prominent in the literature also align, to some degree, with the few recommendations for education made by the economic and labour organizations that are warning about the impacts of the Fourth Industrial Revolution. As was mentioned in Chapter 1, these include developing creative and interpersonal skills in students (Frey & Osborne, 2013; MGI, 2017), as well as critical and systems thinking (MGI, 2017), and increasing their adaptability, resilience and intellectual flexibility (MGI, 2017; PwC, 2018).

As demonstrated by this study, a degree of alignment exists between the major 21st century skills frameworks and education research. Furthermore, this relative alignment also applies to the educational requirements forecasted by global economic entities. These findings highlight the need for researchers to concentrate their efforts towards:

- creating robust definitions for some of the more broadly accepted 21st century skills;
- validating their impact on the future success of learners; and
- identifying evidence-based best practices regarding their integration into curricula.

Best Practices for Teaching 21st Century Skills

The literature confirmed that multiple teaching strategies are being employed in the studies found in the empirical literature in support of 21st century skills development. Among the teaching strategies that were identified during the preliminary review of the literature, there appeared to be the most scientific interest surrounding student-driven learning activities, particularly around project-based learning. Project-based learning is a teaching strategy in which students are tasked with developing a tangible project to solve a realistic problem, often as part of a team of learners (Bell, 2010; Lin, Ma, Kuo & Chou, 2015).

The second most prominent category of teaching strategies identified in the literature are learning activities involving the design of a product. While the type of product varies from

videos to custom maps, all the strategies in this category frame the production of a product as the learning activity.

When the articles in the sample referred to teaching strategies for the development of 21st century skills, they were rarely oriented at the development of specific skills. Most commonly, the articles simply suggest that the strategies in question would help to develop a list of 21st century skills. A few articles, however, did explore the benefits of teaching strategies from the perspective of a specific set of skills. Nonetheless, these articles were too few to represent a significant pattern in the literature.

Furthermore, most of the articles that involved specific teaching strategies did not seek to validate their effectiveness, but rather suggested that they might support 21st century skill development.

All in all, the findings of this study add credence to the notion that these skills are best developed when they are applied in authentic and open-ended situations, such as with hands-on practical projects. While these results serve to highlight the potential of certain teaching strategies for 21st century skill development, they are unable to weigh in on their efficacy. For educators wishing to design learning activities that support the development of 21st century skills, the evidence points to authentic and open-ended scenarios as a good starting point.

Educational Technology and 21st Century Skills

The analysis of the sample identified several instances of educational technology being used in the context of research on 21st century skill development. As most major frameworks refrained from promoting specific educational technologies, it is not relevant to compare them to the findings of this research. However, comparing the educational technology found in the literature with other findings of this study allows some conclusions to be drawn.

To begin, the most often named educational technology in the sample was the use of ICT devices – such as laptops, mobile phones, and tablets – for the participation in collaborative or project-based learning activities and the consumption of instructional media. This finding follows suit with the discovered popularity of student-driven learning activities for 21st century skill development. The way in which these devices tended to be used in the reviewed studies would appear to support such learning activities.

Moreover, communication tools – such as social media and web conferencing software – and collaboration tools – such as cloud-based apps – constituted the second most employed educational technology category. As these tools can be used to develop skills related to communication and collaboration, this finding adds weight to the predominance of such skills in the literature.

Finally, the popularity of digital production and publishing tools, especially for multimedia editing, coincides well with the academic interest surrounding production-based learning activities. Evidently, these educational technology tools have the potential to facilitate the ability of students to produce knowledge products.

Once more, these findings do not assess the ability for the identified technology to support the development of 21st century skills. Rather, it highlights the educational technologies that have sparked interest within the academic conversation on the topic. Nonetheless, these findings can be useful to educational researchers as they point to future areas of study. Notably, research studying which aspects of these educational technologies are contributing beneficially to the development of 21st century skills, and which are not.

Skills That Were Not Identified in the Literature

In addition to the identification of the literature sample's stronger patterns, the review of the literature also drew attention to the expected patterns that the sample did not feature. Notably in terms of the skills that are considered in the academic literature as important to success in the 21st century, and those that are not mentioned in the literature.

As detailed in chapter 1, economists and labour organizations have warned about the potential impact of automation – particularly with artificial intelligence – on the disruption of the job market of the near future. As has been mentioned in that chapter, these disruptions are forecasted to create new jobs in the field of artificial intelligence, such as developing new applications for the technology or operating and maintaining automation software and hardware. The fact that the literature does not seem to recognize or attach importance to skills responding to these forecasts is noteworthy. Indeed, throughout the literature sample that was reviewed, skills related to coding, applying mathematics and statistics or scientific knowledge did not appear to represent a significant pattern.

Another expected pattern that was not identified in the sample was regarding skills, competencies and literacies related to the appreciation of creativity. Although skills such as creative thinking and innovation featured heavily in the sample, mention of skills related to the appreciation and interpretation of the arts was limited to less than 1% of the identified skills. The absence of such skills was unexpected considering the interest that exists around STEAM education, which focuses on an artistic approach to science, technology, engineering and mathematics (Segarra et al., 2018). In fact, the review of the literature sample showed that in terms of 21st century skills, STEAM is considered more as teaching strategy than a set of skills to develop.

Implications

The results of this study bring to light several implications for educational practitioners, as well as the field of education more broadly. As governments integrate 21st century skills into their curricula and teachers transition towards seeking to develop them in their students, this study can help identify certain strategic priorities in this transition. Indeed, by highlighting the most prominent skills categories in the literature – such as communication, collaboration, problem-solving, and critical thinking – teachers wishing to be mindful of their student's 21st century skills development can focus on integrating these target skills into their pedagogy. Moreover, this study highlighted teaching strategies and educational technologies that researchers are investigating for their effectiveness in 21st century skill development. While this study did not seek to prove the effectiveness of these methods and tools, it did home in on certain characteristics that may prove to help 21st century skill development. These include a student-centred approach, approaches based on designing a product, the use of ICT devices in the learning environment and the educational use of social media, communication and web 2.0 tools.

Looking more broadly at the field of education, the results of this study carry certain implications as well. To begin, the characterization of the literature that resulted from this study has highlighted certain patterns that can guide researchers seeking to define and operationalize concepts relating to 21st century skills. Having identified the term skill as the most widely used term in the area of research, for instance, can help accelerate the accrual of scientific knowledge on the concept, which in turn can help measure and track its development in learners. In a similar fashion, the identification of the more prominent skills in the literature can help focus the efforts of educational researchers aiming to propose standardized definitions of 21st century skills. This would facilitate tracking the development of skills and generating evidence for the effectiveness of teaching strategies and tools in promoting this development. Finally, starting points have been

identified through this study, for researchers aiming at evaluating the effectiveness of said teaching strategies and educational technologies.

Limitations

A few issues represent limitations for this study, some of which are methodological in nature while others relate directly to the subject matter. To begin with, although the systematic review included a decade of research articles, the literature is constantly expanding. This constant expansion of knowledge can cause new patterns to emerge and current ones to wane. Furthermore, the socioeconomic changes heralded by the Fourth Industrial Revolution are also continuous in nature. Future developments on this front can further impact the sets of skills that are required by the changing job market.

Finally, the research that was systematically analyzed as part of this study was only examined for its mentions of skills, and teaching strategies and educational technology relating to 21st century skills. This study did not evaluate the evidence regarding the potential impact of 21st century skills, competencies, and literacies on measures of future success. In other words, while the study did characterize the literature on 21st century skills, it did not seek to validate its ideas.

Suggestions for Future Research

A priority, in terms of future research on the topic of 21st century skills, should be an analysis of existing operational definitions for the most prominent skills. Once there is a scientific consensus on what these skills truly consist in, research efforts should pivot towards evaluating their real effect on the future readiness of students. After validating the importance of the main 21st century skills as part of an effective education, a third research priority should be

the evaluation of the effectiveness of student-driven and product-oriented learning activities for 21st century skill development. This type of research should be done within multiple contexts to enable future larger scale studies on the topic, such as meta-analyses.

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