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An exploration of the applicability and utility of Fault Tree Analysis to the diffusion of technological innovation in educational systems

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Abstract

An exploration of the applicability and utility of Fault Tree Analysis to the diffusion of technological innovation in educational systems

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An operations technique used to analyze safety on aerospace projects and a descendant of the systems safety approach developed in the late 1950s and early 1960s, Fault Tree Analysis [FTA] examines systems in terms of potential failure. The purpose of the technique is to improve the likelihood of successful attainment of a specified goal. In this study, qualitative research methods were used to examine the process of FTA in order to determine its practical value as an applicable and useful tool in the diffusion of technological innovation in educational systems. The innovation in question concerned a large, urban college interested in developing and implementing web-based courses and in increasing faculty awareness and use of teaching technologies. Since diffusion of innovation literature suggests that involvement of the intended users in the diffusion process will increase use, this study relied heavily upon the participation of a team of administrators, faculty and technology experts as well as the 543 faculty members of the College. The FTA team identified 228 potential impediments, or failure events [FEs], to the successful accomplishment of their goal. Surveys were distributed to the 543 faculty members for validation of these failure events. The respondents identified the specific

impediments they felt were most likely to occur and negatively impact the attainment of the goal. These FEs fit into the following categories identified in the literature as impediments to the implementation of technology: support; perceived interest; expertise; communication; time; resources; and access. Based on answers to questions pertaining to applicability and utility by the FTA team, members of the focal system, and a study of the information gathered as a participant-observer, recommendations are made as to the applicability and utility of Fault Tree Analysis in the diffusion of innovation in educational settings. Preliminary results indicate that FTA can be an effective information gathering and disseminating tool. Feedback from respondents indicates the process was applicable and useful and provided them with a more systemic view of the college and the challenges they face in attaining the goal. Limitations included time constraints which, in some steps, prevented full team participation and, in others, slowed down the process. The specific context of the findings may also limit their generalizability. Suggestions are therefore offered to address these issues in order to improve the FTA process.

Dedication

To my grandfather, Carl Wagner,
for having loved me unconditionally and never once doubting
I could do whatever I wanted

and

my parents, Mona and Albert Aaron,
for instilling in me a love of books and learning, the determination needed
to get things done and the support that helped me do them.

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An endeavour such as this requires the efforts of more than one person. I am therefore delighted to have the opportunity to publicly recognize and thank:

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Chapter One – Introduction

Based on the identification in the literature of a significant gap between acquisition and use of technology, the intent of this research was to explore the applicability and utility of a modified version of Fault Tree Analysis [FTA] as a potential solution to bridge this gap. FTA is a method of systematically improving the likelihood of success by examining the potential causes of failure when attempting to attain a pre-defined goal – in this case, the diffusion of a technological innovation. Specifically, I conducted an FTA in a college environment currently considering the increased emphasis on, and use of, the internet as a teaching tool. The primary goal of this study was to explore whether or not such an analysis, according to the participants and the findings, was applicable and useful.

In composing the criteria I used for establishing the applicability and utility of FTA, I referred to needs assessments, the merits of which are judged by virtue of the results and outcomes it initiates, and Rogers' (1995) theory of the diffusion of innovation and the application of five of the variables used to determine the rate of adoption of innovations. It is not easy to define applicability or utility as they can be very individual and subjective entities dependant upon ones individual values and beliefs (Richey, 1998; Rogers, 1995; Strike, 1979). Establishing the link between research and practice has also never been easy but there are several steps one can take to help insure the smooth transition. One of the most important, practical and effective steps has been expressed in many different ways by researchers in diverse fields but the essence remains the same – direct involvement in the research process by the individuals whom one wants to benefit most – intended users (e.g., Ely, 1999; Jiang, Muhanna & Klein, 2000; Richey, 1998;

Rossett, 1991; 1999; Strike, 1979). Patton's (1986) model of utilization-focused evaluation is also relevant to this situation. In this model, Patton emphasizes the fact that utility comes about when the assessment is designed with the intended users in mind (Patton, 1986; also, Schwitzer, 1997). Every attempt was made to ensure that the design and results of this study reflected the needs of the participants. The FTA team members were encouraged to be active participants throughout the research and change the course of the research in order to better meet their needs.

Another way of ensuring utility of research is to determine whether or not useable knowledge results from the process. According to Richey (1998), "research should be responsive to the current or emerging needs of practitioners and ultimately to the solution of professional and social problems" (p. 7). Every effort was made to ensure that this research responded to both the gap in the literature and to the practical needs of the participants in the study and lead the way towards solutions in the form of concrete plans of action.

Richey (1998) describes useable knowledge as that which is credible. Credibility was addressed in various ways in this study. Firstly, credibility was addressed by the careful and systemically representative selection of the FTA team. Secondly, the issue of credibility was addressed in the modified FTA process by having the members of the focal system evaluate the final tree for its inclusivity and reflection of their concerns. Lastly, the final evaluation of the process, took place in a group meeting and included a thorough questionnaire, and addressed credibility by asking questions pertaining to the

perceived value and effectiveness of the process, on its own merits as well as how it compared to other analysis situations in which they have been involved.

Each of these methods of gathering information was meant to determine whether FTA is a practical and useful tool for use in educational institutions meeting the influx of a technological innovation. In other words, was it even possible for an individual, in this case an outsider, to enter into a system and gather information which was rich and complete enough, and in a timely and efficient manner, to produce a useful fault tree as described by its originators or would the process prove to be too costly in terms of time and required information? Also, would the members of the FTA team find value in the process and make concrete plans for change based on the results of the FTA? While long-term effects of participating in the process of FTA were not examined in this study, utility was. This research decision was made based on the logic that before one can determine the effects of a process, one must first determine that the process itself – as a process – is viable.

Using technology for technology's sake is an unfortunate off-shoot of the prevalence of technology and the pressure individuals may feel to use it. I am confident, based on past research findings, that FTA, and the modifications I implemented, was an appropriate technology for use in this study – though the strength of this conviction could only be confirmed or refuted once the study was complete.

Problem Statement

> Human behavior can be genuinely purposive because only human beings guide their behavior by a knowledge of what happened before they were born and a preconception of what may happen after they are dead; thus only human beings find their way by a light that illuminates more than the patch of ground they stand on.
>
> P. B. Medawar and J. S. Medawar,
> The life science (1977).
> In D. J. Boorstin (1983), p. 557.

The "knowledge of what happened before" as it effects what could happen in the future is, essentially, what this study is about. Using FTA, a method which fosters the systemic and purposeful involvement of intended users and culls their knowledge, I attempted to gain an understanding of an urban college's outlook on the potential problems they may encounter in the diffusion of technology into their system. I believed that this technique would prove to be a useful tool in helping educational institutions face the daunting challenge of integrating technology into their educational environments. Examining and understanding how technological innovations fail will, according to advocates of FTA, increase future probability of success. FTA also helps go beyond the obvious and get to the crux of the matter, since, in some cases, what teachers perceive to be the problem with technology in the schools may not always be the actual problem (Stephens, 1972). It was believed that participating in the fault tree process, would provide faculty members at the college with a unique opportunity to have a voice in the manner in which a new technology is introduced in their environment. They were given an

opportunity to have a direct say in how, and even whether, a new technology would be implemented. They were involved in a direct and concrete manner. They were not only asked their opinion but were also asked to shape the final result. The participants were also able to see that administrators were willing and cooperative partners in the decision-making process of technological implementation. Lawler, Rossett and Hoffman (1998) and Trilling and Hood (1999), among others, have clearly indicated the importance of a supportive environment in the integration of technology in an educational environment. Clearly, then, anything which improves support can only serve to ameliorate the situation. Involvement in the FTA, which is a systemic procedure, would also allow the FTA team members the opportunity to gain a perspective of their environment other than their own.

Opened in 1969, the college was the first English-language institution in Quebec's new network of CEGEPs. There are currently 7500 full-time day students and 3500 continuing education students enrolled in more than 50 different programmes of study. The college is a multicultural institution and reflects the international and cosmopolitan nature of the city in which it is situated. In fact, only about half of the current student population cites English as their mother tongue.

Discussions and committees have shown that there is a strong element amongst some of the college administration and faculty to be more innovative in their use of technology in education. The ideas are varied but the following two elements of the college's mission statement are particularly relevant for the purposes of this study. "The Mission of the college is:

- to maintain standards of academic excellence essential to our students' future success and to provide the appropriate programs, services and technology to ensure that any student admitted has the opportunity to develop the skills necessary to achieve these standards; and

- to continue to develop innovative and flexible educational approaches to serve the needs of our students."

The college calendar 1999-2000

Both of these statements indicate and emphasize the importance of forward thinking technological use. Students need to be equipped with the skills required to meet the ever increasing technological demands which will be placed upon them. The college seems to be aware of their role in ensuring this occurs.

The current technological situation at the college is reflected in the following description (Team Member #1, Personal communication, November 7, 2000). There are five faculty resource rooms throughout the college. A typical room contains 3 Pentium class PCs, 1 Power Macintosh and a printer. All computers are equipped with internet connections, Microsoft Office, Internet Explorer and Netscape Navigator. Also available on a limited basis are HTML editors and Web Page design applications. Some rooms also contain a scanner. All Department Chairs (about 60) and Programme Coordinators (about 30) have PCs which support web browsers. Another 60 PCs (mostly Pentiums), all with Internet access, are distributed to faculty members throughout the college. In the last five years, courses have been offered on how to use the internal, e-mail, web page design, FirstClass, etc. Most have met with an enthusiastic response but little follow through. Loss of interest seems to be a particularly common problem.

Faculty are dealing with a multitude of pressures – not the least of which will be the encroachment of computer technology into their teaching practices. Teachers will no longer be able, if indeed they are now, to ignore the existence of computers. The machines will be present and, with increasing frequency, in their classrooms. As I will indicate in detail in the literature review, greater and greater demands are being made on teachers to use computers as integral components in their teaching. The technological innovation currently challenging the administrators at the college is the use of the Internet as an integral element of the teaching process. Their goal is to develop on-line courses with an eye towards increasing the school's potential for distance education courses as well as to increase the use of the Internet in the current classroom model. FTA seemed to be a practical tool that may help the college face their goal of technological integration. Testing its applicability and utility in this environment provided a rich basis upon which applicability was assessed.

Significance of the Research

The potential significance of this research is fourfold. Firstly, this is the first study that examined in a rigorous fashion the applicability and utility of FTA. It is the first study to apply this method specifically to the diffusion of a technological innovation in an educational setting. In the education literature, FTA has been used to analyze several non-technology specific problems such as: A FTA of selected policies, procedures and characteristics of the College of Eastern Utah (Nelson, 1976); A fault tree approach to the analysis of perceived internal communication problems in an expanding multi-campus community college district (Long, 1976); A fault tree approach to the analysis of

achieving the major objectives of Community Recreation 12 (Collings, 1975); and A FTA of the Graduate Division of the Department of Physical Education (Copeland, 1976). In each of these cases, the purpose of the study was to analyze a problem using FTA, not to study the applicability and utility of FTA as a tool. In addition to being the first "process" study of FTA, this study also investigated an innovation in the process for the first time – specifically, it addressed the utility and pertinence of contributions from the focal system, beyond the appointed FTA team, and how this information served to guide the FTA team.

Secondly, the research has practical significance to the technology planners, implementers and faculty at the college. The results of this study are directly applicable to a reality-based situation. The members of the FTA team will be able to develop a plan of how best to proceed with the diffusion of the innovation in question – a plan shaped by the direct input and validation of the intended users of the technology – elements which the diffusion literature indicates as crucial to the process of implementation. The FTA team will be able to take the results of the FTA and translate them into direct and concrete plans of action. They will be provided with knowledge which will enable them to make changes to the system to correct for the failure events. This study may also provide insight into the use of FTA within the larger context of educational needs analyses. Granted, this is but one single instance of the use of FTA, but the process is generalizable to similar contexts and problems (i.e., educational institutions dealing with the diffusion of a technological innovation). Indeed, one could go so far as to say that the modified FTA could be used in any situation in which a systemic perspective on the diffusion of innovation is required.

Thirdly, by providing a detailed description of the FTA process (as experienced by the members of the FTA team and experienced and observed by the researcher), this study attempts to fill a gap in the literature concerning the diffusion of technology into educational settings. The literature clearly indicates that the best way to proceed to ensure use when implementing technology is to directly involve the intended users in the decision-making and implementation stages of the plan. Stephens' original model of FTA, while including members of the focal system on the FTA team, did not allow for the direct contribution of the members of the entire system – the modifications made to traditional FTA process by the researcher and the FTA team clearly did. This study examined whether what had been identified as important in theory, worked in practice as well.

Finally, based on the results of this study, a model of FTA in the process of diffusion of innovation in a higher education setting is proposed which can serve to inform the diffusion of innovation literature and have direct utility in other educational systems.

Questions and Assumptions

In order to determine the applicability and utility of FTA in an educational setting into which a technological innovation is being diffused, the following questions were asked. I looked at ways in which the FTA process could be improved based on my observations as well as the input received from the members of the FTA team. I looked for problems I encountered throughout the process, documented them and then attempted to correct for them by modifying the process.

I will discuss the operationalization of these questions and assumptions as they relate to utility and applicability in Chapter Three.

Questions.

1) Is FTA an applicable and useful tool in the diffusion of innovation in an educational setting?

2) Can FTA be used in a timely and cost-effective manner?

3) Will the members of the focal system participate in the process?

4) Will the participants find value in the process?

5) Will the group of individuals responsible for implementing the innovation recognize the information obtained from the FTA and, if necessary, adjust their plans accordingly?

6) Will changes to the system (diffusion plan) be made according to the results of the FTA?

Assumptions.

1) The major assumption under which this study operated is that one can conduct a FTA. The intriguing element manifested itself in the efficacy of the process and how it could be changed, if needed, to be more accommodating to the needs of the system under scrutiny.

   One may construct fault trees under the following conditions (as identified by Stephens, 1972, p. 2-3): "(1) When a statement of an undesired event can be made for any system – an event which would bring about a failure in the system, and (2) when inputs to that event at successive stages can be identified". A major assumption for the current research was that such a statement and inputs could and would be identified. Two stages of development have also been identified: tree construction; and determining the critical paths of failure.

2) The goal statement and an indication of its successful attainment can be formulated.

3) Undesired event(s) can be formulated based upon the goal statement.

4) Failure events and their antecedent causes can be identified.

5) Members of the faculty will participate in the FTA.

6) The FTA team will view FTA as a useful mechanism by which they can gain a greater understanding of the role technology plays in education as well as the role they play in the integration of technology.

7) The FTA team will use the results of the FTA in a concrete and observable manner.

8) The failure events generated in this analysis will coincide with the six factors identified in the literature as impeding the diffusion of innovation in educational settings.

What is Technology?

Definitions of technology abound and are often synonymous with machine. I have found two particularly useful definitions for the purposes of this research, both of which imply that technology is not merely the "machine" but also knowledge and the manner in which that knowledge[1] is used.

The first definition, by J. K. Galbraith, originally written in 1965 and reprinted in Stephens and Wood (p. 298, 1977-78) states that technology is:

> the systematic application of scientific or other organized knowledge to practical tasks. Its most important consequence,
>
> ... is in forcing the division and subdivision of any task into its component parts. Thus, and only thus, can organized knowledge be brought to bear on performance.

---

[1] I will provide a more thorough discussion of how FTA ties in with knowledge and knowledge management in the section entitled 'Why FTA?'.

Similar to the above definition is one by diffusion of innovation specialist E. M. Rogers (1995, p. 12) who defines technology as:

> a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome.

Rogers' definition contains the important element of human communications that is one of the central foci of the current study. Rogers believes that technology is made up of two components; hardware and software, wherein hardware consists of "the tool that embodies the technology as a material or physical object, and software consist[s] of the information base for the tool" (p. 12). Rogers sees technology as information that needs to be processed in a manner similar to what we typically understand as information – a form of communication. Rogers' view of technology as information is based upon Thompson, 1967 and Eveland's, 1986 (in Rogers, 1995) notion that technology concerns the transfer of information. One of the reasons FTA was chosen for this study was its unique reliability upon the input of individuals for whom and by whom the innovation is targeted. Open lines of communication are essential throughout the process if it is to succeed. It is also surmised that FTA will increase communication.

What is 'Diffusion of Innovation'?

Diffusion, as defined by Rogers (1995), "is the process by which an innovation is communicated through certain channels over time among members of a social system" (p. 5). The main elements in Rogers' definition of diffusion are innovation, communication, channels, time and social system. The messages that are communicated are about new

tools, ideas, etc. (new does not necessarily mean the tool is new but is new to the intended users) – newness which can result in uncertainty which must somehow be reduced. Focal to this research is the notion that diffusion is a type of social change. In other words, the very introduction of a new idea, tool, way of doing things, etc., changes the environment in which the introduction occurs. Not only does the innovation change the social environment but the social environment influences the innovation as well. Another reason FTA was chosen as the tool of focus for this study is that it addresses the issue of social context by virtue of its methodology – in order to design a fault tree, one must include the members of the system under scrutiny and one must gain a systems perspective.

A particularly troublesome area when examining the diffusion of innovation comes when one attempts to define terms such as 'success', 'acceptance' and 'integration'. One individual's idea of successful integration, for example, may be very different from someone else's. Without consensus as to the intended meaning, the discussion is rendered meaningless. Indeed, as Dias (1999, p. 11) points out, "teachers are often expected to integrate technology without having a working definition of the concept". Establishing the criteria by which one is measuring the success or failure of an innovation is an essential element in any study, especially since user acceptance has been identified as one of the key elements when it comes to determining the success or failure of new information technology systems (e.g., Davis, 1993; Ely, 1999; Gould, Boies, & Lewis, 1991; Nickerson, 1981; Venkatesh & Davis, 2000) but it happens to be one of the most difficult as well (Spitzer, 1980; Wood, Stephens & Barker, 1979; Venkatesh & Davis, 2000; Zemke & Kramlinger, 1982). Since failure is often easier to define than success, and by

going directly to the ultimate users, FTA seems to address this problem. It is expected that by participating in the process and beginning to think about the innovation by identifying the potential impediments, the faculty members will begin to form a common understanding of what the innovation is and what implementing it would entail.

Diffusion of innovation models.

Multiple diffusion of innovation models have been developed, each of which focuses on a slightly different element of the diffusion process. Innovation diffusion theory (Rogers, 1995), the theory of reasoned action (Fishbein & Ajzen, 1975) and the theory of planned behaviour (Ajzen, 1985, 1991) are general theories. The concerns-based adoption model developed by Hall, Wallace & Dossett in 1973 views adoption of innovations as an individual process dependent upon "the kinds of concerns [individuals] have about the innovation and their skill and sophistication in the use of the innovation" (Loucks & Hall, 1977, p. 18). A major premise of the Concerns Based Adoption Model is that:

> the single most important factor in any change process is the people who will be most affected by the change. Certainly, the innovation itself and the organization into which it is to be incorporated are important variables, but they are secondary in importance to the people who are the intended innovation users. (Hord, Rutherford, Huling-Austin, & Hall, 1987, p. 18).

FTA brings the focus of this study directly upon the individuals who will be most affected by the proposed innovation. Involving the faculty members of the college in this inquiry will provide them with the opportunity to be included in a process from which they are frequently excluded.

Hall (1976), Loucks and Hall (1977) and Hord, Rutherford, Huling-Austin and Hall (1987) describe seven stages of concern. According to this model, "innovation adopters develop along two important dimensions as they implement an innovation: (1) in the kinds of concerns they have about the innovation and (2) in their skill and sophistication in the use of the innovation" (Loucks & Hall, 1977, p. 18). Understanding the types of concerns the individual has, may help managers of change be more effective in facilitating the adoption of innovations. The types of concern vary from 'awareness' to 'refocusing' and change focus from 'self' to 'task' to 'impact'. It is important to note that these stages are not mutually exclusive nor must they be passed through in sequence. Individuals dealing with an innovation may have some degree of concern at each of these levels. The relevance of this model to the current study may be in the underlying intention of FTA which is to have intended users identify what they feel will be problems – regardless of whether these problems exist or not. It may be that merely by articulating their concerns in a supportive environment, intended users will gain perspective and insight and be able to become more confident in their adoption of the innovation.

As important as knowing what innovation to diffuse, is knowing and anticipating the concerns individuals may have about the innovation and what problems these individuals foresee in the implementation and use of the innovation. FTA, by uncovering and then validating failure events or impediments intended users foresee with the innovation in question, focuses directly upon these problems with the goal being to solve them (or, at least, figure out a way to get around them) before the innovation is implemented.

The technology acceptance model (Davis, 1989) applies specifically to information technology. Continuing research on this model and its extension has demonstrated its robustness in explaining the variance in technological innovation use and behaviour (Venkatesh & Davis, 1996; 2000). The premise upon which sociotechnical systems theory (e.g., Cherns, 1976; Pasmore & Sherwood, 1978; Trist, Higgin, Murray & Pollock, 1963) is based is that technology itself means nothing unless looked at in relation to the social practices and influences that surround it. This theory as well as the literature examining the social shaping and cultural elements of technological use (Ellul, 1964; Feenberg, 1991; Mumford, 1934; Williams, 1997) is particularly relevant to the current study.

The social shaping of technology theory avers that technology is a social product that is influenced by surroundings and can not be fully understood without taking the social context into serious consideration. This theory further avers that social factors influence or shape the ultimate form a technology will take. Not only will society shape the form the technology takes, it will also influence the way in which it is used and accepted. The Context Aware Computing Group at MIT has also pointed out the importance of context and how the essential element in technology is humanity and how communication, not complication is what we should be striving for when we use technology (Selker, 2001). While social context was an essential element in the production of the fault tree and attempts were made to identify the social confines and environment in which the faculty were working, it was not the focus of this study. Understanding social context allowed for a clearer picture of, for example, who participates and to what extent. Observational information will be drawn from the researcher's role in the process

and members of the FTA team will be asked to provide a description of the system as they see it, but social context, per se, will not be analyzed as to its specific influence on the fault tree itself. The current situation at the college will be described. This description will take place in the first stage of the FTA wherein the FTA team will define the system and discuss the system bounds and constraints. Understanding these constraints and the context in which the faculty operates provides clues as to the attendant conditions surrounding the use of the innovation.

Defining Fault Tree Analysis

FTA, as defined by the earliest user of this method in educational systems, is:

> a logic diagramming technique relating combinations of possible events (or subsystems within a system) which interact to produce a predefined undesired event [and can be] generally thought of as a technique for increasing the likelihood of success in any system by analyzing the most likely modes of failure, in order to prevent future failures.
>
> (Stephens, 1972, p. 2)

An operations technique used as an analytical tool of systems safety engineering on aerospace projects and a descendant of the systems safety approach developed in the late 1950s and early 1960s (Wood, Stephens & Barker, 1979), FTA examines systems in terms of failure events or impediments standing in the way of achieving a pre-specified goal or goals. The premise behind this tool is that by understanding what is likely to cause failure within a system, one can take pre-emptive action and subsequently increase the likelihood of success.

Until 1967, FTA was primarily used for hard systems such as the Minuteman Missile launch system for which it was developed in 1961 by the Bell Telephone Laboratories and modified at the Boeing Company. It was Stephens, a member of an aerospace group at Boeing, who began to explore the use of FTA for use in educational systems. In 1972, out of the University of Washington, Stephens, for his dissertation requirement, conducted a thorough analysis and adaptation of the use of the fault tree approach to educational systems. Stemming from his work, there were a number of research projects conducted applying the use of FTA to educational systems. This work came out of Brigham Young University (where Stephens was then working) and Utah State University where R. Kent Wood was conducting research using fault tree analyses as well.

Strengths and weaknesses.

There are many strengths inherent to this method of analysis. Perhaps one of the most important is that FTA provides a common language and perspective around which people can unite. Much like the Japanese concept of "Ba", the English equivalent of which is "place" and refers to "shared space[s] for emerging relationships" Nonaka & Konno, 1998, p. 40), which has been discussed in relation to knowledge management, people may have more in common than they assume and it may be that only by looking at things wholistically and systemically can this common ground become known. FTA allows for individual actors within a system to join together for a common purpose rather than remain isolated with both their successes and failures. Maddux, Cummings and Torres-Rivera (1999) have also identified the importance of improving communication

among system members as a means of improving the integration of technology into higher-education instruction.

FTA is a parsimonious tool in that the method also happens to be the product. In other words, by following the steps of the FTA process, one develops the final product as well. It is the emphasis on process, as well as product (even though the product is clearly the goal of this particular process), which may be the essential element unique to this particular analysis tool – an emphasis which also exists in the area of knowledge management (Brown & Duguid, 2000). Furthermore, participating in a process towards a tangible product may provide participants with the sense of ownership previously lacking in the implementation of technological innovations in educational environments. At the end of the process, one obtains a useful and concrete product – a graphical depiction of a system which clearly indicates failure events and the relationships, both lateral and hierarchical, between them. The final tree is visual in nature. At a glance, individuals are able to see potential problem areas upon which they can focus in the search for viable solutions. Given that teachers frequently cite lack of time as an obstacle to their adoption of a technological innovation, this tool may even serve to ease some of the time constraints they face. FTA allows for the understanding of a large and seemingly unfathomable entity in clear, common and concise terms. One contributes to the research environment a practicable and easily referred to product to which all members of the system have had the opportunity to contribute, thereby helping to ensure that the knowledge represented therein is as complete and representative as possible. Another strength of this method is that it can assist in the planning and design of programmes that could better allow for the diffusion and adoption of technological innovations.

One would be wise, however, to heed Spitzer's (1980) words of caution and temper the potential of this technique with circumspection. According to Spitzer, the expression ""garbage in, garbage out" is particularly relevant [when] discussing FTA" (p. 69). One of the main weaknesses of FTA pertains to practical limits and the inclusion of all members of the system. The size of the system under scrutiny may limit the number of individuals who can be involved and it may not be possible to obtain useful input from all members or that all members would participate. While it is probable that not all of the college's 543 faculty members who will be consulted will provide information, they will be at least be given the opportunity to do so. Furthermore, regardless of whether all members of the focal system provide input, this study goes farther in its goal of inclusion than have others using FTA. Other analyses described in the literature indicate that they have relied upon small groups of experts rather than a wider selection of participants. In the current study, while a representative group of individuals selected from the focal system and knowledgeable in its operations worked together as the FTA team throughout the FTA process, members of the focal system were also consulted. They were given a survey asking general technology use and attitude questions as well as three direct questions about each of the failure events that the FTA team generated. The main point of surveying the focal system was to obtain their input as to the validity and inclusivity of the failure events the FTA team generated thereby adding credibility to the findings.

Also, as previously discussed, the sense of ownership over and involvement in the process is something which may be lacking when it comes to the implementation and adoption of technological innovations in educational settings. This study attempted to address this issue by including the members of the focal system. The method of validation

used in this study is in keeping with Janesick's (1998) view as well. She describes validity in qualitative research as having to deal with "explanation, and whether or not a given explanation fits a given description. In other words, is the explanation credible?" (p. 50). While impossible to guarantee, the iterative nature of the method, the use of a panel of experts, literature and members of the system as a whole should help to ensure that the information used to construct the tree was thorough, true to the system and comprehensive. Perhaps we should also heed Janesick's warning to beware of the constant obsession with the "trinity of validity, reliability, and generalizability" (p. 48) and "methodolatry" in which one becomes preoccupied with method to the exclusion of substance. Even though the primary goal of this research was to assess the applicability and utility of FTA as a *process*, it is also crucial to ensure that the *product*, the actual fault tree, meets with the expectations and needs of the FTA team and, by extension, the college as a whole.

Analyzing an objective system, (the initial reason for which FTA was developed) requires an organized structure. Subjective systems, however, pose different problems. The structure of FTA appears flexible enough to be applied to subjective systems so long as the intangible elements such as personal/interpersonal, skill, attitude, belief and motivation are somehow recognized (even though they can not be controlled). I further believe that by observing the process of conducting this FTA, I will be able to discover these elements and acknowledge their presence and potential influence. I would like to reiterate however, that the purpose if this study was not to examine the efficacy of the tree, in the long term, but rather its immediate applicability and utility.

There were a number of successful projects using FTA in educational systems between 1967 and 1979. Since then, aside from references concerning the use of FTA in engineering and other hard systems, I found very little mention of FTA. There was a reference to the use of FTA in management systems made by Spitzer in 1980 and another in 1982 by Zemke and Kramlinger in their text on needs and task analysis. One of the original adapters of FTA to social systems has also included it as a tool to be used in causal analyses (generally the most neglected component in needs assessment) in a text on needs assessment (Witkin & Altschuld, 1995). In this context, it can be used during needs assessments as a means of developing appropriate (and not merely easy) solutions once needs have been identified (Witkin & Altschuld, 1995). FTA is also used as a method in total quality management, especially as regards to product evaluation (Juran, Godfrey, Hoogstoel, & Schilling, 1999).

FTA resurfaced in the education literature in 1999 in a text by Jonassen, Tessmer and Hannum in which they elaborate upon Stephens' model and indicate its potential usefulness in educational systems. To date, I am unaware of the reasons why FTA is not more widely used. Perhaps it has to do with the depth of involvement required to produce a tree. The current research, in attempting to determine whether or not FTA is a practical tool, may be able to answer the question of why FTA is not more prevalent in the literature. Perhaps, too, an alternative means of conducting an FTA will emerge which will allow for its more practical and ready use. Janesick's words are particularly appropriate to the current context. She writes that "qualitative design is adapted, changed, and redesigned as the study proceeds, because of the social realities of doing research among and with the living" (1998, p. 53). FTA appears to be a method which is adaptable

to the needs of the participants. One must be open to new avenues of exploration and remain flexible enough to accommodate situations which may arise during the course of the study. Perhaps we should also heed the words of Ralph Waldo Emerson who stated that "skill to do comes of doing".

Why Fault Tree Analysis?

In choosing to examine the use of FTA in the diffusion of technological innovation, I considered many factors – not the least of which was its seeming ability to point out solutions and not just problems. The premise is that by gaining insight into the obstacles individuals foresee hindering their attainment of a goal, these obstacles can be removed. I was also influenced by its systemic and systematic approach to problems. Understanding the system can only help in the understanding of the problem and discovery of solutions. Systems thinking allows for a greater understanding of the interactions which occur and also provides a framework within which the researcher is able to participate and for which the goal is to understand and not necessarily predict (Banathy, 1992; Carr-Chellman, 2000; Checkland & Holwell, 1998). FTA provides a structure for precise decision making which can be particularly useful in predictive situations, such as the one the college is facing. FTA also provides a bridge between needs and solutions. Identifying needs should be but the first step towards finding realistic solutions. Furthermore, FTA uses a systems-centered approach which "promotes thinking about needs as existing in a network of contributing factors" (Witkin and Altschuld, 1995, p. 252). Such an approach may, according to the literature on diffusion of innovation, promote acceptance and use of technology amongst the intended users.

In a needs assessment, a more traditional and known method of problem analysis, one presumes a discrepancy between what is (actuals) and what is desired (optimals). FTA identifies impediments to attaining the optimal. One of the steps in FTA entails having the FTA team take the desired goal or optimal and reword it as an undesired event [UE] for which failure events are generated, a critical path is identified and solutions are proposed. FTA also allows one to find many possible solutions, providing multiple paths to success, thereby overcoming the predisposition of individuals to see only that which they want to see or to get bogged down in one specific problem.

The reader may be tempted, at this point, to compare FTA to needs assessment and advocate the use of the latter due to its prevalence but, though they do have some things in common, their objectives are somewhat different as are their means of data collection and representation. The major purpose of a needs assessment (or analysis) is to "gather information for setting priorities on needs of people in relation to a system of interest" (Witkin and Altschuld, 1995, p. 18). The information gathered from needs assessments are used to set criteria and allocate resources. The information gathered in a FTA is used to identify critical paths to failure and invoke solutions to avoid them (these solutions may subsequently entail the setting of criteria and the allocation of resources but that is not the primary goal). Once a need has been ascertained, FTA identifies potential causes for the failures to satisfy that need and, due to its hierarchical nature that demonstrates the interdependency of events, proposes means by which these failures can be avoided. A major criticism of needs assessment has been the lack of attention to implementation or concrete action once the assessment is complete (Witkin and Altschuld, 1995). By providing precise areas in which problems exist, and graphically depicting the critical

paths of failure, FTA may be a more practical and systemic tool by virtue of its reliance on, input from and active participation of system members in the process.

Furthermore, research has indicated that needs assessments which rely upon outsiders' input to the exclusion of the insiders' perspective are inadequate (Jasso-Aguilar, 1999). Rossett (1999) also points out the importance of multiple, inside, sources of information. The modification this researcher made to the traditional manner in which FTAs have been done, addressed this issue by providing a distinct opportunity for the insiders' perspectives to be heard. FTA uses specific techniques to gather, organize and represent knowledge in a form that is accessible to a large number of individuals. FTA not only collects information in a manner different than that of needs assessment, but also represents it differently and comes to different, potentially more creative, conclusions as a result. The key, however, to the success of FTA is to ensure that the knowledge depicted on the tree is representative of the system it reflects. In order to ensure such depth and breadth of representation, FTA uses a team consisting of system representatives but, in the current modification, also seeks direct input of all of the members of the focal system. A recent article by Nissen, Kamel and Sengupta (2000) points out the importance and current lack of the integration of knowledge management with systems design – an integration that this modified FTA incorporates.

The changes being made to FTA in the current study also support Rossett's (1999) notion of the use of knowledge management in needs assessment as key to increased system awareness and its ultimate influence over results. The proposed use of FTA may encourage the sharing of information and the sense of working towards a common goal

currently lacking in both needs assessment and FTA. In one sense, then, FTA may be viewed as a tool through which one can gain access to information and transform it into practicable knowledge.

According to Duffy (1999), "knowledge is information which been validated" (p. 4). It is information that is contextualized by the user. I define context as the organizational, personal and social milieu in which one operates on a daily basis. Knowledge is not merely facts, concepts principles and procedures but rather a mixture of these as taken in and processed over time and across experience by the user (Davenport & Prusak, 1998). As important as knowing what innovation to diffuse is knowing and anticipating the concerns individuals may have about the process and the context in which the diffusion will occur. In other words, without accounting for context, diffusion and adoption of innovation may not occur. FTA may allow access to understanding and context and may therefore act as a knowledge management tool. Careful application of this process assures that the innovation fits the intended context.

FTA, discussed under the rubric of knowledge management, may assist in improving the efficiency of organizations by addressing a major problem – that of converting individual knowledge into organizational knowledge. FTA focusses on gaining access to the most relevant information required by the individual and/or the focal system. Knowledge management allows for the easy accessibility of knowledge that may otherwise go unaccessed. Although the bulk of organizational theory research currently discussing the issue of knowledge management is largely focussed on organizations – for-profit businesses – it may have some benefit for educational institutions as well.

Moreover, what better example of a learning organization than one whose main products are not widgets but learned individuals? If, as Schwandt and Marquardt (2000) assert, "brainpower is becoming a company's most valuable asset" (p. 11) then surely educational institutions should be paying heed to the line of research currently being pursued in the business arena – knowledge management. After all, our aim as educators should not be merely to inform but to make knowledgeable.

If knowledge management [KM] is "getting the best information to the right person at the right time" (Boone, 1999, p. 141), and is recognized as being needed in education (Galbreath, 2000), then FTA, with its graphical representation of information gathered from members of the system it is meant to represent and reflect may be an effective and novel knowledge elicitation and management tool. FTA uses specific techniques to gather, organize and represent knowledge in a format that is accessible to a large number of individuals. The trick, however, is ensuring that the knowledge depicted on the tree is representative of the system it reflects. In order to help ensure such breadth and depth of representation, FTA uses a committee made up of system representatives but should also seek the direct input of all of the members of the system under scrutiny. A recent article by Nissen, Kamel and Sengupta (2000) points out the importance and current lack of the integration of knowledge management with system design – an integration that the modifications made to traditional FTA incorporates. Brown and Duguid (2000) also point out how knowledge management is a bottom-up approach which primarily focuses on "effectiveness more than efficiency" (p. 74) and that it is the pull between process versus practice which needs to be examined. FTA, with its bottom-up, systemic and

participatory approach, clearly emphasizes – without ignoring practice or product – the import of process.

Knowledge management is not merely the accumulation of information represented in an easily accessible (such as database management systems) form. Knowledge management is, most essentially, a method by which one establishes what people know *inside their heads* and makes it visible – something which this FTA does. Jonassen and Henning (1999) have also recently discussed how important it is to understand individuals' mental models in order to assess knowledge and problem-solving skills and gain access to both the knowledge inside and outside the individual. In other words, they see the mind as a system to which access must be gained in order for true communication to occur. In addition, Hung and Chen (2000) are currently looking at ways to use technology in order to help establish a community of learners. FTA may be a tool educators can use to address these issues.

Knowledge management is also similar in its premise to the establishment of a link between research and practice. As previously discussed, one of the quandaries facing researchers is how to establish a link between research and practice and how to define applicability or utility (Richey, 1998; Rogers, 1995; Strike, 1979). There are several steps one can take to help insure the smooth transition and, perhaps, the principles of knowledge management can assist. One way of ensuring utility of research is to determine whether usable knowledge results from the process – a concept clearly related to the current discussions surrounding the use of KM. According to Richey (1998), "research should be responsive to the current or emerging needs of practitioners and ultimately to

the solution of professional and social problems" (p. 7). In modifying the FTA process I have attempted to ensure that the modifications responded to the gap in the literature and to the practical needs of the participants in the study and would lead the way towards solutions in the form of concrete plans of action. One of the discoveries Brown and Duguid (1998) made while working with firms was that they were searching for ways in which to identify "best practices, new ideas, creative synergies and breakthrough processes" which can only come about when one makes "effective use of knowledge" (p. xii) – something which the modified FTA clearly attempts to do.

Summary

Given the systemic nature of FTA and the graphical representation of the findings, the modifications made in this study to make the process as inclusive as possible, and with the immediately useful direction for change offered by the results, it is felt that FTA is the method most suited to the goals of this study, in particular, and to address the myriad problems faced in the implementation and integration of technology into educational systems, in general. Needs assessments may identify a valid need but it is FTA which identifies the impediments to fulfilling these needs and offers clear paths toward their solution.

The importance of FTA in the diffusion of innovation is clear. This process improves individual sense of ownership and control by emphasizing direct involvement and system-wide representation and by building cohesive teams which improve and strengthen the social environment into which the technology is being diffused (Jonassen, Tessmer & Hannum, 1999; Stephens, 1972; Wood, Stephens & Barker, 1979) all of which

are factors previously identified as essential to the diffusion of innovation. FTA can lead to attitude change and empowerment due to its systemic and inclusive processes. Drucker (1999) has suggested that today's knowledge workers in the information revolution change from subordinates to partners, thereby increasing the likelihood of successful use. The modified FTA clearly attempts to create an atmosphere of partnership and shared knowledge. FTA appears to be an ideal method to address some of the problems of technological diffusion in educational settings. It is felt that this technique will prove to be a useful by helping educational institutions face the daunting challenge of integrating technology into their educational environments.

Chapter Two – Literature review

The Promise of Technology

> I believe that the motion picture is destined to revolutionize our educational system and that in a few years it will supplant largely, if not entirely, the use of textbooks.
>
> The education of the future, as I see it, will be conducted through the medium of the motion picture ... where it should be possible to obtain one hundred percent efficiency.
>
> Thomas Edison, 1922

> The history of modern education is littered with the trash of technology left behind by unrealistic purchases, naive users, and vendor representatives working on a quota system.
>
> Polley, 1977 (in Albright & Graf, 1992a)

> ...the very efficiency of the machine was drastically curtailed by the failure to achieve in society a set of harmonious and integrated purposes.
>
> Lewis Mumford, 1934

These quotes establish the arc of thought that my research follows. The first quote highlights the promise of a panacea that many people see in any new technology destined for use in educational settings. It seems as if a cure-all is often being sought in the latest technology. Substitute "computer technology", or any other previous new technology (television, radio, etc.) touted as the greatest thing to hit education, for "motion picture" and a statement made in 1922 becomes as relevant, repeated and potentially unrealistic today. People seem all too ready to accept technology as something which is value-free

and necessary (Cornell, 1999; Kerr, 1996; Noble, 1997). Perhaps even more disturbing, is the idea that if a technology can do something it therefore follows that it should be done, and that its mere presence will automatically improve learning, (Ehrmann, 1999). There does not seem to be enough forethought and planning when it comes to using technology in education. Technology is not magic. It is a tool which should be used carefully. If medical technology was used with as little thought for consequences there would be a huge public outcry yet very little such outcry occurs in education. Perhaps it is because the consequences are not as readily apparent but they do occur. As Postman writes in his book The End of Education (1996, p. 41), the role that new technology should play in schools or anywhere else is something that needs to be discussed without the "hyperactive fantasies of cheerleaders". He goes on to call computers and their accompanying technology "Faustian bargains". Hall (1976) remarked that:

> in education, changes that are recognized most easily are the *addition* of things to the classroom. Whenever there is a problem, the cure is to add something more. We have added so many cure-alls without taking anything away that the pile of unused and ineffective remedies has become another problem. Few seem to recognize that change is only accomplished when the individuals who are to use the things change (p. 22).

In other words, we must be more mindful regarding the choices and decisions we make concerning our use of technology in education lest we end up with something cheered about by many but wholly inadequate and inappropriate for the majority of our needs. I have attempted to apply this mindfulness in my choice of Fault Tree Analysis and in my examination of its applicability and utility. I look at technology, in general, as a tool – as something which can be applied in a given situation in order to affect the

outcome in some manner. I do not believe that technology is neutral. Regardless of how one uses it, or the resultant outcomes, the very presence of technology brings with it certain inherent features which will influence the situation in which it is used. This belief certainly applies to FTA as well. While the situations in which it is used and the outcomes which it produces will vary based on specific social contexts, FTA, *itself,* has inherent features which influence outcomes. Understanding this may allow for more tempered and responsible use of all technology.

Like Postman's "Faustian bargains", Polley ,1977 (in Albright & Graf, 1992) also felt that perhaps far too much emphasis was placed on the acquisition of technology without first fully understanding what those acquisitions would imply. Polley's words illustrate that the unchecked and poorly thought out use of information technology in the schools has resulted in somewhat of a backlash. Yet this backlash has occurred throughout history with very little consequence. Polley's statement at the beginning of this chapter is but one of many such examples of disappointment people feel in the reality new technology often provides. There is a large contingent of technological cautionaries attempting to temper the frequently unchecked enthusiasm the technological advocates put forth. Critics (see, for example, Winner, 1998, 1999; Postman, 1985, 1988, 1996; Oppenheimer, 1997; McKibben, 1992; Mander, 1992) of the heavy and costly emphasis of placing the latest information technologies into the schools argue that with so little evidence for their effectiveness, this effort would be much better placed on other aspects of schooling.

Experience with technology seems to indicate that the crux of the problem lies between acquisition and use. It is clear that the diffusion of innovation is not merely a matter of purchase. What happens between the promise and the reality? Why do some technologies take hold and others collect dust in a corner? Why is it that some schools, such as the Jeanne R. Meadows School in San Jose, California, where multi-media technology is used to help the students gain "global understanding and interdependence" (p. 18) and Turlock High School in California where technology is embedded in an economics course (Boston, Chan & Mukai, 1991) are able to seamlessly integrate technology into their curricula while others can only manage the most rudimentary use of technology? Appleby Elementary School in Marathon, New York is also an excellent example of successful integration (Sherwood, 1999). Even entire school districts, such as Chittenden, Vermont, for example, which is widely renowned for its use of technology (Brauer, 1995) have successfully incorporated technology.

This situation regarding the use of technology in education does not only apply to the elementary grades. It seems particularly acute in the higher education setting. Dalton (1989) notes that in spite of the impact computer technology has had on society in general, the impact on the practice of education has been relatively minor. According to Spotts and Bowman (1995), the influence of technology on higher education pedagogy has been weak to almost non-existent and, while access has increased, use has not increased at the same rate (Dusick, 1998; Rocheleau, 1999-2000). The results of a survey measuring instructional technology awareness and use amongst faculty members indicated that, while faculty recognize the importance of instructional technology, they do not currently use, nor plan to use, instructional technology in their teaching (Spotts &

Bowman, 1995). The results also indicated that, while the majority of faculty have a high degree of knowledge and experience concerning older technology such as video and film, fewer than 20% of them actually use *any* technology on a regular basis. Maddux, Cummings and Torres-Rivera (1999) also point out how slowly institutions of higher education are adopting new technologies. Groves and Zemel (2000) have also shown that the use of technology, while increasing, still has not yet reached its hoped for level and impact. They further point out the importance of a supportive infrastructure.

Despite the problems and resistance, there are instances of the successful integration of computing technology in higher education settings. Two such examples are the Acadia Advantage programme at Acadia University in Nova Scotia and the Ubiquitous Computing Model at Wake Forest University in Salem, North Carolina. Keep in mind, however, that both of these institutions are small with total student enrollment of approximately 6000 and faculty to student ratios of 15:1 at Acadia and 10.5:1 at Wake Forest.

The programme at Acadia began in 1995 with the notion of providing all incoming students and faculty with fully supported laptop computers which would be integrated into the undergraduate curriculum by the year 2000. In contrast to other situations where equipment is provided with very little forethought regarding support, training or outcomes, the innovators at Acadia had a clear objective and path in mind and the willingness to provide the support necessary for its success(Cutright & Griffith, 2000).

Support for this initiative is offered to both faculty (students also receive support though most come to the university already technologically literate) from a centralized

location. Called the Sandbox, its purpose is to provide a location for faculty members to come and discuss the problems they may encounter when implementing technology-based enhancements in their teaching (MacDougall, 1998).

The Acadia Advantage has met with success. Students come to Acadia knowing it has a reputation for integrative technology use. They use the computers in their studies and as a communication tool and, in many instances, are serving as mentors for the faculty (Cutright & Griffiths, 2000). Acadia has demonstrated how technology can serve to integrate the learning and community experience of education (Cutright & Griffiths, 2000; Watters, Conley & Alexander, (1998).

The computer initiative at Wake Forest University began in 1995 with the title "Plan for the Class of 2000", the goal of which was to provide extensive computer networking throughout the university and to provide all students and faculty with laptop computers by the year 2000. David G. Brown, Vice President and Dean of the International Center for Computer Enhanced Learning at Wake Forest University believes that the central tenet behind the use of computers in education surrounds their ability to improve communication. His philosophy can best be summed up in the following two statements:

> computers allow a single individual to establish and maintain connections in more subgroups, with more people, from more places, with greater intensity for longer periods of time.
>
> Brown, 1999, p. 1

> Computer enhanced learning will transform the practice of education in all countries, at all levels --- and the world will be a better place for it!
>
> Brown, 2000, para. 29

While the latter statement may be seen as somewhat optimistic, the former is one to which attention should be paid. Brown (1999) believes that computers can have the greatest impact as a means of improved communication, findings which have been borne out by studies conducted with Wake Forest faculty and students.

A recent longitudinal study (Mitra & Steffensmeier, 2000) conducted at Wake Forest indicates that students had a positive attitude towards the integrated use of laptops in their education and, while the researchers recognize that definitive answers regarding the effects of technology on learning have yet to be found, they do conclude that networked institutions providing supported access "foster[s] a more positive attitude toward the use of technology in teaching and learning" (p. 431). Another study looking at the effects of ubiquitous computing on faculty found that training, access and support were all essential in improving their attitudes towards the importance of computers in their academic lives (Mitra, Steffensmeier, Lenzmeier & Massoni, 1999). Support was identified in both the Acadia and Wake Forest initiatives as inherent to the success of the diffusion of any technological innovation (see, for example, Brown, 1999; Cutright & Griffith, 2000; Ganzert & Watkins, 1997; MacDougall, 1998).

Generally however, in spite of the success institutions like Acadia and Wake Forest have had, use in higher education still seems to be concentrated on the communication aspects of computers (e-mail, presentations, etc.) rather than on integration with the

curriculum (Kilian, 1996; Mitra, Steffensmeier, Lenzmeier & Massoni, 1999; Rocheleau, 1999). Even Acadia University, where there is an 85% adoption rate of the Acadia Advantage initiative, there is resistance to change based on faculty perception that the technology removes their sense of total authority in the classroom (Cutright & Griffith, 2000). Faculty has long been resistant to advanced technology-based education and while, as Rickard (1999) argues, faculty seem more willing to use new technology and are even engaging in the development of such courses, there remains a well-entrenched skepticism not in the technology necessarily but in the ability of the educational institution in which they work to support its use. Support for the technology, then, seems to be one area to which attention should be paid. FTA, by virtue of its inclusivity (at least my variation of it to promote inclusivity) and involvement of members from the entire focal system, engenders this notion of support. If members of the focal system participate, alongside members of the administration responsible for providing support, perhaps an environment of support will be encouraged which may not have previously existed. Also, the FTA will uncover the specific failure events which contribute to the lack of support thereby providing a clear indication of how to improve support. The analogy of "scaling-up" technology to the process of climbing a mountain (Griffiths, 1999), seems particularly apt. However, unlike Sisyphus, advocates are hoping to reach the summit and, while they may eventually fall down the other side, to remain for a good length of time first.

Others believe that too much is being invested, at too great a speed, in technology that has yet to be proved to increase educational quality and productivity (Larson, in Rickard, 1999). Larson also argues that where evidence does exist that technology "can

actually help improve educational quality [it] is really just the tendency of technology to make course material more engaging" (para. 12). In other words, paying more attention to engaging our students in the learning process may, even without technology, be all that is needed to make education more effective. If one applies this rationale to FTA, which engages participants in the process, it may add value to the process of diffusion.

Cornell (1999) cites an example of the use of Internet classes in one of Florida's state universities. Faculty members were concerned about the emphasis being placed on using the Internet as a major means of course delivery. They feared the loss of control and ownership over their courses. Recognizing that "faculty tend to concentrate on the things they both enjoy doing and are able to do well" (Cornell, 1999, p. 91), the university, as had another university some 30 years prior regarding the use of audiovisual methods and materials, changed their policy and reduced the amount of instruction required to be delivered via the Internet. Recognizing the importance of faculty perspectives and needs, will go a long way towards the increased use of technology (Soloway, 2000). It is also important to recognize and reward the contribution in time and intellectual input made by faculty members towards, for example, the development of web courses. University of North Texas, for instance, pays royalties to professors (based on a percentage of tuition from students enrolling in the course) for developing on-line materials which are used by themselves or other professors (Young, 2001).

Fueling the increasing emphasis on incorporating technology into higher education is a recognition that students entering our universities are far more computer literate than ever before and will demand as much from their instructors (Frand, 2000). Furthermore,

the skills demanded of college graduates once they join the workforce are changing. It is the responsibility of higher education to ensure that graduates leave the university with the skill and understanding required to successfully enter the workforce (Bates, 2000; Bleed, 2001; Davis, 1997; Gueldenzoph, Guidera, Whipple, Mertler & Dutton, 1999; Klor, de Alva, 2000; Rossett, 2000). Cutright and Griffith (2000) point out that all of Acadia's students are highly sought after in the job market and get jobs. In spite of successful student job placement and the increasing demand for higher education institutions to provide the technological skills and attitude needed in the workforce, there remains a resistance to the influx of technology in education when so much already in place needs improvement. Griffen (1999), for example, claims that technology "serves to divert rather than enhance critical thinking" (p. 17) and feels that we must address "our obsession with means over ends, virtual reality over authentic being, and economic growth over environmental sanity" (p. 22).

The debate about the effectiveness and even the appropriateness of technology in education is a fascinating one and one which is sure to continue. I have discussed it to the extent that understanding the debate will help place the current work in its proper perspective. And while the debate will not be the focus of this research, understanding the place of technology in higher education is crucial as that is, after all, where the teachers of tomorrow will obtain their training (and perhaps attitudes) towards its continued use (Pellegrino & Altman, 1997). This element of the discussion is also relevant because the method being examined in the current study, FTA, can also be considered a technology. Therefore, any argument made about the utility and implementation of technological innovations in general must also apply to this technological innovation in particular.

Mumford's understanding, gained sixty-five years ago, that the society in which a technology is to be implemented needs to be in agreement over the implementation process and desired outcomes, may hold the key to successful technological diffusion in educational settings. The process of FTA and the modification which has been proposed clearly attempts to achieve this agreement. The supposition that the manner in which technology is introduced, and the elements at play in the context in which this introduction occurs, will, by virtue of its systemic nature, come to the fore while conducting the FTA. The first step in FTA is system definition – a definition which includes a discussion of the factors, both positive and negative, which serve to influence the system. I believe, and there is literature (e.g., Akrich, 1993; Burt, 1973; Van Den Akker, Keursten, & Plomp, 1991; Walsh, 1991; Walsh & Bayma, 1996) to substantiate and support this belief, that Mumford's words concerning the importance of social context highlight what is frequently an absent element in the diffusion of new information technologies into educational settings – the direct involvement of the intended users of the innovation. The modification I have proposed to FTA (i.e., involvement of members of the entire system in the FTA process) clearly attempts to address this void. It seems apparent that, in spite of the critics and the lack of concrete and unconfounded proof of effectiveness, information technologies are going to be bought and attempts are going to be made to integrate them into educational settings (an effect that has been described as the "bandwagon effect" (Abrahmson & Rosenkopf, 1993)) – it therefore behooves us to research and understand the most effective ways in which this can be accomplished.

This not to say that technological determinism is inevitable, but past patterns of use of technology seemingly indicate that educators use what is offered, perhaps looking for a

solution to the "problem" of education. Given this initial willingness and the rush to use technology, with reflection and planning often suffering in its wake (Jenkins & Rossett, 2000), and a history which indicates that continued use rarely occurs, finding ways to help ensure reasonable, responsible and productive use is crucial. Furthermore, providing legitimate reasons when not to use technology will also be of benefit. One needs to determine and carefully think about the particular innovation and answer questions pertaining to use. An understanding of why one wants to use a particular innovation, how and even if it should be used and whether, given ideal circumstances, it will succeed when used is essential. As others have indicated, I too believe that there is far too much emphasis on technology for technology's sake without nearly enough emphasis on the social context in which the technology will be utilized or even if it should be utilized at all. Technology may not be entirely pernicious but it is also most certainly not innocuous nor a panacea. In any case, it is certainly not neutral. Technology has inherently positive and negative features. In some circumstances, these features and their subsequent impact create positive results. In other circumstances, the impact of these features, particularly unintended ones, can be negative. It is important to keep this in mind when deciding whether or not, as well as how, to proceed with a technological intervention. While acknowledging and accounting for the positive and negative features inherent to FTA, it does appear to be an excellent tool by which we can gain insight into the types of impediments intended users of a technological innovation foresee facing, thereby significantly adding to our understanding of how best to implement technology into educational settings.

Technology and Education

> The first teacher ever, the priest in preliterate Mesopotamia who sat down outside the temple with the kids and began to draw figures with a twig in the sand, would be perfectly at home in most classrooms in the world today. Of course, there is a blackboard, but otherwise there has been little change in tools and none in respect to methods. The one new teaching tool in the intervening 8,000 years has been the printed book. And that few teachers really know how to use--or else they would not continue to lecture on what is already in the book.
>
> The priest in ancient Mesopotamia was also the first doctor. If he returned today to a modern operating room in the hospital, he would not conclude that he could do as well. Yet today's doctors are no better men than the first doctors were. They certainly are no better than the "father of medicine," Hippocrates. They stand on his shoulders. They know more, and above all, they know better. They have a different methodology. They have different tools. As a result, they do entirely different things, and do them differently.
>
> Drucker, 1969, p. 347

Whether or not one fully agrees with Drucker, the contrast between medicine and education is striking and it is also obvious to any educator or student that there is truth to his idea that very little has changed in today's classrooms. One need only sit in on a majority of university classes to see that generally, as was the case hundreds of years ago, the teacher talks while the pupils listen. That is not to say, of course, that new technologies have not been developed and attempts at use have not been made. In fact, introducing, implementing and ultimately integrating technology into classrooms, as well as businesses, government facilities, etc., is not a new phenomenon. From slate to radio to the overhead projector to the multi-media computer platform, a variety of technologies

have been introduced into various environments with varying degrees of success and failure (Cuban, 1986; 1993; Pellegrino & Altman, 1997; Cornell, 1999; Rickard, 1999). It is not sufficient to have functional equipment – the equipment must be accepted and integrated in order for it to be used. The best of intentions are one thing – actual use another. Recently, Drucker (1999) reiterated the same conclusions he made in 1969 regarding the use of technology in education, though on this occasion he turns primarily to the influence the information revolution has had on the business community. According to Drucker, while routinization of traditional processes has occurred, "almost none of the effects of information envisaged forty years ago have actually happened (1999, par. 16). He argues, though, that the psychological impact of technology has been far greater, especially on the manner in which children learn. Drucker maintains, as he did in 1969, that the manner in which schools teach is inconsistent with the way children learn. In other words, schools are still behind where they should be.

Five critical factors, culled from decades of literature, inhibiting the use of technology in the schools have been identified by Leggett and Persichitte (1998). These factors are: time; expertise; access; resources and support. Perceived need has been identified as an essential factor when it comes to the successful integration of technology (Barrett, 1999; Dusick, 1998; Sherwood, 1999), as has perceived usefulness and ease of use (Davis, 1989; Venkatesh & Davis, 2000). Technology programmes therefore need to be developed which are systemic and intentional or purposive (Coughlin, 1999). Based on the findings in the literature regarding examples of the failure of diffusion of information technology in different settings, and using the above characteristics as a means of categorizing the findings, it may be possible to develop a model of successful diffusion of

innovation easily applicable and suited to the needs of educational institutions implementing a new technology. It will be interesting to see if the FTA uncovers these factors as those contributing to the failure (or potential failure) of the innovation in question.

A model of successful technology staff development (which is, after all, a first step in successful integration into teaching practices), proposed by Bray (1999) includes the following eight steps:

1. Create a team
2. Set your goals and vision
3. Identify your needs
4. Define where you are now
5. Develop a list of learning opportunities
6. Design and implement an action plan
7. Design and support individual learning plans (ILPs)
8. Evaluate and address the effectiveness of your plan.

While this model does contain some elements of inclusion, it does not specifically address, as does FTA, failure events. Barrett (1999), in exploring factors which influence the effective use of information systems, identified the importance of a systems approach to successful implementation. He also concluded that a "thorough understanding of each component and how it interacts with the others is crucial" (p. 14) – FTA is precisely such an approach which is yet another reason why it was chosen for this study. By examining potential sources of failure, a more complete picture of the system may emerge. Providing members of the focal system with an opportunity to voice their thoughts and trepidations regarding the innovation will serve to strengthen the system itself while providing input into the most effective manner in which to implement the technological innovation. Barrett's research on the effective use of a Student Management Information

System (SMIS) concluded that it is the user's perception of the innovation that primarily influences effective use. Rogers (1995) also identified perception as an influencing element. FTA, by virtue of its pellucid systems approach, allows for a clearer understanding of the innovation, and its potential impact, to unfold than would a more opaque and less systemic approach. FTA provides a structure in which perceptions are essential and are used to modify plans accordingly. Perceptions also play a major role in the aforementioned Technology Acceptance Model designed by Davis in 1989 and whose continued research demonstrates its endurance.

The premise behind the power of an FTA is that by understanding what does not work, an understanding of what will work can emerge. Given the theoretical literature basis and the practical FTA findings, I intend to postulate a process or technique which may help to ensure successful diffusion of a technological innovation in an educational setting (with implications for other innovations and settings as well).

Large sums of money and huge investments of time are being expended on technology in the schools with, seemingly, very little success (Coughlin, 1999; Maddux, Cummings & Torres-Rivera, 1999; Sherwood, 1999; Venkatesh & Davis, 2000). In light of the technological failures in the past and the continued amount of money that is being spent on technology, FTA may prove to be a viable and practicable method schools can use when dealing with the influx of a new technological innovation, thereby saving huge amounts of time, money and frustration. While practitioners and researchers alike currently agree that there are problems with the use of technology in the schools and efforts have been made to look into these problems, there has been no systemic and

systematic study of failure of the sort FTA offers. Education is clearly a success-oriented endeavour. Indeed, it has oft been said that if one focuses on failure, one probably will. FTA may focus on failure but it does so with the goal of success in mind. Furthermore, the very process of FTA improves the individual sense of ownership and control over the technological diffusion, loss of which, as previously discussed, teachers fear. The process, which includes direct involvement and system-wide representation, also serves to build a cohesive team which improves and strengthens the social environment into which the technology is being diffused (Jonassen, Tessmer & Hannum, 1999; Stephens, 1972; Wood, Stephens & Barker, 1979) – factors which have been previously identified as essential in the diffusion of innovation. The current study clearly involves the individuals to whom the innovation is being targeted. FTA appears to be the ideal method to address some of the problems of technological diffusion in educational settings. I believe that this technique will prove to be a useful tool in helping schools face the daunting challenge of integrating technology into their educational environments.

As previously mentioned, of inevitable focus while constructing the fault tree will be the social context or environment of the focal system (a context which will be defined and described, by the FTA team, in the first stage of the analysis). Being aware of the social context in which a technological innovation appears may shape the innovation and influence the way the innovation is used (Salomon, 1998). While it is not possible to wholly separate social context from other elements of the system, being specifically aware of the-day-to-day realities of the members of the focal system will add an element of inclusion for which FTA seems ideally suited.

Merriam, 1998, refers to social context as "social worlds". Indeed, according to Merriam (p. 6, italics in original) a:

> key philosophical assumption ... upon which all types of qualitative research are based is their view that reality is constructed by individuals interacting with their social worlds. Qualitative researchers *are interested in understanding the meaning people have constructed*, that is, how they make sense of their world and the experiences they have in the world.

FTA, as it attempts to involve as many members of the system as possible, seems to be an excellent tool to gain entry into the social worlds of the system under scrutiny. Of utmost concern in this study is to allow the voice of the intended users of the innovation to be clearly heard. It is the meaning of the stake-holders within the system upon which this research relies – meaning which may best be elucidated using FTA. The key is to gain as much information, in the respondent's own words, as possible. A balance needs to be attained between how the researcher has conceptualized the issues and how the respondent has. Not allowing the participant to express his or her thoughts and feelings regarding the innovation, without the researcher's limits, will limit the usefulness of the study (Bogdan & Biklin, 1998; Merriam, 1998). It is, after all, the participant's point of view being sought. One must also be mindful, however, of what the researcher brings to the situation. According to Janesick (1998), it is important "situate and recontextualize the research project within the shared experience of the researcher and the participants of the study" (p. 39). One of the essential elements accepted by qualitative researchers is that is driven by ideology and that there is no "value-free or bias-free design" (Janesick, 1998, p. 41). Recognizing and accounting for these biases and

allowing for recurring ethical dilemmas will provide a much richer picture than would otherwise be possible.

Bogdan and Biklin (1998) stress that one must fully evaluate one's study in terms of "the limitations it possesses for understanding the context that produced the material and the meaning of the material to those who produced and/or have used it" (p. 59). Indeed, context is of critical import to this entire study as it is integral to conducting a successful FTA. Not just in terms of understanding the context in which material was produced but, perhaps even more importantly, in terms of how the context influences the entire process of diffusion. FTA seems to be able to provide insight into contexts and meanings by virtue of the involvement required by members of the system in order to produce and validate the fault tree. While the specific goal of this study is to look at the applicability of FTA and not to analyze the social context, by documenting the process and conducting the analysis, the social context will inevitably unfold. The influence the context has on the process will also become apparent as the process moves forward.

Examples of Technological Innovation

In this section, I will discuss three instances of technological innovation and how the differing attitudes and approaches towards these innovations affected their ultimate outcomes. I purposely chose examples from very different areas in order to demonstrate that the problems of diffusion span different systems, therefore so too should any proposed solution.

Television in the classroom.

The use of television in the classroom, as an example, was looked upon with promise yet, for the most part, failed to live up to the expectations that were placed upon it (Coltman, 1994; Graham, 1997; Strommen, 1995). We are currently undergoing another technological revolution (Gray, A., 1997; Ohler, 1995; Owston, 1997). Nevertheless, in some instances, computer technology too has not been as successful as previously hyped and hoped (Cuban, 1986; Cuban & Kirkpatrick, 1998; Gilbert, 1994; Graham, 1997; Oppenheimer, 1997; Wallis, 1995; Winner, 1998).

A current example of the influx of both television and computer technology, for both educational and commercial purposes, in Canadian schools is the Youth News Network project. This project, similar in nature to Channel One currently being broadcast in the United States, has met with considerable controversy and opposition. In fact, a proposed pilot-run of the programme in three Quebec high schools, has recently been cancelled. In 1989, Channel One, developed by Whittle Communications and currently owned by Primedia which is owned by RJR Nabisco (Buckingham, 1997), began broadcasting a 10-minute newscast with two minutes of commercials. In exchange for receiving the Channel One broadcast, schools are required to sign a contract stating that 90% of the students will watch Channel One for 90% of the time; that each program will be watched in its entirety; that a program cannot be interrupted; and that teachers cannot turn the program off (Fox, 1997).

Channel One has received a lot of criticism for its commercialism. As early as 1990, Channel One was being condemned by various teacher groups (Considine, 1990) a critical

outcry which has not diminished over the years (Buckingham, 1997; Miller, 1997) and has now been picked up in Canada by opponents to the Youth News Network [YNN] (British Columbia Teachers' Federation, 1999; Canadian Teachers' Federation, 1999; Kikot, 1999; SchoolNet Weekly, 1999). There are researchers (Considine, 1990; Buckingham, 1997) who point out that, rather than criticize the commercials and throw the baby out with the bath-water as it were, perhaps educators should use the commercials to teach students about the economic, ethical and educational aspects of advertising. Providing viewers with the necessary tools with which to become media literate (Kelley & Gunter, 1996) in a world increasingly inundated with media images would be one way to use the commercials on Channel One and YNN as a opportunity for growth rather than a reason to gripe.

Educational researchers Celano and Neuman (1997), conducted an investigation of the use of Channel One in one high-school and concluded that Channel One producers should be encouraging teachers to use the newscasts as an integral part of their curriculum. The focus in the literature seems to be most concerned with the aspect of commercials in the classroom yet commercial-free programmes are also available to Channel One viewers. In addition to the newscasts that contain the advertising, Channel One Communications also provides other educational programming. In a 1995 survey of 200 schools in the United States, Tiene and Whitmore (1995) found that 39% of respondents used the additional broadcasts of previously aired PBS programmes between one and four times a week, 32% used it five times per week and 20% used it more than five times per week (which would indicate use of more than once a day as there are only). Furthermore, 83%

of respondents indicated that because of the Channel One Network these schools increased their overall use of educational television.

The fact remains though that research into the educational value of Channel One news (and presumably that of YNN as well should it be implemented) indicates that the value is negligible and that the program is disproportionately picked up by school districts in low-income areas (Canadian Teachers' Federation, 1999). Jan Eastman, president of the Canadian Teachers' Federation perhaps sums up the sentiment against YNN best when she states that,

> YNN represents an insidious and aggressive takeover of instructional time and curricula content with students as a captive audience. YNN's previous attempts since 1992 to gain access to schools have been resisted through strong public opposition by teachers' organizations, parent groups, school boards, media literacy groups and a number of ministries of education. We are urging these groups to voice, once again, their clear opposition to YNN.

In its favour, Channel One Communications, as does YNN, offers a satellite dish, several videocassette recorders, a head end unit to send the television signals to the classrooms, wiring throughout the school and a television set in every classroom with a 25 or greater student capacity – equipment schools would not have if they did not sign on to the service (Tiene & Whitmore, 1995). In the face of tight economic constraints, schools would be hard-pressed to refuse the equipment even in light of the criticism I have described earlier. Indeed, 40% of United States middle and high schools are Channel One subscribers and there is a consistently high rate of contract renewals (Buckingham, 1997). Creative educators, in partnership with broadcasters, could take the equipment and use it to their advantage. The creative and active participation of broadcasters with their

intended utilizers is something that should be stressed. It is not necessarily the technological tool that is important but, rather, how and in which context that tool is ultimately used. Going through the process of FTA in a school facing the prospect of YNN may provide insight into potential failure events and, subsequently, indicate how to turn those failure events into successful use of YNN.

Langdon Winner, a critic of technological innovation, stated in a recent interview that "we are not especially clever or careful as we approach heavily promoted new technological innovations" (Winner, 1998, p. 7). Winner also cites the rush to install computers in schools as a prime example of this lack of deliberate thought. One particularly good question Winner proposes that educators ask themselves prior to selecting a particular piece of software is: "if the software appeared in book form, would [they] be equally enthusiastic about buying it and requiring every student to use it (Winner, 1998, p. 7)?" It is interesting that teachers put so much thought into the selection of textbooks and methods of evaluation, assignments, etc., but too frequently take it as a given that if a piece of software is available it follows that it must be good. Teachers may have different levels of control over textbook selection and other material than they may have over software selection but the control lies with someone and Winner is arguing that more care needs to be taken to ensure that appropriate software is selected. Winner questions what it is that makes common sense disappear in the face of technology. Is it perhaps that people have come to "regard technology as something like Big Magic? Behold: this will transform our lives for the better (Winner, 1998, p. 7)!"

Fogo Island.

Returning to my supposition that consideration of context or social surround is an integral element in the successful diffusion of innovation, I will describe a situation in which social context and, especially, interaction was essential to the ultimate success of a particular technological endeavour which took place thirty-three years ago. In this case, understanding failure led to ultimate success. In this particular situation, the innovation was empowering people and giving them a voice – a means by which they could be heard – where they previously were, or at least perceived themselves to be, mute. FTA is a means of examining failure and inherent in the method is the provision of voice for the actors. Providing the members of the college faculty with a constructive and precise mechanism by which their voices will be heard may encourage them to take a more positive approach when the innovation is ultimately implemented. In 1991, I had the privilege of interviewing the producer and director of these films, Colin Low, and from our conversations I gained an in-depth understanding of what it takes to utilize technology in a manner which is of benefit to those individuals one is attempting to help. Perhaps the most important characteristic is humility and an ability to put oneself in another person's place and see things from their perspective – to gain entry into their social context. Colin Low had this unique ability.

In 1967, Colin Low, a producer and director at the National Film Board of Canada (NFB) went to Fogo Island off the coast of Newfoundland to do a film on a community development worker, Fred Earle. At that time, plans were being made by the Newfoundland government to resettle Fogo Island. It was Earle who was helping to

channel the Islander's desire to remain into concrete results. He helped to establish an island development committee and in 1967 organized a fisherman's conference in order to explore Fogo's problems as well as the possibility of establishing a fisherman's cooperative. It was Memorial University that funded the conference and it was the Newfoundland government that refused to help fund the fishing cooperative. It was into this mixed atmosphere of hope and despair that Low entered.

Low felt that he could go to Fogo Island and make a film about a good community development person. It did not work that way though. Low said that even on Earle's coattails the people did not accept him. He said that he felt the resistance to him. He would get so far into a conversation and then get no further. So Low changed his tactics and instead simply asked people to talk to him in front of the camera and eventually they did. In return, he gave them full, participatory editorial control over the films. What they did not like could be changed or edited out and if that did not work, they could choose to have the entire film destroyed. The Islanders were the first to view the films and they gave or withdrew permission for them to be shown to others. Baggaley (1975) and Henny (1983) have discussed the importance of editorial control and full participation by the people in order to gain the most via media.

The films (twenty-eight were made) then served as a dialogue amongst and between communities. People who had never met someone from a neighbouring community were now discovering that they had much in common. Not only were the films viewed by the different communities, they were also shown to government officials who responded in kind, on film, to the people of Fogo Island. Eventually, the need for the films was no

longer there and people, Islanders and government, began talking about what they could do to help the Island communities. The communities were not resettled and a fishing cooperative was formed. These films, and especially the process by which they were made and diffused, are a very good example of how technological innovation can work when the people for whom the technology is intended are consulted throughout. This is one example of how taking social context into consideration worked to help achieve the desired outcome – for the people not to be resettled and for them to become more financially independent.

The lesson to be learned from this story is that the people saw the benefit of the technology and therefore accepted it and used it to their advantage (one of Rogers' key tenets). In this case, there was no need for the technology to remain since its "voice" had been replaced with the people's own voices. Film empowered them and once empowered, they took over. I do not see it in the least bit ironic that films were no longer used. In the strictest sense, one could argue that true diffusion did not occur but diffusion also applies to ideas and in this case those ideas were fueled and put into power via technology. Once the ideas diffused, there was no longer any need for the technology. Technology is a tool to be used. It was used very successfully. The people of Fogo Island gained a voice. To use an old and familiar proverb as a particularly apt metaphor in this situation – they were taught how to fish and not merely given a fish.

The Fogo Island example demonstrates the use of technology for attitude change and empowerment. It was the process that was important which led to successful outcomes. The Fogo Island process, as Drucker (1999) has suggested be done with today's

knowledge workers in the information revolution, turned subordinates into partners, thereby increasing the likelihood of successful use. The modification I have proposed to the FTA process also attempts to create an atmosphere of partnership and shared knowledge. The current research focuses on process and whether or not it produces a successful outcome. There are similarities between the two cases that warrant the inclusion of the Fogo Island story. Without acceptance and trust, there would have been no films. Had Low not looked at failure or taken the social context in which the films were being made into consideration, the outcome would not have been nearly as successful. Lack of attention to failure and social context is exemplified by an earlier film project carried out by the Challenge for Change programme of the National Film Board. The film, The Things I Cannot Change, was about a poor Montreal family of ten children. The children seem to be the only thing that gave the parents joy so they keep having more. When the film was shown, the family suffered many negative consequences. The film failed for numerous reasons, not least of which was the failure to fully consider social context (Jones, 1981).

Technology for empowerment.

Media has always been present in both rural and urban communities. From the low-tech, though not unsophisticated, to the high-tech, some form of it has always been used in social processes (Henny, 1983). In post revolution Russia there were innovative and pioneering filmmakers who were using film for social change (Henny, 1983). One of the most famous directors who was using film to reflect the society and perhaps change it was Sergei Eisenstein (Leyda, 1985). The themes of Eisenstein's works were themes of

the social mass. Eisenstein strongly believed in the power of the people themselves to best portray and understand their own situations. The current research into FTA is aimed at gaining an understanding of the process of implementation and the impediments faced in its use.

There is a danger in the use of technology. It can be abused. Low (C. Low, personal communication, November 8, 1991) says that media is too often seductive and flashy and crusading. To be really effective it can not be based on mass-media expectations. When using any technology it is crucial to keep in mind the intended users. One can not just go in with a one-shot, quick fix. For technology to be effective there must be a vision in mind – a major, long-term, goal. Without this, technology becomes nothing more than fancy and expensive toys and is ultimately wasted. Colin Low is a man who is fully aware of the power and pitfalls that come with the use of any medium. He went to Fogo Island with strong beliefs and he adhered to those beliefs. At first, Low said that no one wanted to talk to him and that he had to make the islander's more curious of him than afraid. He succeeded and the enthusiasm of the Islanders was so great that Low reluctantly had to turn people away. Low was giving power and action to people who had never before been powerful. Understanding what occurred at Fogo Island adds to the current argument by pointing out the importance of involvement in the process and its subsequent effects on success (regardless of how success is defined).

During our conversations, Low told me that it is "crucially important to appreciate that the films are subsidiary to the purpose they serve and the process deals with community action rather than film-making". "Fogo," says Low, "is not a process but an

attitude. It essentially regards silent people - the silent man, the silent majority, or the silent minorities for that matter - as worthy of the privilege of a voice-expression" (C. Low, personal communication, November 8, 1991). I come back again to the idea and ideal of empowerment and ownership. These are indeed, visions in their own right and are crucial to the success of any educational technology. Low, rather than merely being a man with a mandate to fill, was and is a man with a vision.

> If you want to change things. If you want to get involved with people. You've got to go and get your gumboots on and pull some fish in and try and figure out what they (the people, not the fish!) really think. To me, that's the most interesting. Colin Low, personal conversation

While the technology may change, it is entirely possible that the lessons about diffusion of innovation for success or failure remain the same in all human/machine contexts. It is important to consider the people and the social context in which technology is to be implemented and it is this concept which will guide my research. I see technology as a tool. That tool can be for learning outcomes or for attitude change but it remains a tool. In both of these examples, the tool is, as Rogers (1995) would describe it, a communication medium. I see FTA as a communications tool as well. By virtue of conducting a FTA, the actors in the system will gain skills in team-building, communication and a sense of common ground (Jonassen, Tessmer, & Hannum, 1999; Spitzer, 1980; Stephens & Wood, 1976; Wood, Stephens, & Barker, 1979) thereby strengthening social context and perhaps leading to greater success in the diffusion of whatever innovation they are grappling with.

Boxed beef in a social context.

Another instance, specifically related to the diffusion of innovation (albeit in a very different setting), in which recognizing failure and the importance of social context played a key role in the acceptance of an innovation was in the retail food industry. In 1991, Walsh, currently a sociology professor at the University of Illinois, examined three examples (frozen meat, boxed beef and price scanners) of a technological innovation in the retail food industry. Using what he described as archival research supplemented with interviews, Walsh (1991) delved into the historical background of these three innovations with an eye towards exposing and highlighting the social system reorganization element involved in the acceptance or failure of the innovations. Walsh discovered that understanding the process by which technologies are innovated and diffused, specifically their social and political elements, may enable a more streamlined and successful process.

Walsh and Bayma (1996) continued examining the relationship between social context and technology in a study that examined the incorporation of computer-mediated communication amongst university faculty in four different fields of research. Walsh and Bayma conducted interviews with 67 scientists in four different fields and found that use depended on field and attributed this variance to the differing social structures and work organizations inherent to each field.

Giuseppe Mantovani (1996), in an investigation of human-computer interaction research looking at computer-supported cooperative work, computer-mediated communication and distributed artificial intelligence, proposed a conceptual model which "conceived of contexts as including not only physical objects and other people but also

social *norms* which influence both individuals and organizations [and that] computer system use occurs in social scenarios" (p. 237). Van Den Akker et al (1991) have proposed a framework in which to place factors influencing the implementation of an innovation. Understanding the context at the college, therefore, is one of the elements the FTA team will uncover in the course of the FTA process.

Summary

The literature has identified a gap between acquisition of technology and actual use in educational settings. The literature also points out that purposeful involvement of the intended users of the technology in the process of diffusion may bridge the gap. FTA appears to be a method by which both of these factors can be addressed.

To summarize: the purpose of this research was to explore the applicability and utility of a modified version of FTA as a potential solution to bridge the gap between acquisition and use of technology. Specifically, an FTA was conducted in a large urban college interested in implementing web-based courses and increasing the use of technology in teaching by the faculty. The applicability and utility of FTA will be examined by answering the following questions:

1) Is FTA an applicable and useful tool in the diffusion of innovation in an educational setting?

2) Can FTA be used in a timely and cost-effective manner?

3) Will the members of the focal system participate in the process?

4) Will the participants find value in the process?

5) Will the group of individuals responsible for implementing the innovation recognize the information obtained from the FTA and, if necessary, adjust their plans accordingly?

6) Will changes to the system (diffusion plan) be made according to the results of the FTA?

Chapter Three – Method

Introduction

The strategy of inquiry used in this study relies primarily on qualitative data. Qualitative research has manifested itself in various ways but the essential elements seem to remain the same, and that is the emphasis placed on the "socially constructed nature of reality, the intimate relationship between the researcher and what is studied and the situational constraints that shape inquiry" (Denzin, 2000, p. 14) all three elements of which are present in the current study. Also, if the purpose of research is to produce new knowledge, and knowledge, as defined by Duffy (1999, p. 5), is "influenced by the subjective context gained as a result of action taken by the user – action that was based on the available information" then this study fits the description. Knowledge, however, is not merely data or information but rather the amalgamation and processing of data and information. What makes knowledge valuable is the context in which it occurs and the contribution of those it concerns. The research I undertook, in partnership with the FTA team and focal system, is rich in context and therefore more meaningful than would have been the case without their active partnership and participation.

A case-study of one particular use of FTA, this research can also be described as participatory action research in that I aimed to "produce knowledge and action directly useful to a group of people...[and] to empower people...through the process of constructing and using their own knowledge" (Reason, 1998, p. 269). While the subjects are hardly the disempowered and politically oppressed individuals sometimes associated with participatory action research, the essence and goals of the study remain the same. To

use a term popularized by Paulo Freire, the *consciencization* of the members of the college community was a major component of this research. I proposed that playing actives roles in the research would engender a feeling of ownership and encourage the participants to subsequently take a more active and proprietary role in any ensuing implementation of new technologies.

This research was cooperative in nature and full respect and consideration was given to the participants. The goals and realities of the participants as well as those of the researcher were considered at all times and changes were made throughout the process in order to reflect the participants' needs. As a participant-observer in this research, I strove to ensure that the participants' voices were heard and their needs were met while fulfilling the academic and ethical requirements under which this research took place. I played a role in the research process but I observed and recorded the process as well. I informed the members of the FTA team that I would be observing the process. I asked for, and received, their permission to use unattributed anecdotes (verbatim accounts in transcripts of actual sessions) in the final document.

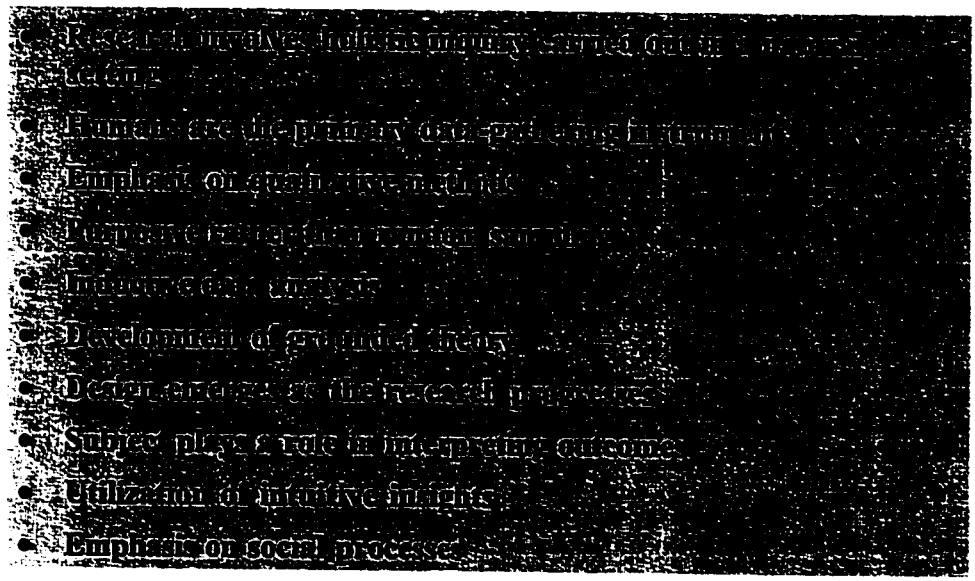
Since the purpose of this research was to determine the applicability and utility of Fault Tree Analysis, I documented the process of constructing the tree. No prior research using FTA contained such process or anecdotal evidence. It was therefore important that the participants' observation on the process, as well as my own, be noted. In this way, emic and etic perspectives were gained.

Research Design

Ten characteristics of qualitative research (see Table 1), culled from leading writers in the field and generally accepted by most, are listed in Borg and Gall (1989, p. 385-387). The FTA subsequent evaluation the FTA team and I conducted respects each of these tenets.

Table 1

Characteristics of qualitative research



While clearly a study which fits in the qualitative domain, it is difficult to categorize this research into one specific method as it draws upon more than one. Furthermore, this research was emergent in nature and uses another method, Fault Tree Analysis, in its execution. FTA, while initially designed as a method to be used in hard systems analysis is wholistic and comprehensive in nature. My modifications of the method have made it even more systemic, responsive and participatory than did its original adapter to soft systems. The tenets of participatory action research are strongly represented in this work

by providing the participants ample opportunity to adjust the method to suit their realities and by using the information gained to affect change in their immediate environments. I am careful to refer to the individuals in this study as participants and not subjects – the fundamental difference being that these individuals were not subjected to a process but shaped it by participated fully in it.

Also represented is a participant observation strategy in that the participants and, to a much greater degree, I were called upon to not only complete the process but to objectively observe and evaluate its efficacy as well. However many ways there are to label this study, the essence of collaboration and the emphasis on practicable knowledge is what remains important.

Triangulation

Triangulation is the process of using different data collection methods to explore a single problem. Four types of triangulation identified by Denzin in the 1970s and discussed by Janesick (2000) are: data; investigator; theory and methodological. Data triangulation is addressed in this study by the multiple methods of data collection used: group meetings (which helps serve to put individual responses in context); interview; written survey information; participant observation; and direct observation. It is believed that each of these sources and types of information is used as a portion of the evidence which contributes to the conclusions reached in this study. Investigator triangulation is addressed in only one instance – inter-rater reliability for the categorization of failure events. Though, it could be argued that investigator triangulation is also addressed by having the FTA team members evaluate the process in addition to my own evaluation.

Theory triangulation is addressed by relying upon the different areas of literature discussed in the first two chapters of this document with which the findings of this work will be situated. Methodological triangulation is addressed by adhering to the tenets of participatory action research, participant observation research and the Fault Tree Analysis method itself.

As important as triangulation is, some qualitative researchers are now thinking of it more in terms of a circle than a rigid triangle (see, for example, Janesick, 2000; Richardson, 2000). Richardson (2000) argues that traditional ideas of triangulation may call upon different methods but fundamentally come from the same basic assumptions. She proposes, instead, that we crystallize instead of triangulate and look to the image of the crystal as one with a "variety of shapes, substances, transmutations, multidimensionalities, and angles of approach" (Richardson, 2000, p. 934). This FTA, by virtue of its systemic and inclusive nature sought to fulfill these goals.

Participants

Two groups of participants were required for this study – the members of the FTA team which were drawn from the administrative, technical and academic staff of the college and the faculty of the college (the focal system).

Roles of the FTA team, the focal system and the researcher.

Members of the FTA team were responsible for producing nearly all of the information required in this study. Team members were required to define the system, establish the goal statement, define successful attainment of that goal, determine the

impediments (failure events) to achieving that goal, validating the fault tree, comprehending and addressing the information provided by the focal system and determining how they would best address the results of the analysis. FTA team members were also responsible for providing both formative and summative evaluation information on the process itself. From our very first meeting, I made it clear to the team members that they should critically evaluate the process as we proceeded and provide input on how they would choose to modify it. Team members were very forthcoming with their opinions and practical advice and took their role as critical participants very seriously. Finally, upon completion of the FTA, the FTA team completed a thorough evaluation of the entire process. They completed a questionnaire and participated in a group discussion. FTA team members were, therefore, both participants and observers in this process. It is interesting to note that two of the team members took on the additional role of researching sources of information which would be of interest to the team and bringing this information to them.

Including the focal system in the FTA process was unique to the current study. Their role, however, was one which the diffusion of innovation literature deems as critical to successful adoption. Focal system members were asked to complete a two-part questionnaire – the first section dealing with statements regarding their use of and attitudes towards internet and other computer technology. The second section of the questionnaire was directly related to the failure events generated by the FTA team. The members of the focal system were asked to provide input on these items. They were also asked their opinion on the perceived usefulness of gathering their input. Their role, in

other words, was to help determine whether the findings of the FTA team was an accurate representation of the system as a whole.

My primary roles in this process were as a source information, guide, observer and participant. It was my responsibility to guide the team members through the FTA process and provide them with the information they needed. I participated in the process but was careful not to influence the outcome of the analysis. The fault tree was meant to be a reflection of the college's reality and not mine. As such, it was important for me to allow the team members the freedom to produce a fault tree which was useful and meaningful to them regardless of how rigourously that tree adhered to what the original designers of the process intended. Once more heeding the principle behind successful diffusion of innovation, I gave the FTA team the freedom they needed to make this process their own.

FTA team recruitment, construction and logistics.

To form the FTA team and gain access to the faculty and professional staff, I initially approached the head of research and development at the college with my idea in November of 1999. He spoke with two academic vice-deans as well as the head of computer services. All individuals expressed an interest in participating. When I met with these four individuals, in December of 1999, I briefly outlined what my project would entail in terms of participation and time requirement. At this meeting, the academic vice-deans expressed their interest in the development and implementation of web-based courses at the college and they thought that the analysis I wanted to do would serve their purposes very well. I explained at this point that the entire premise of FTA rests on the

willingness of the 'planners' to seek and use input from the people for whom the plans are being made. I further emphasized that the goal they had at our initial meeting may have to be modified in order to meet the needs and wants of the other members of the FTA team and the focal system as well. They agreed that it was important to listen to the other members' opinions but one of the academic vice-deans also expressed it very clearly that regardless of what other ideas were put forth, his idea needed to be examined as well. Essential to the essence of this research was the inclusion of as many members of the college professional community as possible. The academic vice-deans and a science faculty member provided me with names of individuals who may be interested in participating. I contacted these individuals using e-mail and the internal FirstClass computer conferencing system (see Appendix A – "FTA team recruitment letter") asking them if they would be willing to participate.

The preliminary FTA team consisted of nine members, including the researcher. Two members represented the administration, two represented technical services and four were faculty members representing various subject areas in the college (science, fine arts, and radiography). A representative sample of as many subject areas and types of expertise was sought while also keeping group size manageable. All nine members participated in the first three meetings which discussed and defined the college as a system, identified the goal and defined what successful attainment of the goal would entail. Seven members, including the researcher, (two science faculty members were no longer able to devote the time required) completed all steps up to and including the identification of the failure events for the tree. Five members (one academic vice-dean, the technical officer, the fine arts and the biology faculty members, plus the researcher)

completed the entire process. The two members (one of the academic vice-deans and the independent researcher) who left did so because they left the college for other jobs. Any problems associated with the changing nature of the FTA team and its subsequent impact on the information provided will be discussed in the results and interpretation sections.

Time constraints were a significant problem for all members of the FTA team. Weekly meetings were scheduled but attendance was not always possible. A FirstClass computer conference area was set up in order to enable continued participation and discussion between meetings. The computer conference was also used to allow members unable to attend a meeting to participate and keep current as to the FTA team's progress. The extent to which this forum was used will be discussed in the results and interpretation section.

The focal system.

The second group of participants in this study were the 543 faculty members at the college (the focal system). This group of participants provided input by completing the survey which contained questions about technology use and attitudes, questions specific to the failure events identified by the FTA team and questions concerning the FTA process itself.

I believed that providing the members of the focal system with an opportunity and encouragement for contributing would increase the likelihood of a positive response towards the innovation. As discussed in the literature review, providing opportunities to intended users of an innovation to participate in the process of implementation will likely

increase their sense of ownership and subsequent use. The procedure followed in this study, while not guaranteeing full participation, at least provided an opportunity to do so.

Process

The process of FTA, as formulated by Stephens (1972), described in Wood, Stephens and Barker (1979, p. 8) and elaborated upon by Witkin and Altschuld (1995, p. 252-271) and Jonassen, Tessmer, and Hannum (1999, 230-233), are outlined below. I used the original steps as a guide and modified and adapted them as the FTA team members and situation warranted. The final FTA process differs from the proscribed original but is a better representation of practice. Also, as adaptive as this process was, there are still changes which can be made to better the process and make it even more practicable – changes I will delineate in the discussion section.

1. Defining the system.

Systems definition: objectives, goals, boundaries and constraints.

a) During the initial meeting held with the four members of the administration prior to the selection and formation of the FTA team, we determined that the innovation we would examine with the FTA would concern some aspect of the internet in teaching. This idea was subsequently presented to the FTA team with the reassurance that it was but the starting point for the discussion and could be modified as they saw fit. The objective of this step was to begin defining the goal statement upon which the FTA rested.

b) The first FTA team meeting was held on March 31, 2000 and was scheduled for 1 1/2 hours. The meeting was recorded on audio-tape with the consent of all members. Using audio-tape allowed for a more natural environment in that the researcher was free to participate and facilitate the discussion rather than be concerned with getting every word down on paper. Since the actual process of the FTA was one of the foci of this study, it was important to have a record of the meetings. The FTA team was assured that only the researcher or other team-members would hear the tapes.

c) At the first meeting of the FTA team, I stated the purpose of the research and explained the FTA process.

d) Participants were encouraged to ask questions. The teams members did ask a few questions but, for the most part, were very eager to get started defining the goal statement.

e) Discussion of the goal statement (a statement of the goal, purpose or intent of the group) took place for about one hour. At the end of the hour we had decided upon a preliminary goal statement. The FTA team was asked to continue the discussion on the electronic conference site.

I strongly emphasized that consensus, through compromise, must be attained on the goal statement before the process could continue.

Examples of goal statements from previous Fault Tree Analyses were given to the FTA team:

> "Make improvements in the formal internal communication among designated management personnel in an expanding multi-campus community college district" (Long, 1976).
>
> "[The College of Eastern Utah will] provide educational opportunities to serve immediate and continuing long-range academic, vocational, personal, social, cultural, and professional needs of students, college personnel and community" (Nelson, 1976).
>
> "Prepare highly qualified leaders who will function as teachers, researchers, supervisors, administrators, and therapists in the field of physical education. These leaders will be prepared to make a unique contribution because of their exposure to a philosophy that stresses the sacredness and particularly the spiritual and eternal significance of the body" (Copeland, 1976).

f) At the end of the meeting, I discussed the importance of obtaining a system definition in order to contextualize the findings of the FTA. A brief discussion took place as to the components of such a definition. The participants were asked, over the course of one week, to write a description of the system of the college as they view and experience it. The team members were asked that the definition include the boundaries of the system and the constraints under which it operates. A discussion, and further modification, if necessary, of these definitions, was to be discussed and the beginning of the next FTA team meeting.

The reasoning underlying this task is as follows. According to Rogers' (1995) theory of diffusion of innovation, the nature of the social system, its communication channels and type of innovation decisions which occur

are three variables which determine the rate of adoption of an innovation. Understanding the system from the perspective of the intended users, therefore, will serve the dual purpose of determining the applicability and utility of the FTA process as well as aid in the ultimate diffusion of the innovation the FTA is designed to examine.

g) Finally, the FTA team was asked to take the last five minutes of the meeting and write a short paragraph describing what they would like to achieve/attain by participating in the research. This paragraph was revisited at the end of the study when the participants were asked whether and to what degree the actual outcome met with their desired outcome. These paragraphs appear in Table 3.

2. Mission analysis.

Once a goal statement was decided upon, the group discussed what the accomplishment of the goal would look like. Stephens (1979) refers to this as mission analysis. In other words, the participants began to define the types of things that would indicate the successful accomplishment of the goal. These discussions took place in the face-to-face meetings. Electronic discussions were also meant to take place but for various reasons this did not occur to the degree anticipated. I will discuss the implications of this in the next chapter.

3. Identification of undesired event(s).

a) An undesired event [UE] is the failure to achieve a goal. In other words, the FTA team decided, based on their previously defined goal statement, what they *did not* want to have happen. (e.g., failure of faculty to increase their use of the internet in their daily teaching activities.). An FTA team might find more than one undesired event.

b) Group discussions, in person and using the electronic conference area established for the purposes of this study, were held until consensus was reached as to 'undesired events'.

4. Fault hazard analysis.

Once undesired events[2] were identified, the FTA team was to, with face-to-face and electronic discussion, rank them according to relative importance. Failures, or undesired events, may occur at the goal, function or task level and the FTA team identifies these levels.

5. Identify failure events contributing to the undesired event(s).

a) Members of the FTA team, in conjunction with the researcher and with reference to the appropriate literature, determined the most likely failure events necessary in order for the undesired event to occur. FTA team

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[2] The undesired event is the inverse of the goal statement. Failure events, which I also refer to as impediments, are those factors which contribute to the occurrence of the undesired event.

members were asked to generate as many impediments or failure events as they could. They did this individually and then submitted them to me electronically. I then assigned each team-member an impediment and asked them to generate as many failure events as possible for that fault. This list was also individually generated by the FTA team members and submitted electronically.

Over the next two, face-to-face meetings, disclosure and discussion of these failure events took place. The identification of the failure events by the seven-member FTA team (two academic vice-deans, technology officer, contract researcher, fine arts and science faculty members, researcher) took approximately four hours (divided into two, two hour meetings held one week apart).

b) Once the impediments the FTA team agreed would contribute to the failure of the overall mission (attainment of the goal) were identified, they were turned into failure statements each of which was written in the following format: "Failure of .... because of ...." Ultimately, based on the decision of the FTA team, the wording of these statements was changed to be more congruent with the everyday language of both the FTA team and the members of the focal system. The researcher sorted through the responses and eliminated redundant ones.

c) Upon completion of Steps 5a and 5b, the failure events were categorized, as suggested by Witkin and Altschuld (1995), in the following groups:

events which are completely in control of the system, events which are under partial control of the system and events entirely beyond the control of the system. Categorizing the failure events in this manner provided a better position to determine which areas can be redesigned or where contingency plans may help avert problems (especially in cases of externally controlled events).

This task was completed by myself and not the FTA team as originally anticipated due to time constraints. However, all remaining team members were consulted and their opinions were included in the final categorization,

6. Specification of the logic gates between the contributing events.

a) Initially, the arrangement of the failure events was meant to be a team activity. Logistically, however, this proved to be impossible. The FTA team members were leaving for their summer break and could not participate in the process for approximately eight weeks. Therefore, I decided to organize the events while receiving feedback from the team members whenever possible. As the fault tree developed, some feedback was obtained from FTA team members who were still available via electronic means.

b) [3]When the team members returned from their summer break, the remaining four FTA team members (academic vice-dean, technology officer, fine arts and science faculty members) and I met to examine the fault tree displayed on a large wall in an art studio at the college. They were asked to carefully look over the tree to move and change any of the failure events as they deemed necessary. The team members were encouraged to write comments on the tree and change the wording as well. They also examined the relationships between the events and decided whether the events were joined by AND or OR gates. The team concluded that, except for one instance, all of the events were joined by OR gates. They also decided that adding these gates to the diagramme was not necessary because they would just complicate the tree for uninitiated readers. Therefore, the final tree does not contain any gates, though they are implied.

7. Develop the tree to the next lowest level until complete.

During face-to-face discussions, steps 5a and 6 were repeated at each lower level of the tree until the FTA team decided that no further development could occur – a decision which was based on their opinion that these failure events were too far out of their control. The items on the lowest level of the tree are represented by diamonds. At this point, I finalized the tree incorporating the FTA team's input.

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[3] Steps 6b, 7 and 8 all took place in a two-hour session with the four remaining FTA team members and myself.

8. Validate the fault tree against the system it represents.

This step of the process was carried out in two stages. The first stage was completed by the FTA team and the second was accomplished by surveying the members of the focal system.

The tree was validated initially by the FTA team. The purpose of this step was to examine and confirm the accuracy of each of the hierarchical and lateral relationships in the tree. Since reliance upon subjective measures of tree construction may call the tree's validity into question, steps built into the method help overcome this weakness. I have added a step to the process by having the focal system validate the tree as well (refer to Step 10). The method of tree-validation which the FTA team followed, as described by Wood, Stephens and Barker (1979, p. 13) indicates that:

> 1) Each rectangle [which appears on the tree] should state an undesired [or failure] event.
>
> 2) Each terminal event [events which can no longer be analyzed] should be studied closely, and the question asked: "If this event really happens, is there a legitimate way around it?". *If any way can be found to avoid occurrence of the event,* or an exception found to it, then an AND gate should be drawn above the event (it would replace the OR gate if there was not an AND gate previously) and a new event explaining the exception would be inserted in the tree.

Once the tree was validated by the FTA team in this manner, the following questions, delineated by Witkin and Altschuld (1995, p. 267-8) were used by the FTA team as guidelines for further evaluating the tree and ascertaining the best way to way to proceed towards a solution:

1) Are there any AND gates? If there are few or none, can the success plan be altered to provide backup systems, alternatives, or offsetting strategies?

2) Are some events depicted that expert judgment indicates could be very critical in contributing to the overall UE? If so, highlight those. If the same or similar highlighted events or paths occur in more than one branch of the tree, are they related to each other? Redundant events magnify the criticality of potential failures manyfold.

3) Are there events that might occur because of the effect from external sources, such as regulatory agencies or some environmental hazard? Are offsetting strategies available?

4) What about the timing of the potential event? If [for example] the student fails a required course in the last quarter of the senior year, the event is much more critical than if it occurred a year earlier. The "difficulty of rectification" factor increases in magnitude.

5) Did you choose the right UE?

9. Label the fault tree.

I labeled the tree due to time constraints which precluded FTA team member involvement. Also, I did not see the value-added in including the entire FTA team in this very straightforward process. This step is usually only indicated when quantification of the tree also occurs and is normally completed by the researcher and not the entire FTA team (Wood, Stephens & Barker, 1979). The purpose of this step was to identify each of the failure events on the tree for easy reference. Events which are directly below the undesired event are labeled A, B, C, etc. Events that contribute to event A are labeled AA, AB, AC, etc. A letter is added to each event as one moves down the tree.

10. Quantitative evaluation.

Quantitative evaluation, as described by Stephens, was not deemed necessary by the FTA team. The tree was small enough that we were able to determine the most critical areas upon which to concentrate.

11. Validation of the tree by the focal system.

Survey data were collected from this group after the FTA team completed the fault tree and their preliminary validation as described in Step 8. Each faculty member received a questionnaire containing technology use and attitude statements in order to obtain supplemental and contextual information (see Appendix B for a copy of the questionnaire). Additionally, each survey contained a randomly selected branch (or branches) of the tree; for each failure event, faculty members were asked to respond to the following three questions: 1) This event is relevant to the accomplishment of the goal; 2) This event is likely to effect my accomplishment of the goal; and 3) This event is likely to occur. Knowing which failure events were relevant to the goal, likely to effect individual attainment of the goal and, perhaps most importantly, which events were most likely to occur, provided insight into the accuracy and validity of the tree as it was developed by the FTA team.

I divided the tree into nine sections, each of which contained one to three branches of the tree and randomly distributed them amongst the faculty members.

Each survey package contained an introductory letter, a consent form, a questionnaire, a tree branch or branches, a ticket for the random prize drawing, a

reminder sheet, a return envelope and a pen. The surveys were delivered to the mailroom on Friday, September 8, 2000. The respondents were told that they had until Monday, September 25, 2000 to return them. The surveys were distributed using the college's internal mail system. The mailman distributed the surveys and returned the extras. Respondents were instructed to return the completed surveys via their internal mail system and I picked up the completed surveys from the college mail room.

A reminder notice was delivered to all faculty members via the college's internal mail system on Wednesday, September 20, 2000. A reminder message was also posted on the college's FirstClass intranet system.

The results of the focal system validation of the fault tree, in which faculty were asked not only to validate the information provided but add their own failure events as well, will help serve to indicate the degree to which the tree produced by the FTA team actually reflects the concerns of the focal system. After the tree was validated by the FTA team and the focal system, the FTA team modified the tree as necessary, formulated recommendations to offset potential failure sequences and formulated plans of action.

12. Validation of the Fault Tree Analysis Process by the FTA Team

Process evaluation.

In conjunction with the FTA team, the researcher assessed the degree to which the results of this study contribute to the field and the environment (the college) in which the

study was conducted. I constructed the measures of applicability and utility mindful of both of these responsibilities. Based on assessments of needs analyses, theories of diffusion of innovation and project implementation principles, the process evaluation questionnaire (see Appendix C) was developed.

The remaining four FTA team members (academic vice-dean, technology officer, fine arts and biology faculty members) completed the questionnaire and then group discussions were held. All four FTA team members were not able to be present at the same meeting so two evaluation sessions were held. The first had three FTA team members (academic vice-dean, technology officer and biology faculty member) and the second was a one-on-one session between the fine arts faculty members and the researcher.

Category evaluation.

Once the tree was completed according to the appropriately adapted methodology as described above, the researcher and two independent coders each categorized the failure events according to the following six criteria identified in the literature as common impediments to use of technology in educational settings: time; expertise; access; resources; support and perceived need. According to the literature, there should be a strong match between the failure events generated by the participants and these six criteria. A seventh category was identified in the FTA process: communication. If there are events generated which do not fit the categories, the possibility exists that the categories are incomplete or they do not adequately account for system idiosyncrasies. To help ensure the accuracy of this categorization, inter-rater reliability percentages were

calculated based on the categorization of these events by the independent coders and myself. A good measure of utility is the extent to which the failure events the FTA uncovered are similar to those which the literature indicates should exist. It is also possible that new categories will be found.

A coding scheme was developed for the coders to follow which consisted of the categories and their definitions. All coders used the list of failure events generated by the FTA team and used the list of categories and their respective definitions (see Appendix D for the instructions, categories and their respective definitions). The coders marked the first letter of the category (i.e., S for Support) into which the failure event fit next to each event. Once the researcher and the two independent coders completed the task, the researcher worked with Coder #2 in order to establish a common understanding of the categories and perhaps improve the degree of overlap in their categorizations.

Inter-rater reliability was established by having the researcher and two independent coders code the list of failure events that had been generated. All three coders categorized a common list of 228 failure events into one of the seven categories listed above. Three Cohen's Kappa, a method of calculating percentage of agreement between coders which purports to correct for chance, were calculated. One for the researcher and Coder #1; one for the researcher and Coder #2 and one for Coder #1 and Coder #2.

Based on the answers to the questions pertaining to applicability and utility, the input of the FTA team and the members of the focal system, and a study of the information gathered as a participant-observer, interpretations and recommendations were

then formulated as to the applicability and utility of FTA in the diffusion of innovation in educational settings and a model of FTA was developed.

Chapter Four – Results

Introduction

I remind the reader at this stage that the purpose of this study was to conduct a process evaluation of the applicability and utility of conducting a Fault Tree Analysis [FTA] in an educational setting contemplating the implementation of a technological innovation. Accordingly, the results reported in this chapter arise from two distinct parts of the study: information which the FTA team used to carry out the FTA and construct the fault tree; and the information concerning the applicability and utility of the FTA process itself.

Questions

The main questions I set out to answer with my study were:

1) Is FTA an applicable and useful tool in the diffusion of innovation in an educational setting?

2) Can FTA be used in a timely and cost-effective manner?

3) Will the members of the focal system participate in the process?

4) Will the participants find value in the process?

5) Will the group of individuals responsible for implementing the innovation recognize the information obtained from the FTA and, if necessary, adjust their plans accordingly?

6) Will changes to the system (diffusion plan) be made according to the results of the FTA?

The assumptions under which I began this study are outlined on pages 10 and 11.

Types of Information

Two types of information were collected in this study: fault tree construction information – the input used by the FTA team to construct the fault tree; and process information – the information used by the researcher to evaluate the FTA process. The two main types of information collected are summarized in Table 2. The first type of information is referred to as FTA construction information, which includes the methodological steps of FTA and all information deemed useful by the FTA team in contributing to the construction, understanding and usefulness of the fault tree. Answers to the questions on the focal system survey dealing with technology use and attitude would be included in this category. This type of information will help inform the FTA team as to the familiarity with, and attitudes toward, technology and help them to place the FTA results in context.

The second type of information is referred to as process information and includes all researcher observations, and information, listed in Table 2 and provided by the FTA team and members of the focal system.

Table 2

Type and source of information collected and reported

Type of Information	Source of Information
Construction	FTA team input – group meetings Focal system input – questionnaire information Demographic information Technology attitude and use questions Validation of failure events
Process	Observation Personal goal statements given by the FTA team members System definition Self-reported comments Process evaluation questionnaire Group discussions Inter-rater reliability Focal system responses to evaluation questions Focal system interviews

The FTA process

1. Defining the System

Proposal meeting.

All four academic administrators present at the preliminary discussions held in December 1999 expressed an interest in having the college pursue the development and implementation of web-based and distance-education courses. These individuals expressed the belief that the college needed to show a presence in this area and be represented amongst the other colleges as one that offers distance-education courses.

First team meeting.

There were seven members (two academic vice-deans, one technology officer, one independent researcher and three faculty members[4]) plus the researcher present at the first meeting. One faculty member was not able to attend but had previously spoken with the me and expressed her desired goal for the FTA and asked that I pass along this information to the other team members. I began the meeting by introducing myself and making sure everyone present knew each other as well. I then described FTA and broadly outlined the steps we would be following. I also included an estimate of the amount of time each team member would have to give (based on previously conducted FTAs described in the literature, I estimated that each team member would have to provide 10 - 15 hours of their time). The team members listened to my explanation and all expressed a keen interest in participating in the process as fully as they could. At this point, one of the team members (TM#4) proceeded to provide background information surrounding our initial meeting wherein he, and the other participants, discussed the idea of having the college begin developing and offering web-based courses both for local and distance education students.

Identification of the goal statement.

The discussion of the goal lasted for about one hour. During this time the merits and attainability of developing and offering web-based courses were discussed. Two of the

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[4] In order to protect the anonymity of the FTA team, they will be referred to as TM#1 - #7. I will use the masculine form of address.

faculty members wanted the goal to encompass increasing the awareness and use of computer technology amongst the faculty. They were also interested in emphasizing the need for support of these initiative. Two of the administrators on the team already had another goal in mind. This made initial meetings of the entire FTA team, once formed, somewhat tense at times. Two faculty members felt that the goal the administrators had in mind was too narrowly targeted and would not have meaning to a majority of the faculty at the college. That goal seemed to be targeted solely to those members of the faculty already using technology and would therefore ignore (and perhaps further disinterest) the majority of the faculty who do not use technology in their teaching activities.

Discussion was lively and awkward at times. I played a neutral, yet guiding, role in this process and was always mindful of my responsibility to the person with whom I initially spoke; to meeting his goals yet also meeting the goals of the other members of the team and the college as a whole. I strongly emphasized to the FTA team that consensus, through compromise, on the goal statement, must be attained before the process could continue.

After the meeting in which the goal was first discussed, I posted the goal statement in the FTA team's conference area in FirstClass. The FTA team was asked to continue the discussion on the electronic site. Two team members responded with comments and suggestions. A week later, I posted some examples of other goal statements. One member had a question. Using the 'history' function which displays the name, date and time of

the person who read the message, I was able to determine that all of the FTA team members read the messages.

Discussions of the goal continued in the second, third and fourth meetings; at the end of which the goal statement was finalized as follows:

> By the end of the next academic year (May, 2001), the college will:
>
> develop and implement (in September, 2001) at least one, fully-contained, web-based credit course in each of the Core, Pre-University and Careers sectors which will serve as templates (guides) to the development of other such courses in the future; and
>
> foster an increasing awareness amongst faculty members of the existence, potential and actual uses of the new technologies as applied to their teaching functions.

System and personal goal definition.

The participants were asked, over the course of the following week, to write a description of the college as a system as they view and experience it. The team members were told that the definition should include the boundaries of the system and the constraints under which it operates. The descriptions were discussed with the FTA team. A group definition was not made but efforts were made to ensure that a broadening of perspective was attained by sharing different system perspectives. A evidence of this, three out of the four team members (see Table 17) responded, on the final process evaluation questionnaire, that participating in the FTA process had increased their understanding of the system (the college). Team members also made the following comments:

> It forced me to think of areas now that I would have only dealt with at a much later time normally.
>
> It forces us to look deeper into questions (faults).

The FTA team was asked to take the last five minutes of the first meeting to write a short paragraph describing what they would like to achieve/attain by participating in the research. These paragraphs were to be revisited at the end of the FTA process in order to determine if the process met their personal goals. The reproduced paragraphs of the four FTA team members who completed the process appear in Table 3.

Table 3

FTA team members' personal goals for participating in the FTA

TM#1	I hope to get new experiences in electronic warfare as a weapon against ignorance. I hope to find new and innovative techniques for helping my students learn. And I want to establish long term relationships and forums for the exchange of ideas and experiences with my students and future colleagues.
TM#2	• learn more about the process – "Fault tree" • camaraderie of my colleagues • learn more about possible uses of the internet • help you in your research • learn more about FirstClass
TM#3	To help people with everything that is web related. Support in the main ingredient. This research project permits me to get closer to a diversified group of people all at once: administrators, teachers and researcher. Innovation is often scary to many people. Here is a chance to join people who will study how this is happening at the college and it will benefit everyone. The fault tree analysis is new for me and will certainly permit me to view things differently and perhaps re-orient how we do things at the college.
TM#4	Goal statement not provided.

Note. TM#1 & 2 represent faculty; TM#3 represents technical services; and TM#4 represents administration.

These paragraphs were revisited when we validated the FTA process and the participants were asked whether the actual outcome met with their desired outcome. Of the four FTA team members who completed the evaluation process, three indicated that the process met their personal goals and expectations. The fourth participant had written about long-term goals which could only be met once the web-based courses had been implemented. See Table 4 for the team members' specific responses.

Table 4

FTA team members' responses to whether the outcomes met their personal goals

TM#1	My paragraph addresses outcomes that will only materialize after an initial run of the courses.
TM#2	Yes I met many of my goals. I enjoyed learning about the fault-tree process, however, I still believe the terminology is a little off-putting. I find it more difficult to think in the negative, some of the subtleties of the statements go unnoticed until closer inspection. This I think is a problem with the technique. Vis-a-vis the other goals of camaraderie and learning more about the internet and FirstClass – all those were accomplished.
TM#3	It is quite accurate. But it took longer time than I had first anticipated but not too much time.
TM#4	There were no real surprises. The outcome did meet my expectations.

Note. TM#1 & 2 represents faculty; TM#3 represents technical services; TM#4 represents administration.

2. Mission Analysis

During the third and fourth meetings, group discussions took place to determine what the accomplishment of the goal would look like. The participants began to define the types of things that would indicate the successful accomplishment of the goal. Electronic discussions were also meant to take place but, despite repeated invitations to do so, these discussions did not occur, though I do not believe that the information gathered was any less complete as a result. The implications of lack of on-line participation will be discussed in the next chapter.

During these meetings consensus was reached on the importance of a strong web-site management tool. The discussion centered on FirstClass or WebCT. The question was also raised as to whether or not the college should choose a standard or leave it up to the individual faculty member to decide which one would best be suited to their needs. Names of faculty members whom the team felt would be interested in producing and

offering the courses were suggested. A couple of the FTA team members were concerned that if the only people to whom efforts were directed were those who were already interested then a large segment of the faculty would be ignored. The question was therefore raised as to how we can increase the interest and involvement of faculty members not already interested in the use of the internet in their teaching. It was felt by some team members (but not TM#4) that it is not enough to include only interested faculty members in the web-based course design project. These team members felt that it may be seen as exclusionary to ignore faculty members who are not interested. They argued that there needs to be a mechanism in place by which interest can be fostered and faculty not currently using the internet or developing courses could become part of the process in some way. Just as confining the course (as TM#4 wanted to) to students who possess the necessary computer equipment may be seen as elitist (especially since it is a public college) so too would only including faculty already producing or interested in the internet and ignoring everyone else.

Another topic was the recognition that students who apply must demonstrate that they have a minimal level of technical competency (i.e., e-mail; computer skills; access to computer). Questions were raised about how, and by whom, such skills would be measured. TM#4 did mention that the hours of operation of the existing facilities could be expanded to meet the increased need of students taking the courses. Concern about the provision of technical support for the faculty and students were also raised. There is currently only one person (TM#3) to take care of all of these technical needs. Members of the FTA team asked whether it will be possible to get another person, even part-time, who would be responsible for support of these courses.

In order to help ensure success of the course, adequate enrollment was necessary. One suggestion was to offer the courses through community centres and libraries in smaller communities (though everyone agreed that the initial registrants of the course would most likely be members of the college's student community not wanting to come to the college or wanting to take a course in a unique manner). A suggestion for helping to ensure successful completion of the course was the production of a CD-ROM of course information and content be given to each student in order to reduce the amount of time they would have to spend on-line. Some of the discussion, especially from TM#1 and #4, seemed to suggest that the initial on-line course offering would be easy to produce, simply as a matter of transferring text to the on-line environment. The question of taking advantage of the interactive requirements in a good on-line course kept getting put aside. The team members recognized the importance of interactivity but were more concerned with simply making whatever course material currently exists accessible on-line.

Part of the discussion surrounding the successful attainment of the goals concerned course evaluation and whether and by whom the course should be pilot-tested; whether the success-rate of the on-line course compares favourably or not to the in-class version whether and how formative and summative evaluation should be incorporated into the development plan. The suggestion was raised that we use advanced students (those who had already taken the in-class course, for example) to evaluate parts of the course as they are developed.

The issue of this being a new course or the transfer of an existing course was discussed. During the previous meeting, TM#1 made it very clear that the development of

a new course and the incentives that would mean for the department would be very strong motivating factors for faculty involvement. TM#5 explained that in order for a new course to be approved, it must go through a variety of steps of approval. The course must meet set objectives (an existing course, even though it was being transferred to the internet, would presumably have already gone through these steps and have met the requirements.). The programme committee must approve the course and it would also have to go through the registrar. It is much easier to simply take an existing course and make it a web-based course.

All team members agreed that there needs to be a strong commitment from the administration that the on-line course is treated as *at least* the equivalent of an in-class course. They said *at least* since everyone agreed that, at least initially, the on-line course would entail far more work than the in-class course and may therefore warrant more recognition. This thread of the discussion was picked up again when the FTA team began defining the failure events. All team members agreed that without a strong commitment from the college to support the web-based course and treat it seriously, the course could not succeed no matter what other problems were solved. This failure event became the one event joined by an 'AND' gate.

Other suggestions made by the FTA team:

get the students interested by:

- advertising in the college's daily bulletin and on the web-site
- informing continuing education
- explaining the flexibility of on-line courses
- pre-testing the course on students

The following issues were also discussed:

- teachers who are developing the courses should meet regularly
- if there is a sector in which the courses do not work – ask why not
- is there a teacher who will volunteer
- release time
- extra course offering (i.e., add the web course to the pool)

The second part of the goal statement pertaining to fostering faculty awareness of the new technologies was also discussed. TM#4 was not at the meeting where we decided upon this as an important goal to pursue. He asked in today's meeting where this goal came from. His tone became defensive and it almost became an 'us against them' thing. He mentioned a few times how our (his and my) original discussion centered on the development of on-line courses and had nothing to do with increasing awareness of these technologies amongst faculty members. We got beyond this though and TM#4 became, if not an active participant in the discussion, more willing to listen to the ideas and problems being discussed.

Suggestions of how to measure successful attainment of the second part of our goal statement included: the number of times audio-visual carts were used and that when demand surpassed supply, more equipment was necessary; the number of FirstClass conferences that exist and are used; the number of web pages that exist. Team members suggested that pages contain a feature which records the number of times they are accessed. Team members also agreed that paying for access to the internet should not be a departmental responsibility as this places an unfair burden on them. It was agreed that, if at all possible, the college infrastructure should be such that all departments receive the same basic internet access and support. The team members put forth the idea that there

should be a person whom faculty members could contact for issues related to computer use. They agreed that Macintosh and PC environments should both be equally supported.

The discussions about the goal statement and the successful attainment of the goal accomplished the specific outcome delineated in the FTA process but also served to introduce the different FTA team members' different perspectives. These discussions were varied and intense.

3. Identification of Undesired Event(s)

The undesired event [UE] is the failure to achieve the goal decided on by the FTA team, and would read:

> Failure of the college, by the end of the next academic year (May, 2001), to:
>
> develop and implement (in September, 2001) at least one, fully-contained, web-based credit course in each of the Core, Pre-University and Careers sectors which will serve as templates (guides) to the development of other such courses in the future; and
>
> foster an increasing awareness amongst faculty members of the existence, potential and actual uses of the new technologies as applied to their teaching functions.

For simplicity's sake, we summarized this as "Failure of the college to complete the mission", with the understanding that "mission" stood for the goal statement we had devised.

4. Fault Hazard Analysis

Once undesired events were identified, the FTA team was to, with face-to-face and electronic discussion, rank them according to relative importance. Failures, or undesired events, may occur at the goal, function or task level and the FTA team identifies these levels.

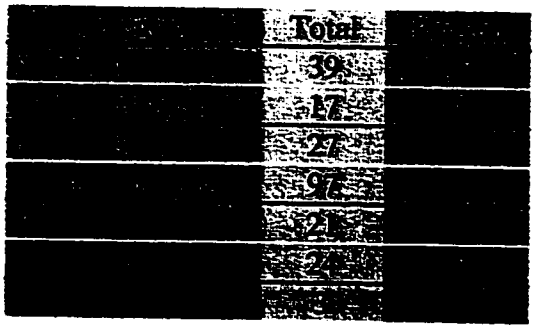
Since only one undesired event was identified by the FTA team, this step was not necessary.

5. Identify Failure Events Contributing to the Undesired Event(s)

A total of 228 failure events were identified by the FTA team (the Fault Tree is included on the enclosed disc). These failure events, classified according to the SPECTRA scheme of categories (see pages 81-82) are listed by total and percent in Table 5.

Table 5

Total number and percent of identified failure events classified into the SPECTRA categories



Of these 228 failure events, nine first level events, (failure events at the top of the fault tree directly below the undesired event) were identified by the FTA team. These events are listed in Table 6.

Table 6

First-level failure events identified by the FTA team

FAILURE OF THE COLLEGE TO COMPLETE THE MISSION BECAUSE OF:	
1	Failure of the Ministry of Education to support the college
2	Failure of the college to offer a commitment to offer the web-based courses
3	Failure of the College to provide centralized system support for building and maintaining the distance education infrastructure
4	Failure of the college to provide adequate access to modern equipment in a useful space
5	Failure to use a minimum standard set of guidelines for course development, design and delivery
6	Failure to follow through
7	Failure to make technical assistance in course development available to faculty who are encouraged to use it
8	Failure of the students to enroll in the web-based courses
9	Failure of the students to succeed in a web-based course

After the fourth meeting, I posted a message to the FTA team asking them to consider the following two tasks: generate as many failure events or impediments as they could. The researcher then assigned each team-member one of the generated failure events and asked them to generate as many more failure events as possible. This list was

individually generated by the FTA team members and submitted electronically. The identification of the failure events by the seven-member FTA team (two academic vice-deans, technology officer, contract researcher, fine arts and science faculty members, researcher) took approximately four hours (divided into two, two hour meetings held one week apart). During these meetings, disclosure and discussion of these failure events took place. I read out the lists of events and wrote them on a flip-chart. The FTA team discussed these events and either eliminated or added events.

Once identified, failure events were turned into failure statements each of which was written in the following format: "Failure of .... Because of ....". Ultimately, based on the decision of the FTA team, the wording of these statements was changed to be more congruent with the everyday language of both the FTA team and the members of the focal system. I sorted through the responses and eliminated redundant ones. At the end of the process, a total of 228 failure events were identified. See Appendix E for the complete list.

6. Specification of the Logic Gates between the Contributing Events

The hierarchical and lateral arrangement of the failure events to form the fault tree was meant to be a team activity. Logistically this was not possible because the FTA team members left for their summer break and did not participate in the process for approximately twelve weeks. Due, however, to the initial manner in which the failure events were developed, much of the arrangement had already been done. I, therefore, simply organized the events myself according to the sequence in which we had discussed and developed them during the final two sessions before the summer break. As the fault

tree developed, some feedback was obtained from FTA team members who were still available via electronic means of communication.

When all of the team members (except for the two how had left the college for other jobs) returned from their summer break, a meeting was held at which time the entire fault tree was displayed on a large wall in an art studio at the college. The remaining four FTA team members (academic vice-dean, technology officer, fine arts and science faculty members) were present and carefully looked over the tree, reordering and changing failure events as they deemed necessary. The team members wrote comments on the tree and changed some of the wording as well. The relationships between the events were also examined and decisions were made as to whether the events were joined by AND or OR gates. The team members concluded that, except for one instance, all of the events were joined by OR gates. They also decided that adding these gates to the diagramme was not necessary and would just complicate the tree for uninitiated readers. Therefore, though implied, the final tree does not contain any gates.

7. Develop the Tree to the next Lowest Level until Complete

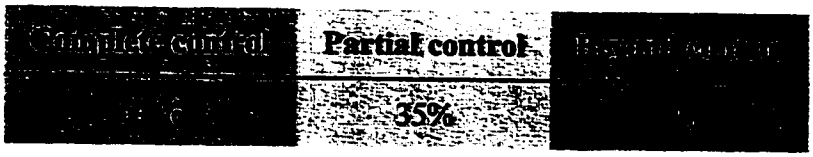
During this meeting, and after careful examination of the tree, the team decided that no further development could occur – a decision they based on their opinion that these failure events were too far out of their immediate control and would require an immense amount of effort to analyze and overcome. An example of a failure event the team members agreed was beyond their immediate capacity to further breakdown was 'lack of confidence in message being heard'. The team members agreed this was an event that had to do with an individual's psyche and was therefore beyond the scope of their

intervention. The FTA team members developed the tree to what they all agreed upon as the lowest level (though, given more time and resources, the tree could have been developed further). Items on the lowest level of the tree are represented by diamonds which is the symbol used to indicate that the event can not be developed further due to: lack of information; remote chance of occurrence; or other constraints such as time or resources (Wood, Stephens and Barker, 1979).

At the end of the FTA, one of the faculty team members familiar with the college (not the entire FTA team as originally anticipated due to time constraints – though all remaining team members were consulted at this point and their opinions were included in the final categorization) was asked to categorize the failure events, as suggested by Witkin and Altschuld (1995), in the following groups: events which are completely in control of the system; events which are under partial control of the system; and events entirely beyond the control of the system. These results quite clearly indicate that the majority of the failure events identified in the FTA are under complete or partial control of the system, thereby improving the likelihood of successful intervention. Refer to Table 7 for the results of this categorization.

Table 7

Percentage and degree of system control over identified failure events



8. Validate the Fault Tree Against the System it Represents

This step of the process was carried out in three stages. The first and third stages were completed by the FTA team and the second was accomplished by surveying members of the focal system.

The tree was preliminarily validated by the FTA team in the previous step (step 7). The purpose was to examine and confirm the accuracy of each of the hierarchical and lateral relationships in the tree. Since the reliance upon subjective measures of tree construction may call the tree's validity into question, steps are built into the method which address this weakness. The method of tree-validation which the FTA team followed during this session, described by Wood, Stephens and Barker (1979, p. 13) indicates that:

> 1) Each rectangle [which appears on the tree] should state an undesired [or failure] event.

The FTA team examined the entire tree and established that each rectangle on the tree contained a failure event which contributed to the undesired event.

> 2) Each terminal event [events which can no longer be analyzed] should be studied closely, and the question asked: "If this event really happens, is there a legitimate way around it?". *If any way can be found to avoid occurrence of the event,* or an exception found to it, then an AND gate should be drawn above the event (it would replace the OR gate if there was not an AND gate previously) and a new event explaining the exception would be inserted in the tree.

This was briefly discussed. The FTA team found the discussion of AND and OR gates to be somewhat confusing. After about 10 minutes, the team decided that all of the gates were OR gates. The one AND gate was between 'failure of the college to support web-based courses' and the remaining eight first-level failure events.

The following questions, delineated by Witkin and Altschuld (1995, p. 267-8) were also used by the FTA team as guidelines for further evaluating the tree and ascertaining the best way to way to proceed towards a solution:

1) Are there any AND gates? If there are few or none, can the success plan be altered to provide backup systems, alternatives, or offsetting strategies?

One AND gate was identified. As mentioned earlier, however, the team decided not to label the tree in this manner as they felt it would confuse the uninitiated reader.

2) Are some events depicted that expert judgment indicates could be very critical in contributing to the overall UE? If so, highlight those. If the same or similar highlighted events or paths occur in more than one branch of the tree, are they related to each other? Redundant events magnify the criticality of potential failures manyfold.

The one failure event which was fairly critical in the minds of the FTA team was the support of the college to offer the web-based courses and treat them as legitimate alternatives. All of the FTA team members agreed that without the college's support the goal could not succeed.

3) Are there events that might occur because of the effect from external sources, such as regulatory agencies or some environmental hazard? Are offsetting strategies available?

The FTA team felt that issues surrounding funding and recognition were external and only partially within or beyond their control. They felt that presenting strong plans to the funding agencies or Ministry of Education would help. They recognized that the impetus was upon them to communicate these plans. The team were also aware that they may have to begin on a small scale with the resources that were already available to them and then present them to funding and government agencies as successful examples of what they can accomplish thereby providing concrete evidence worthy of their support.

4) What about the timing of the potential event? If [for example] the student fails a required course in the last quarter of the senior year, the event is much more critical than if it occurred a year earlier. The "difficulty of rectification" factor increases in magnitude.

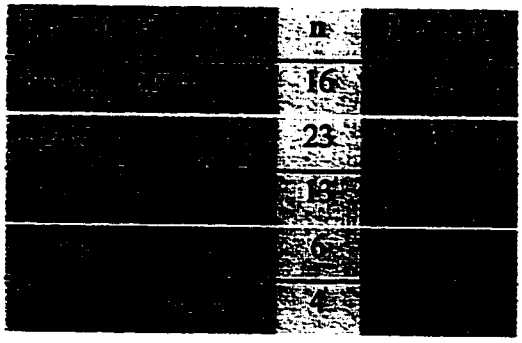
The nine first-level events on the were sequenced in an order the FTA team agreed was important to follow. Some of these events are more easily rectified than others but their sequence follows a logical pattern of course support, development, implementation and student participation and successful completion.

5) Did you choose the right UE?

When asked, during the process evaluation, whether they would modify the goal, all of the FTA team members responded that they would not. Furthermore, when members of the focal system were asked if the goal devised by the FTA team was worth achieving, 63% strongly agreed or agreed that it was worth achieving (see Table 8). Since the undesired event is the inverse of the goal, this satisfaction with the goal naturally extends to the undesired event as well.

Table 8

Percentage of focal system respondents who believed the goal developed by the FTA team was worth achieving



Note. N=75; n=62

9. Label the Fault Tree

I independently labeled the tree. Initially, the FTA team was supposed to label the tree but, due to time constraints, this was not feasible. I do not believe, however, that this compromised the integrity of the labels or the tree in any way. It is actually easier for one person to do this task than for a group to do it. The purpose of this step was to simply label each of the events on the tree for easy reference. Events which are directly below the undesired event are labeled A, B, C, etc. Events that contribute to event A are labeled AA, AB, AC, etc. A letter is added to each event as one moves down the tree. Please see Appendix E for the labeled list of failure events.

10. Quantitative Evaluation

The FTA team decided that quantitative evaluation, as described by Stephens (1979), was not necessary. The tree was small enough for the team to able to determine the most critical areas upon which they wanted to concentrate their efforts.

11. Validation of the Tree by the Focal System

Information from the focal system was gathered using a questionnaire (see Appendix B). As described in the Method chapter, the questionnaire consisted of twelve questions on technology use and seven attitude statements which were rated on two different Likert-type scales.

These questions provided information on the background, experience and attitudes of the focal system respondents. Additionally, each survey contained a randomly selected branch (or branches) of the tree. For each failure event on their branch of the tree, focal

system members were asked to respond to the following three questions: 1) This event is relevant to the accomplishment of the goal; 2) This event is likely to effect my accomplishment of the goal; and 3) This event is likely to occur.

Of the 543 faculty members who received a questionnaire, seventy-five (14%) completed and returned it. When the members of the FTA team were asked if they were satisfied with this response rate, 3 out of the four said they were not satisfied and provided the comments in Table 9.

Table 9

FTA team members' responses to whether they were satisfied with the focal system's response rate

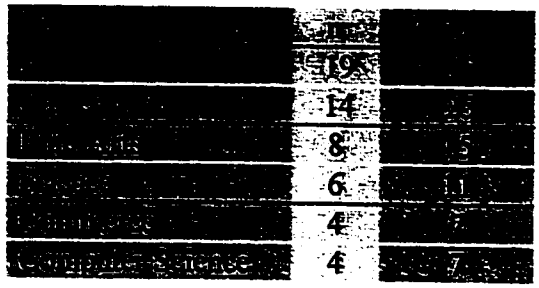
TM#1	Not satisfied, but I know that is a normal response percentage.
TM#2	I believe that the college faculty could be more involved with what happens in the community. There is great apathy and lack of compliance on their part.
TM#3	Yes, but when broken down in sections, the sampling rate becomes too low.
TM#4	While it may be statistically valid, it indicates a level of apathy within the college.

Note. TM#1 & 2 represents faculty; TM#3 represents technical; TM#4 represents administration.

Demographic information concerning subjects and years taught by the respondents are shown in Table 10 and 11. The majority of respondents were from the Arts and Career segments of the college and had been teaching a minimum of sixteen years.

Table 10

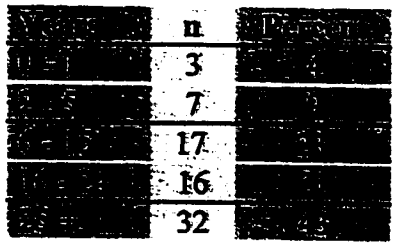
Subjects taught by focal system respondents



Note. The highest number of potential responses was seventy-five (75).

Table 11

Years taught by focal system respondents



Note. The highest number of potential responses was seventy-five (75).

In the next section of the questionnaire, members of the focal system were asked to respond to nineteen technology use and attitude questions and statements. The purpose of this information was to situate the responses to the questions pertaining to the failure events within the larger context. Specifically, the FTA team members used these responses to gain insight into the members of the focal system and look for areas of opportunities they could capitalize upon in pursuit of their goal.

The results of this survey were discussed with the FTA team during the final three group meetings. While the vast majority of faculty members who responded to the survey do not use technology in their teaching (Table 12), their attitudes towards it are positive

and indicate a willingness to learn more (Table 13). The FTA team members all agreed that these results indicate that there is a perfect opportunity, given improved communication and support, for increased use of technology by the faculty at the college. The FTA team members, especially TM#4, were very pleased with the fact that as many as 16 of the 75 focal system respondents were interested in becoming 'technology mentors' to other faculty: "... 16 out of 600 saying that they're willing to be technology mentors is pretty good" (TM#4). For the 89% of respondents who said they use a computer to produce course materials, TM#4 was interested in finding out what type of use (i.e., giving hand-written notes to the secretary who then uses the computer to make a hand-out or something more elaborate). I mentioned that several of the respondents indicated a willingness to be interviewed further and while these interviews were beyond the scope of this study, I would conduct them at a later date as part of my commitment to the college.

Tables 12 and 13 contain the compete results of the technology use and attitude questions the focal system was asked to answer.

Table 12

Percent response from the focal system on technology use questions

Technology use questions	Always	Almost always	Sometimes	Almost never	Never	N
Do you use a computer to produce course materials?	78% n=57	11% n=8	4% n=3	0% n=0	7% n=5	73
Do you use the internet to research material for your course(s)	10% n=7	10% n=7	45% n=32	18% n=13	17% n=12	71
Do you use information technologies to present material in your course(s)	6% n=4	12% n=8	33% n=23	17% n=12	32% n=22	69
Do you use e-mail or FirstClass to correspond with other faculty?	10% n=7	20% n=14	37% n=26	10% n=7	23% n=16	70
Do you use e-mail or FirstClass to correspond with students?	7% n=5	7% n=5	32% n=22	17% n=12	36% n=25	69
Do you use the internet as an integral component of your class (es)?	9% n=6	1% n=1	19% n=13	22% n=15	49% n=34	69
Do you use FirstClass as an integral component of your class(es)?	1% n=1	3% n=2	3% n=2	4% n=3	88% n=60	68
Do you use e-mail to receive work from your students?	4% n=3	4% n=3	16% n=11	22% n=15	54% n=37	69
Do you use FirstClass to receive work from your students?	1% n=1	3% n=2	0% n=0	9% n=6	87% n=59	68
Do you use e-mail for group work and discussion?	1% n=1	4% n=3	6% n=4	14% n=10	74% n=51	69
Do you use FirstClass for group work and discussion?	0% n=0	3% n=2	4% n=3	4% n=3	88% n=60	68
Do you talk to other faculty members about the use of technology in teaching?	13% n=9	15% n=11	50% n=36	10% n=7	13% n=9	72

Note. The highest number of potential responses was seventy-five (75).

Table 13

Percent response from the focal system on technology attitude statements

Attitude statements	Strongly agree	Agree	Undecided	Disagree	Strongly disagree	N
The internet is a valuable teaching tool.	26% n=19	37% n=27	21% n=15	14% n=10	3% n=2	73
FirstClass is a valuable teaching tool.	6% n=4	9% n=6	72% n=47	9% n=6	3% n=2	65
I am interested in learning more about the use of the internet as it applies to my teaching.	34% n=25	39% n=29	14% n=10	8% n=6	5% n=4	74
I am interested in learning more about FirstClass as it applies to my teaching.	23% n=16	31% n=22	33% n=23	7% n=5	6% n=4	70
Web-based courses are an effective alternative to traditional (classroom-based) courses.	12% n=9	19% n=14	33% n=24	18% n=13	18% n=13	73
I am interested in learning more about developing web-based courses.	22% n=16	32% n=24	20% n=15	16% n=12	9% n=7	74
I am interested in becoming a 'technology mentor' to other faculty members.	13% n=9	10% n=7	22% n=16	28% n=20	28% n=20	72

Note. The highest number of potential responses was seventy-five (75).

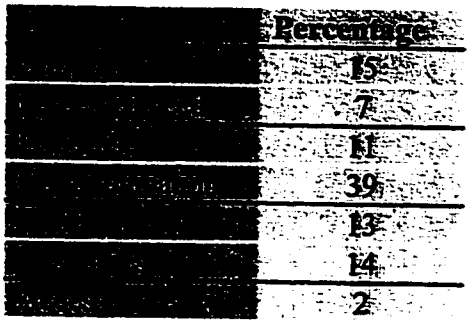
Failure event validation.

To assess the validity and systemic representation of the FTA process, responses were provided by the focal system to three statements specifically related to the 228 failure events that the FTA team generated. The statements were: 1) This event is relevant to the accomplishment of the stated goal ; 2) This event is likely to effect my accomplishment of the stated goal ; and 3) This event is likely to occur. You will recall from the Method chapter (Step 11) that the fault tree was divided into sections which were then randomly distributed to members of the college faculty. Using the following scale: a) Strongly agree; b) Agree; c) Undecided; d) Disagree; and e) Strongly disagree, the respondents rated each of three statements for each failure event they were given.

Focal system respondents identified 123 (54%) failure events which they strongly agreed or agreed were likely to occur. Identification of such events is one of the main reasons for conducting an FTA. As the data show (Table 14), the vast majority of failure events identified by the focal system as likely to occur can be classified as communication problems. The least likely type of events to occur are events related to access. A complete categorization of events is presented in Table 14.

Table 14

Percentage and type of failure events that focal system respondents strongly agreed or agreed were likely to occur

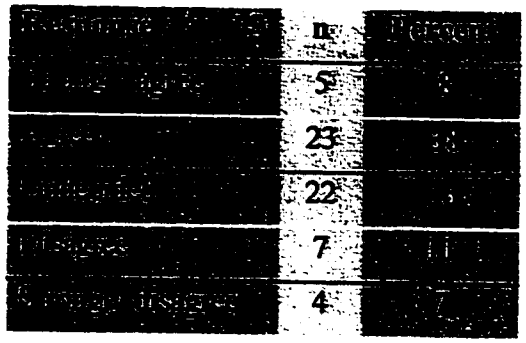


Goal and process opinion questions.

On the questionnaire that was sent to all faculty members of the focal system, 63% responded that they strongly agreed or agreed that the goal established by the FTA team was worth achieving (see Table 8). Twenty-one percent of respondents were undecided but at least not entirely dismissive. The trend of these results indicates that the goal is, at the very least, worth pursing and that increased information may be all that is needed to encourage them further.

Table 15

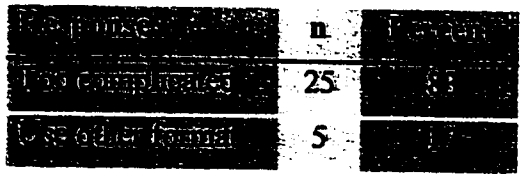
Percentage of respondents who felt that the survey and presentation of information was useful



Note. N=75; n=61

Table 16

Percentage and type of changes suggested by respondents to improve the method



Note. N=75; n=30

12. Validation of the Fault Tree Analysis Process by the FTA Team

Process evaluation.

The final two FTA team meetings were used to evaluate the FTA process. Team members were given a questionnaire and as much time as they needed to fill it out. Table 17 shows the teams' responses to ten questions pertaining to the practical use and benefits of FTA. The team responses are generally positive.

Table 17

FTA team responses to statements regarding the benefits of FTA

Statement	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
The FTA was completed in a length of time suitable to my needs.					
I feel that I have spent too much time on the project.					
Faced with a similar problem in the future, I would use FTA again.					
The fault tree is useful.					
I now feel better able to address the problems identified.					
The process was valuable to me in terms of increased understanding, practical use, etc.					
I now feel better able to devise a concrete plan of action.					
Participating in the FTA process increased my understanding of the innovation.					
Participating in the FTA process increases my understanding of the system in which I am operating.					
Participation in the FTA process changed my view of the goal.					

Note. Each filled quarter, identified with a subject number, represents a member of the final FTA team.TM#1 & 2 represents faculty; TM#3 represents technical; TM#4 represents administration.

The FTA team were also asked to assess the FTA process in relation to the six categories identified in the literature as common impediments to the use of technology in educational settings. Responses to these statements are in Table 18.

Table 18

FTA team responses to statements regarding potential impediments

Statement	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
I received sufficient support throughout the FTA process.					
The FTA process required too much expertise.					
The FTA process takes too much time.					
I was provided with sufficient resources needed to accomplish the task.					
I had sufficient access to FTA examples.					

Note. Each filled quarter, identified with a subject number, represents a member of the final FTA team.TM#1 & 2 represents faculty; TM#3 represents technical; TM#4 represents administration.

When asked to discuss the usefulness of FTA as compared to other similar problem-solving techniques they had used, there was a mixture of responses. Two of the team members perceived the FTA process to be useful while the other two were more reserved in their judgement and preferred to wait until they could see longer-term results after having implemented the process before making a judgment as to its perceived usefulness.

Finally, FTA team members were asked to assess the FTA process in terms of the five variables Rogers (1995) identified as helping to determine the rate of adoption of innovations.

Table 19

FTA team assessment of FTA according to Rogers' adoption of innovation variables

Statement	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
FTA has an advantage over other methods.		1 3		2	
FTA is compatible with our way of doing things, the system and the problem.		3	1 2 4	4	3
FTA is too complex.		1 2 3 4		1 2	
Practice and time (trialability) increased my understanding of the method.		2 3 4	1		
Observing how FTA works in practice was helpful and provided me with ideas as to how else to use the method.		2 3 4	1		

Note. Each filled quarter, identified with a subject number, represents a member of the final FTA team.TM#1 & 2 represents faculty; TM#3 represents technical; TM#4 represents administration.

One of the FTA team members gave the following comment when asked if participating in the FTA process had changed his view of the goal. He said it had not changed his view and that:

> "it made me aware that some people had other goals but that the pursuit of my goals will occur nevertheless, and that I can safely relegate achievement of the other goals to the others".

In addition to questions and statements the team members responded to on a set scale, the evaluation questionnaire also contained open-ended questions. The written responses to these questions appear in Table 20.

Table 20

FTA team responses to open-ended process evaluation questions

Did you learn anything new about the system because of the FTA process?	
TM#1	It forced me to think of areas now that I would have only dealt with at a much later time normally. I don't yet know that this was necessary.
TM#2	Not really, however, I'm involved in many different levels at [the college]. That is, I sit on several of the academic and sectoral college-wide committees. And, I talk to lots of the individuals involved in policy making at[the college].
TM#3	Yes, it forces us to look deeper into questions (faults).
TM#4	No response given.
What modifications do you feel should be made to the process?	
TM#1	Get the implementation crack team together within the first few weeks. Have them provide feedback from the fronts. Also, I think it is important that we have a bigger team, as diverse as possible, with a strong commitment and ability to attend each meeting.
TM#2	Good process when it comes to the focus group. It should have been scheduled for a few (3-4) consecutive days in May/June, when all the participants would be available without other commitments (I know this is almost impossible). As for the survey, I don't know if the idea of larger group/community-type meetings would not also have been helpful.
TM#3	Start earlier during the semester so that we do not have to stop for holidays.
TM#4	I believe that positive attitudes tend to influence goals. Inevitably always looking for failures and negative outcomes can influence the outcome negatively.
Will you make any changes in how you proceed with the innovation because of what you learned in the FTA?	
TM#1	Not really. As far as I can judge, the web-course will occur when some individual gets the ball rolling and hammers away at the obstacles as they make themselves appear – in the order that they appear – in an ad hoc fashion.
TM#2	I believe I have a better idea about the technique, but would have a difficult time using it myself. I would, nonetheless, use some elements from it, such as the systemic approach to the problem at hand.
TM#3	The in-depth approach will be more closely followed.
TM#4	I am more aware of the faculty reluctance to begin development of web-based courses and the reasons for it.
Will you try to find solutions to the failure events discovered during the Fault Tree Analysis?	
TM#1	No. I will search out my allies in this process and address problems as they arise. Addressing fault tree problems is a time luxury that is spent on potential problems. The "real" problems are the ones that need to be dealt with first. The rest of my energy should go into developing the product.
TM#2	Realistically, no. I'm not in a position to make policy myself, therefore, I am not a major player at [the college]. This is not to say that I will not pursue some of the ideas that resulted from this process.
TM#3	Yes. The idea is to try to anticipate what will or could go wrong before we go into action.
TM#4	Yes. We have endeavoured to provide better and more resources in private areas. We will try and reassure faculty that the web based offerings are either fully integrated in their CI's or are aimed at non-traditional [college] students.

Table 20, cont.

FTA team responses to open-ended process evaluation questions

Do you consider yourself more or less likely to participate in web-based course design or the increased use of technology in your teaching as a result of participating in this process?	
TM#1	More likely. This process has shown me that enough people are committed to the idea.
TM#2	No change.
TM#3	No change.
TM#4	Not applicable.
What actions will you take or anticipate taking because of participating in this process?	
TM#1	Next semester I will develop a template course (alone or with company). As a first step I will convene a group of interested colleagues to gauge their willingness to work with me.
TM#2	Take a closer look at the facilities and what's available for the creation of a web-based course in photography/visual arts. Keep on top of the literature concerning the design and use of web-based instruction.
TM#3	More research and consultation on what could go wrong in a project.
TM#4	(Answer was the same as for another question)
Write a brief statement as to your thoughts concerning the use of Fault Tree Analysis as a tool for the use of diffusion of innovation in educational settings.	
TM#1	I am a hands-on person in this regard. I believe having a mock-up up and running with workshops to demonstrate the idea and its possibilities would carry a lot more weight.
TM#2	The tool is a good one for making the players in a system recognize the importance of the individual parts. There is comfort in seeing individuals come to a systemic understanding and vision (way of thinking). As such, I would say that the greatest benefit to the FTA technique is to the systemically uninitiated. Too many people working at [the college] (and maybe other institutions) never give any thought to the inter-dependence of the entire system. This tool appears to have had a positive effect on the thinking of the focus group players.
TM#3	It takes a bit of time to get used to it. But it works.
TM#4	It is too difficult for me to think constantly in the negative. Possibly FTA would be more useful in preventing a negative outcome rather than helping prepare for a positive one. i.e., goal: prevent terrorist disruption of the Olympics.

Category evaluation.

One approach to validity, drawn from the literature and applied to the failure events identified by the FTA team was to define the events according to the categories identified in the literature as being likely impediments to the diffusion of technological innovations in the classroom. These categories are: support; perceived need; expertise; time; resources; and access. Also, while not specifically defined as an impediment, Rogers (1995) makes clear the importance of communication in the diffusion process.

After several meetings with the FTA team, and listening to some of the issues that concerned them, it became clear to me that communication should be included as a category. Therefore the final categories into which the failure events were categorized were Support; Perceived need; Expertise; Communication; Time; Resources; and Access [SPECTRA]. The acronym fits nicely too as these categories certainly do make up a continuous range or sequence of events. This range became even more apparent when trying to categorize the failure events according to the definitions I was using from the literature. The nature of these definitions was such that, except for very clear instances, a lot of the failure events could be slotted into more than one category. See Appendix D for the instructions, categories and their respective definitions.

Inter-Rater Reliability

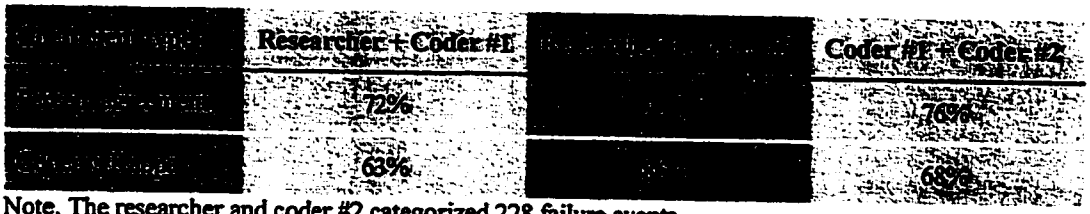
The purpose of calculating inter-rater reliability was to determine whether the failure events generated by this FTA could be categorized into the six categories identified in the diffusion of innovation literature as factors which influence the adoption of

innovations, and a seventh – communication – identified during the course of this research.

Inter-rater reliability percentages were calculated between the researcher, Coder # 1 and Coder #2 and between Coder #1 and Coder #2. Two methods of calculation were used: straight percent agreement (n/N) and Cohen's Kappa (a method of calculating percent agreement which verifies that the result obtained is greater than chance and accounts for chance agreement between coders). The results of these calculations are shown in Table 21.

Table 21

Percent agreement and Cohen's Kappa coefficients between coders



Note. The researcher and coder #2 categorized 228 failure events.
Coder #1 categorized 224 failure events.

Based on the answers to the questions pertaining to applicability and utility, the input of the FTA team and the members of the focal system, and a study of the information gathered as a participant-observer, interpretations and recommendations as to the applicability and utility of FTA in the diffusion of innovation in educational settings will be discussed in the next chapter.

Chapter Five – Discussion

In the previous chapter, I presented information provided by the FTA team and the focal system at various points throughout the FTA process. Information was collected using survey, group and individual discussion, written correspondence and observation. In this chapter, I will pull these varied sources of information together in order to form a cohesive picture of both the process of conducting an FTA and the applicability and utility of FTA. In the first section, I will discuss the direct results of the FTA – namely the fault tree itself. In the second section, I will discuss process issues which arose during the FTA. I will then summarize the results, discuss the limitations of this study and propose future questions.

The Fault Tree

As detailed in the previous chapter, specific steps were followed during the FTA process, the ultimate goal of which was the production of a fault tree. A fault tree containing nine main branches and 228 failure events which could be classified into the seven SPECTRA categories was developed. The failure events identified in the analysis corresponded to events identified in the literature (e.g., Barrett, 1999; Cuban, 1996; Leggett and Persichitte, 1998; Sherwood, 1999) as significantly impeding the integration of technology in educational settings, adding credence to the applicability and utility of the FTA process.

The failure event described as critical by members of the FTA team was the failure of the college to support the web-based course. The team agreed that without this

support, no course could possibly succeed. Given the criticality of this failure event, we discussed the likelihood of its occurrence. The importance of support as a critical factor in the adoption of technology in education has been strongly supported in the literature by, among others, Ely (1999), Groves and Zemel (2000), Hagner (2000), and Maddux, Cummings and Torres (1999). These authors conclude that administrative and technical support needs to be firmly established and given high priority. Maddux, Cummings and Torres (1999) state that the "primary impediment to the integration of technology into higher education instruction is the lack of an efficient faculty support system for instructional technology" (p. 43).

The general consensus was that if a course is developed, demonstrated to be pedagogically sound and falls within the designated curriculum, there will be a greater likelihood, but no guarantee that the college will support it. The team decided that it would be most effective for one (or more) faculty members to take the initiative and develop a course and then offer it to the college for approval. One of the team members has taken on the task of initiating the development of such a course with the intention of offering it in September 2001.

Failure events categorized as support and communication issues (see Table 5) were most frequently cited by the FTA team and the focal system as potentially impeding accomplishment of the goal. Expertise, resources, perceived need and access were the next most frequently cited impediments. One of the team members commented that "if you reduce everything to its simplest, there's really nothing but time or money that could be an impediment. I suppose you could [also] say inclination." While time, money and

inclination have certainly been shown to be critical factors in the successful implementation of innovations, it was not fully borne out in this particular FTA. Time was recognized as an important factor but lack of time, by itself, would not, according to the respondents, result in failure to accomplish the goal. It appeared as if, given open lines of communication, administrative and technical support and resources, motivated members of the FTA team and focal system would be willing to make the time to accomplish the goal. These individuals indicated a recognition of the importance of the goal and were therefore more willing to overcome certain obstacles in order to achieve it.

As I mentioned, the majority of failure events identified in this FTA were related to communication and support. This finding is supported by Rogers' (1995) theory of diffusion which emphasizes the importance of strong channels of communication over which ideas concerning an innovation can be disseminated. Also upheld is the notion that supporting an individual's endeavour to effect change will help ensure that change occurs. Rogers defines communication as a "process in which participants create and share information with one another in order to reach a mutual understanding" (1995, p. 5-6). Similar to knowledge management which takes what people know inside their heads and makes it visible to others, this FTA promoted communication and the sharing of knowledge amongst the FTA team members and opened the lines of communication with the members of the focal system as well. Since diffusion occurs when information about a particular innovation is communicated – FTA can therefore be looked upon as both a diffusion of innovation and knowledge management tool and not only as a method by which obstacles to a particular innovation are uncovered. One of the team members suggested that presenting the FTA to a wider group of interested individuals would be an

excellent start to improving communication and begin talking about the issues raised as a result of this FTA.

Communication and a sense of community were identified as failure events that are likely to occur and effect the accomplishment of the goal. Involving more people in the initiative, especially given the fact that focal system respondents indicated a strong willingness to learn more about web-based courses and computer conferencing technology (see Table 13), seems to be to one way in which improved communication and a sense of community can occur. I therefore find it somewhat discouraging, but understandable given the lack of existing communication and cooperation as well as the mixed attitudes members of the focal system have towards web-based courses (see Table 13), that only one or two individuals are currently taking an initiative to develop a web-based course. Perhaps, though, having been alerted to the interest the focal system has in learning more about the internet, computer technology and web-based courses, members of the FTA team and other individuals already taking technological initiatives will be more inclined to share their efforts and disseminate information. Evidence to support this supposition can be found in the FTA team's responses to statements regarding the benefits of FTA (see Table 17) wherein three of the four team members (one remained undecided) agreed that: they felt better able to address the problems identified (failure events) and devise a plan of action; and that the FTA increased their understanding of the college (system). The following quote, made by TM#2, sums up the importance of a strong understanding of the system and the usefulness of FTA in fostering such an understanding.

> The tool is a good one for making the players in the system recognize the importance of the individual parts. There is

> comfort in seeing individuals come to a systemic understanding and vision (way of thinking). As such, I would say that the greatest benefit to the FTA technique us to the systemically uninitiated. Too many people working at [the college] (and maybe other institutions) never give any thought to the inter-dependence of the entire system. This tool appears to have had a positive effect on the thinking of the focus group players.

The significance of this quote goes to both the applicability and utility of FTA to the members of this system and, perhaps, other systems as well. I remind the reader that the primary reason for selecting FTA as an applicable tool for this study was due to its systemic nature and its seeming ability to fill the identified gap between acquisition and use of technology. The fact that the FTA process helped to increase systemic understanding provides support for FTA's utility in this system and, likely, other systems as well.

The finding that the majority of failure events identified in this FTA were related to issues of communication, an impediment to the diffusion and use of technology not specifically identified in the literature, highlights the need for further investigation. Perhaps improving communication in educational systems considering the diffusion of technology will help bridge the gap between acquisition and use. Brown (1999) has identified improved communication as perhaps the most important contribution computer technology can make and this FTA has demonstrated that communication problems exist and that the process of participating in an FTA is an excellent first step in alleviating some of those problems.

The following sections each deal with a specific aspect of the FTA process. These elements are dealt with in the order in which they occurred in the process. I discuss each

problem that occurred and describe potential solutions and avenues of research worth pursuing.

Goal development.

Development of the goal for the FTA was discussed by the FTA team. During the preliminary meeting with the two administrative team members, they indicated their desire to have the development of web-based courses be the focus of the FTA. The following exchange which took place in our first team meeting indicates the different opinions held by the FTA team members as to what the goal should be and how, once decided upon, the goal would be defined. TM#4's main interest was establishing a web presence for the college. TM#1 came to understand this as well and agreed that it was a worthwhile goal to pursue. The team members agreed that the best way to accomplish this would be to take an existing course at the college and adapt it for an on-line offering. The passage also highlights the initial defensiveness felt by the team – a defensiveness which was gone by the end of the process as evidenced by the team's agreement that they would not change the goal, still agree it worth pursuing, and have a greater understanding of the process (see Table 17).

TM#4: Mandie came to us asking if she could use us as a site to test this and it was at a time when TM#5 and I were both looking for ways of trying to inspire faculty to create web-based courses. We felt that this would be a useful tool for us. I think Mandie's concern is really evaluating the usefulness of the tool and we're actually being a test-case for how it can be implemented. That being the case, I think that we've already circled around the idea that our goal, or our mission

statement within it, is to develop on-line courses. Whether it be phrased in terms of develop on-line courses, period, or develop an on-line suite of internet courses or whatever and phrase it in the negative so it falls in to the ....

TM#1: Do you mean that when you say that? That the goal when you originally set up was to establish on-line courses or is to establish a web presence for existing courses?

TM#4: Ah, well, we could discuss that but it seems to me that they're almost the same thing ....

TM#1: Oh no. They're very different.

TM#4: Well, alright. Okay – let's discuss that too.

TM#5: Because what I think – there is a kind of basis for web-assisted learning in a number of existing courses already without saying that this is a web-based course. Certainly in science you've got various units that contribute to a course without being a course.

After a realization that compromise would be necessary and the inclusion of one interest did not exclude the other, two sections to our goal statement were identified (see page 88). One section was very specific and was the initial reason TM#4 wanted to be involved in this project. The other was more general and reflected the opinions of the non-administrative members of the team which all members eventually embraced to varying degrees.

The major problem in determining the goal for the FTA was in the pre-conceived ideas one of the team members held and his feeling that his goal should take priority as he was my initial contact. While this team member did eventually see the importance and

allow for the inclusion of the other goal, the initial atmosphere was somewhat tense. Self-serving interests of participants is a potential problem in any participatory research endeavour (Cousins, 1996). It was natural and to be expected that each of the members had their own personal and professional reasons for participating in this study. There is evidence that the FTA process helped the team members come to a common understanding and a willingness to compromise.

In order to help eliminate pre-conceived ideas and the subsequent feeling that ones ideas were discounted, I suggest meeting with the entire FTA team *before* any discussion of the specific goal occurs. The main focus of the FTA should be clear a priori but the specific goal should be left up to the team to determine and not one or two individuals. In this way, individual members will not feel as if their ideas had been discounted before they even had a chance to propose them. Also, as was the case in this FTA, it is likely that anyone conducting an FTA will have to gain entry via an administrative route thereby setting up the appearance of a top-down initiative. Since top-down innovation initiatives are generally not as effective as bottom-up initiatives even the appearance of this should be avoided.

Identification of failure events.

Once the goal was defined and a definition of its successful attainment described, the team was required to determine the failure events they foresaw as impeding the accomplishment of the goal. This was a crucial and complicated step in the process as it required insight, imagination and a thorough understanding of the system under scrutiny. As I reported in the previous chapter, the FTA team described 228 failure events which

they felt could impede the accomplishment of their goal. The method described by Stephens specifies that each failure event be worded as follows: "Failure of .... Because of ....." Initially, the negative and repetitive wording of each of the failure events was off-putting to the team members, especially TM#4 who made the following comments: "it's hard to think in double negatives" and "can't you find a more positive way of phrasing a negative?" And "The negative perspective makes it very, very difficult for me to navigate." Comments from the focal system supported the fact echoed in the responses from the focal system that misunderstandings could arise from complicated phraseology.

Eventually, though, all except one of the team members became more comfortable with the phrasing. In spite of his discomfort with what he perceived to be the 'negativity' of the process and his comment on the process evaluation questionnaire that "I believe that positive attitudes tend to influence goals, this team member did come to accept and use the terminology and understand its place in the FTA process. Inevitably always looking for failures and negative outcomes can influence the outcome negatively", this team member found value in the process and changed his behaviour as a result of participating in it. The important thing to keep in mind is that, throughout the process, we were thinking of the negative while *always* keeping solutions in mind. We looked for potential problems *before* they happened in order to help make sure they do not happen and this is the purpose of a Fault Tree Analysis.

Even though the team members came to understand and accept the use of the negative and agreed that people do tend to like to complain about things, they recommended that I simplify the wording when I presented the information to the focal

system. Their feeling was that they had been exposed to the FTA for months while the focal system would be getting a one-time exposure and may find the negative wording off-putting or difficult to understand.

Each failure event represented on the tree repeats the previous event (i.e., failure to follow-through because of failure to predefine the goal; failure to predefine the goal because of inability to reach consensus; etc.). Very early on in our discussions of the failure events, the team suggested that I should eliminate the redundancy. I attempted to do so but found that some of the items became difficult to understand once, even though it was written directly above it, the immediate context was lost. Due to the ensuing lack of specificity and context, I believe that more time should have been spent getting the wording right before sending the tree to the focal system for validation. I also believe that some form of symbol system (see next section) should have remained part of the tree. While trying to make the tree easier for the uninitiated to understand, too many contextual clues were removed perhaps causing the reported difficulties and confusion some members of the focal system had. It is important to find a way to present the information to people in such a way that they do not get lost in the negativity of the exercise but see it for the positive outcome it is supposed to bring about.

Identification of AND and/or OR gates.

Step six of the FTA process was the specification of the logic gates (AND and/or OR gates) between the failure events. As I reported in the previous chapter, I arranged the failure events in their hierarchical and lateral tree formation. When the team and I met again after the summer hiatus to evaluate the tree and add the AND and/or OR gates, I

found the discussion surrounding the issue of the logic gates to be very brief. The placement of the logic gates is one of the elements which differentiates FTA from other forms of analysis and should have had more emphasis placed upon it by the FTA team. The purpose of these gates is to clarify the relationship between the failure events on the tree thereby indicating events which can be avoided. For instance, an AND gate between two failure events indicates that these events must occur at the same time in order to produce the more general event above them thereby making failure less likely to occur. OR gates, on other hand, indicate that the occurrence of any of the contributing events would cause the more general event above to occur making failure more likely since any of the events will bring about failure. Providing these gates on the tree allows an observer to rapidly understand the relationship between the failure events. Excluding such contextual clues may lead to a less comprehensible tree for uninitiated observers.

Wood, Stephens and Barker (1979) indicate that for behavioural systems, AND gates occur with far less frequency, or not at all, than do OR gates. This finding was demonstrated in the current study and it makes intuitive sense since there are far fewer controls on behavioural systems than there are on the hard systems for which FTA was originally designed. Given the FTA team's understanding of the AND gate, they indicated that the one event joined to the others by an AND gate was 'failure of the college to support web-based courses'. All of the team members agreed that if this event occurred, along with any of the others, failure of the overall mission was certain to occur.

I would have liked to have seen a more thorough discussion of each of the failure events and their adjoining gates take place. I did what I could to explain the importance of

the gates but since according to the FTA team they were all, except one, OR gates, and the FTA team felt that the tree was less complicated without them. While I do not believe that their absence on the tree comprised its usefulness in any way, I do think that some of the potential richness was missing. The fault tree was meant to be a useful tool to the members of the system and they felt it was far more useful to them without the gates than with.

Were I to conduct another FTA, I would ensure that the FTA team understood the importance of this step and was willing to follow it. While the absence of the AND and OR gates did not compromise the integrity of our fault tree for the initiated members of the FTA team, a tree with the gates may have made the tree more comprehensible to the uninitiated members of the focal system or other interested readers.

Quantification of the fault tree.

As I mentioned in the preceding chapter, quantification of the fault tree did not take place since the tree was small enough for the team to able to determine the most critical areas upon which they wanted to concentrate their efforts. Quantitative evaluation is described by Woods, Stephens and Barker, 1979 as the "ranking of specified failure events against each other in order to determine high priority failure event sequences" (p. 15). In other words we are asking, which of the identified events, or sequence of events, is more likely to occur and cause the most problems when it does. When contemplating this issue, it is important to remember that FTA was originally designed and intended for use with hard systems where the occurrence of failure events have immediate and potentially disastrous consequences. In such cases, it may be essential to quantify the tree in order to

determine the likelihood or probability of their occurrence or the critical path of failure. When FTA was adapted for use in soft systems, Stephens included the option of quantifying the tree but he also allowed for the possibility that such quantification may not be needed. Stephens and his colleagues specifically indicated that for small trees of fewer than 300 failure events it is possible to gain valuable information from the tree without completing the quantitative calculations (Wood, Stephens and Barker, 1979).

The tree developed in this study consisted of 228 failure events and the FTA team were able to look at it in its entirety and determine the areas upon which they felt they should concentrate their efforts. It is also interesting to note that of the failure events identified, a large percentage of them (43%) were categorized as communication problems. The FTA team concluded that one of the most important steps they could take to achieve their goal was to improve the methods and avenues of communication that exist in the college.

Based on the positive results of this FTA, quantification of the tree does not appear to be necessary when there are few enough items, divided into categories, for easy visual assessment of the critical path of failure. The FTA team members in this study were able to identify this path without quantification and the results were of practicable value to them.

Distribution of branches amongst the focal system.

It is recognized that due to the random distribution of the tree branches and the small numbers of respondents per branch, drawing concrete conclusions may be

problematic. However, since the sole purpose for obtaining input from the focal system on each of the three statements for each of the failure events on the tree was to validate the work done by the FTA team and to inform the team as to how they should proceed with further investigations, this information clearly served its intended purpose. In spite of the low number of responses per individual failure event, overall percentage of focal system members' responses to the categorized failure events indicates specific areas which need attention.

Information pertaining to events most likely to occur and effect the accomplishment of the goals was given to the FTA team and, based on that information, they subsequently decided upon various ways of addressing the most problematic issues that the tree uncovered. For example, in response to the finding that access to computer equipment was cited as a potential failure by the focal system, increased numbers of computers have been made available to faculty members with more still being planned.

When asked how they might improve the questionnaire, 25 of the 30 focal system members who responded indicated that a less complicated presentation of the information would have been helpful. I tried to present the information in a clear yet cost-effective manner but that proved to be inadequate for the uninitiated members of the focal system. Given such a large system (543 members) it was possible to give each individual a copy of the entire tree. What I would do the next time though if faced with such a large system would be to hang the tree in a central location to which all focal system members had easy access. I would also provide them with two different views of the branch of the tree they were asked to evaluate. I would give them the graphical representation in order for them

to be able to visualize the hierarchical and lateral relationships of the failure events. I would also give them a list of the events along side the three questions. Making the questions easier to answer and representing the information in different ways may help improve the rate of participation. It is also possible that due to the random distribution of the tree branches and the resulting lack of context, respondents may have been less intrigued and interested in some of the topic areas than they would have been for others. While it was not possible to do for this study (due to focal system size and cost), efforts should be made to ensure that all members of the focal system see all elements of the tree.

Categorization of failure events.

Coding the failure events was a measurement of the degree of fit between what the diffusion of innovation literature had defined as impediments to the diffusion and adoption of technology and what the FTA team and focal system saw as their impediments. Since each of the failure events discovered in the study fits into at least one of the categories defined in the literature and there was a large amount of overlap between the coders' classification of these events, one can state with confidence that the failure events uncovered in the course of the current Fault Tree Analysis were accurate and valid representations of the literature. Furthermore, one can also state with confidence that these events are most likely not unique to this particular system and could be generalized to other such educational institutions facing the influx of technology. Perhaps, rather than beginning from nothing, other educational institutions or systems could use the SPECTRA categories as a starting point for their own FTAs.

Cohen's Kappa calculations resulted in a high (86%) inter-rater reliability coefficient between me and coder #2. This Cohen's Kappa is higher than the one calculated between me and coder #1 or coder #1 and #2. Discussions with the coders indicated that the definitions of the categories were somewhat ambiguous but that, more importantly, it was possible to fit each failure into more than one category. As a result of this ambiguity, I decided to meet with one of the coders in order to try and improve the inter-rater reliability coefficient. Coder #2 and I had discussions about the failure events and made sure we had a common understanding of the events as well as the categories into which we had to classify them. After these conversations, I calculated the Cohen's Kappa and was satisfied that: 1) we had reached a common understanding of the failure events and the SPECTRA categories; and 2) the failure events identified in our FTA coincided with those previously identified in the literature.

FTA Process Issues

It is important to be rigorous in ones application of a method or procedure since without rigour the results may be called into question. However, one must also consider practical elements of any particular method and the situation in which it is applied. The goal of research should be to demonstrate that methods work in realistic situations – situations which are in constant flux. Any method must therefore be rigourous enough for replication yet remain flexible enough for adaptation to each unique system in which it will be applied. In this study, I attempted to find a balance between a replicable method and one which remains flexible enough to meet the challenges of being applied in ever-

changing and idiosyncratic systems. I believe that the results of the process evaluation indicates that this was accomplished.

The changing nature of the FTA team.

The first process issue I will discuss concerns the FTA team, its changing nature and whether that had an impact on the FTA process. According to Wood, Stephens and Barker (1979), the individuals consulted during a FTA should be as systemically representative as possible in order to ensure that all perspectives are accounted for and all areas of expertise are tapped. When I began constructing the FTA team, I sought to make it systemically representative and was mindful of including administrative, faculty and technology provider viewpoints. I was somewhat limited, however, by the availability of faculty members to participate. The initial seven members of the team were systemically representative and within the first hour of the first meeting it became apparent that they each had their own idea as to what they wanted to accomplish and were looking at the process from their own particular vantage points. One of the faculty team members (TM#2) made the following comments resulting from a discussion we were having on the various goals team members had in mind:

> To me there are two [viewpoints] – that's why, I would think, that Mandie has so many different groups around this table – because from a teacher's point of view, to develop an on-line distance education course is not necessarily my objective because I'm not an administrator therefore I would never even consider it because you wouldn't accept me telling you 'well, I'm at home, my course is going on right...'

What this comment seems to indicate is that there was, even from the beginning, a tacit recognition that current thinking between faculty and administration was not necessarily in synch and that in order for anything substantial, with system-wide impact, to occur, there needed to be a common understanding. I am confident that the FTA team and the goal we used as a focal point for the analysis were both systemically representative – the verity of which was substantiated by the focal system, a full 63% of whom (refer to Table 8) agreed or strongly agreed that the goal was worth achieving.

By the fourth meeting, one of the faculty members (TM#7) was no longer able to attend. He had never intended to complete the process and only agreed to participate in the stages relating to goal formulation and his departure was therefore expected and non-disruptive. The team then remained stable until the summer hiatus. Again, based on the input from the focal system which indicated that all of the events we identified were relevant to the accomplishment of the goal and that 54% of them were likely to occur as well, I am confident that the FTA team represented their system very well and were able to look beyond their specific needs and potential impediments and identify those which have a broader impact.

At this point, the summer hiatus began and it was impossible to meet with the team members, though I did stay in touch with them via our FirstClass conference area. The break lasted for about eight weeks and caused us to lose our momentum. Neither the team nor I believe it had a detrimental effect on the quality of our tree but we all agreed that anyone conducting an FTA set specific start and finish dates with no long breaks in between.

During the summer hiatus, two members left for other jobs. One of the team-members (TM#6) had not played a very active role (see next section). It was the loss of TM#5 that caused the greatest impact on our team. We learned of his leaving during the hiatus. The following exchange took place on our FirstClass computer conference area.

TM#4 Hi All,

Well it's two steps forward and one step back (or is it the other way around?)

Some of you may know that TM#5 is no longer with us. He has accepted the position of Academic Dean at_____. Good luck to him. Woe is us.

TM#1 I learned about this last week. I plain refuse to accept this information. It's almost a bereavement! TM#5, if you read this, make room for us at_____! Either that or we will have to send a commando team trained with special extraction techniques. I am distraught...

TM#5 had been a very open-minded member of the team and had served as an excellent bridge between administration and faculty. He was able to see many sides of an issue and contributed enthusiastically to the team's progress. He was a very cohesive force as well. This particular member was an open-minded, wholistic thinking individual to whom the idea of broadening all of our perspectives was a good one. We received his input at the crucial stages in the FTA and our tree reflected his perspective and expertise. Evidence indicates that the tree we developed was systemically accurate and complete and since the majority of the work was finished before he left, there is no evidence that indicates his departure had a negative impact on the quality of the tree. There is evidence, though, that his leaving, coupled with the long break, served to damper the rest of the

team's enthusiasm when we returned for our first meeting. One of the team members wrote the following to me:

> ...a major "down" in the process is the loss of _____. You cannot underestimate the effect a single person can have on motivating others in a team. I enjoyed working with him on many levels, and taking him out of the process at this late date causes major "realignment" problems, if nothing else. Ergo, failure #999: failure to protect the working groups from life's vicissitudes.

Enthusiasm was found again once the results of the focal system surveys were in and the remaining team members were able to see concrete results of all of their hard work but the spirit was never quite the same again.

The comments of these team members clearly indicated that the loss of this particular individual was a serious one and one which needed to be addressed. Unfortunately we were unable to meet during the hiatus when the event occurred and when the remaining four did return in September, the absence of this particular member was almost palpable. It is interesting to note though, that aside from the statements to the effect that this person's loss to the team could not be overstated and the motivation was just not there, no discussions took place. It was almost as if, for whatever reason, it was still too difficult to discuss and the remaining members recognized that they would have to proceed regardless. I did not push the discussion for a couple of reasons, the most important one being that there was no attempt at discussion from the team members. While I had come to know the team members over the course of the FTA, I was still an outsider and it was really not my place to explore their feelings on this matter. I may have been losing this individual from my study but they were losing him from their working

lives and clearly felt badly about the loss. In retrospect, I wonder if I should have encouraged the discussion to continue and really examine what this individual's loss meant to the FTA team.

Both of the team members who left during the summer hiatus were invited to see the final tree, provide input and complete the process evaluation questionnaire. TM#6 did not respond to multiple requests and TM#5 said he worked too far to come and see the tree and felt that, after looking over the evaluation questionnaire, he was too far removed from the FTA process to be able to effectively answer the questions. While input from these two team members would have been beneficial, there was little I could do other than to thank them for all of their input up until then and let them know that I would still be available if they wished to discuss any part of the process.

Were I to conduct another FTA I would ensure, to the extent possible, that members of the FTA team were able to consistently attend all of the group meetings. I would try and have meetings more closely spaced, perhaps as one of the team members suggested, during three days in a row of professional development days (though given the learning curve of FTA, also noted by members of the FTA team, I would still have the process last over a few months.) In order to alleviate the frustration expressed in the following comment I received from TM#1 during the summer hiatus, I would also be quicker to provide some concrete evidence of their work and progress and to encourage work to begin as soon as possible on the development and implementation of whatever innovation the FTA is intended to analyze.

TM#1 I haven't seen any of the past input lead to anything concrete. There is only so much reflection and planning that I can take personally before setting out and physically getting the task done.

While only one member of the team expressed his frustration over the lack of concrete action to me directly, I believe it is important and an element I will be mindful of in future FTAs.

Ultimately, it is not possible to determine what effect the absence, at any one time, of any one team member had on the outcome of the analysis. The reality of any situation will remain, though, that members of a FTA team may drop out before completion. I do not look upon this as a problem detrimental to the success of FTA but rather as a reality and challenge that needs to be faced. After experiencing this problem first hand I feel stronger in my conviction that including input from the focal system as validation and additional sources of information should remain an essential element of any FTA.

Group dynamics and compromise.

Each of the FTA team members contributed to varying degrees during each of the meetings. One of the team members (TM#6) did not play a very active role in the meetings. This individual was an independent researcher hired on a contract basis to examine the use of computers amongst the faculty at the college. He expressed to me privately on several occasions that he did not feel comfortable speaking in front of the others. There was one team-member in particular with whom he felt uncomfortable. He felt that TM#4 was not interested in what he had to say. I did not observe this directly during any of our meetings though I did observe TM#6's reticence and lack of

participation in our group discussions regardless of how often I tried to engage him in the discussion. I asked if TM#6 was willing to meet with me separately to discuss some of the issues being raised in the team meetings and he agreed though he did not allow me to tape-record our session.

One of the first things TM#6 mentioned during our private meeting was that he had observed poor communication between administration and faculty. He indicated that there was a poor collaborative effort and that, though there was a task-force looking into encouraging use of the internet, there were no faculty members on it. It was TM#6's opinion that the administration was not flexible or willing to take advice, and they generally do not respect the opinions of others. While I was not involved in the project TM#6 was referring to, I have had different experiences at the college prior to and including this study and did not find any evidence of the type of behaviour TM#6 was referring to. Further evidence supporting the willingness of the team members to listen to and learn from each other was provided during the process evaluation stage when they indicated they would be making changes in their behaviour in order to reflect their discoveries.

Aside from the initial discomfort shown when the goal statement was being devised, there was respect for all voiced opinions. I found the team members to be interested in what the others had to say and were open to learning about elements of the college they were not familiar with. The team was cooperative at all times and were able to agree on all of the elements which were incorporated into the tree.

The two faculty members on the team are very active in the college community and knowledgeable of the system. They also come from different academic areas – fine arts and science. Interestingly, since the end of my study, one of the faculty team members has changed roles – he is now an associate dean whose mandate includes the integration of technology at the college. When I heard the news, I wrote to congratulate him and this was his response:

> Now let's watch this FTA thing kick some b**t!!!! Watch out e-world!!! :-).

While he was in a position as a faculty member to use the results of FTA, it would have, naturally, been on a much smaller scale. He is now able to cast a wider net and encourage more faculty members to get involved as well as provide essential administrative support. This is a very positive move and given this particular individual's enthusiasm for the use of technology and his expressed need for concrete action, I am confident that progress will be made at the college and that many of the ideas we discussed during the FTA process will be brought to fruition. This is not to say, however, that the FTA would not otherwise have had an important impact as well. Perhaps, though, the speed at which technology will be discussed and implemented and the support it receives in the process now has a better chance of being augmented.

Time constraints.

Time has been identified by Leggett and Persichitte (1998) as one of factors which people consistently cite when considering the implementation of technology. While time accounted for only nine percent of the failure events identified in this FTA, it was a factor

in the FTA process itself. Time constraints were a significant problem for all members of the FTA team. We had ten meetings of approximately two hours each. This is a substantial amount of time for people with many other responsibilities and not all team members were always able to attend each meeting. Time constraints will be a reality in any FTA where team members are also engaged in their full-time work activities. As such, it is important to expect them. It is interesting to point out that the one team member who told me right from the beginning that the likelihood of his being able to participate was very small, disagreed with the statement that the FTA process takes too much time (see Table 18) and strongly disagreed with the statement that he spent too much time on the project (see Table 17). In fact, the four FTA team members who completed the process evaluation all agreed that the FTA process was completed in a length of time suitable to their needs. Two team members did say that the process takes too much time, overall, but still did not feel that they had, personally, spent too much time on it.

My interpretation of these responses is that the FTA team members were satisfied with their involvement and comfortable with the amount of effort they expended in relation to what they received but that the process itself could be more streamlined. I do not believe that it is possible to conduct a thorough FTA in less time than we did. In fact, I believe that we may have needed more time. Perhaps, though, having fewer but lengthier meetings might help. Also, as one of the team members suggested, having a few days in a row put aside at three different times may have been helpful. Weekly meetings were simply more than the team members' schedules could accommodate and put pressure on them to attend. That said, I would still try and hold weekly meetings in order to sustain momentum and interest. I would, however, make it clearer to the team members that

meeting attendance is required and would work with the necessary individuals to ensure that team members were given time for this activity.

There is no evidence that the amount of time this study required negatively effected the outcomes. There is some evidence, offered by one of the FTA team members, that the amount of time served to help, as the more they learned about the process and the system the more they were able to understand and offer in ways of suggestions. There is also evidence that the amount of time the process took served to enhance understanding and solidify the findings. The one way the amount of time this process took negatively effected the outcome was due to the summer hiatus and the concurrent loss of two FTA team members. Had I scheduled things better and begun the analysis at the beginning of the term in January, rather than waiting until March, there would have been no summer pause and no loss of membership (though there is no guarantee that some other, unforeseen, problem would not have occurred effecting team membership).

FirstClass conference use.

A FirstClass computer conference was used to deal with administrative issues and to enable continued discussion between meetings. Except for a discussion of the goal statement and the development of failure events, discussions did not take place. The team members participated in our intense face-to-face group discussions and, while additional discussion is a possibility in any situation, there really was no need for it in this case as all the information required for our analysis was obtained in the face-to-face discussions. Also, given the time constraints under which all team members were operating, it was not reasonable to expect that they devote time to on-line discussions in addition to our

weekly meetings. In this situation, the purpose best served by the FirstClass conference was an administrative one. However, depending on the size of the focal system, computer conferences may be used to include them in the process beyond responding to the written survey.

Focal system participation.

Including the focal system in the FTA was an element unique to this particular FTA. To the best of my knowledge, no other FTA sought to include all members of its focal system (which is why FTA methodology emphasizes the importance of a systemically representative FTA team). As I reported in the previous chapter, 75 or 14% of the focal system responded to the survey. While it would have been more interesting had a larger number of people responded, I was satisfied with this result as everyone I spoke with at the college had warned me that survey participation generally runs at about five to ten percent. Even the mailman told me that faculty members frequently do not even pick up their mail. While FTA team members voiced dissatisfaction with the response rate, they expected nothing more. One of the faculty team members made the following comment on his questionnaire:

> I believe that [the college] faculty could be more involved with what happens in the community. There is great apathy and lack of compliance on their part.

This lack of community spirit is also evidenced by the number of failure events identified as problematic and likely to occur which are categorized as failures pertaining to communication (43% of all 228 failure events and 39% of the 123 failure events identified by the focal system as likely to occur) and support (17% of all 228 failure events and

15% of the 123 failure events identified by the focal system as likely to occur). Given this evidence, it seems that improved communication and increased support between and amongst faculty and administration would help solve the potential impediments identified in this FTA. Failure events considered relevant to the systemic and personal accomplishment of the goal and likely to occur may be areas upon which the FTA team and innovation implementers can concentrate their efforts before actual diffusion of the innovation commences.

It is possible that the low response rate from the focal system even substantiates the verity of some of the failure events we identified. Without a feeling of community or a sense that one's word carries weight or will be supported, it is only natural that one's willingness to participate would diminish over time. I believe that the relatively high (for this particular system) response rate we did get indicates the uniqueness of this opportunity and provides a perfect opening for administrative follow-up indicating direct support for some of the problems identified by the focal system. TM#4, who represents the administration, has already taken concrete action by:

> endeavour[ing] to provide better and more resources in private areas. We will try and reassure faculty that the web based offerings are either fully integrated in their CIs or are aimed at non-traditional [college] students.

While the numbers of responses may have been smaller than hoped, the FTA team members were satisfied with the quality of the input we received. Responding to three questions for approximately 100 failure events takes a considerable amount of time and concentration. I estimate that each focal system respondent had to have spent at least 30 minutes answering the questions and, while this does not guarantee the quality of the

input, it does imply interest in the topic and a willingness to participate. As I mentioned in the previous chapter, responses from the focal system on the technology use and attitude questions indicated a lack of use but a keen interest in learning more. While impossible to know for certain, such individuals' responses may be influenced by their readiness to adopt and indicative of the reasons they have not thus far adopted. Readiness to adopt an innovation is influenced by certain elements. Two of these elements are perceived need (Sherwood, 1999) and perceived value (Barrett, 1999; Sherry, Billig, Tavalin & Gibson, 2000), both of which responding members of the focal system indicate they have. Given the presence of these two elements, it appears to be an opportune time for diffusion to begin.

As previously discussed, one of the main impediments identified during our FTA related to issues of communication and support. Including the focal system in the process was an excellent way to let them know their opinions are important and give them a sense of ownership as well. A sense of ownership has been identified as an essential element in the successful implementation of technology and when attempting to effect systemic change (Bray, 1999; Brown, 1999). Following through and overcoming some of the problems the focal system identified will further serve to indicate that they have administrative support. Support has been identified in the literature as essential to the successful integration of technology (e.g., Hagner, 2000; Lawler, Rossett & Hoffman, 1998; Sherry, Billig, Tavalin & Gibson, 2000). TM#1, who was a faculty member throughout the FTA and is now an administrator whose mandate is the integration of technology amongst faculty, commented that:

> I believe the survey, independent of the response rate, served as a way of informing faculty of our existence and ambitions.

The survey also served to bridge a gap identified in the literature as impeding the successful integration of technology by directly involving and including the specific individuals for whom the innovation is intended to serve – a factor considered crucial to the successful implementation of technology by multiple authors in various fields of study (e.g., Jiang, Muhanna & Klein, 2000; Richey, 1998; Rossett, 1991; 1999; Strike, 1979; Wilson, 1999). Cousins (1996) talks about the importance of participatory and collaborative research and how validity of such research is enhanced due to the informed input of the practitioners themselves. The practitioners to whom he refers were, in this case, the FTA team and members of the focal system. Carr-Chellman (2000, p. 29) also writes about the importance of participatory and collaborative research and sums up the significance of focal system participation as an essential element of systems change when she writes that:

> one of the cornerstone values of systemic change and systems thinking is the fundamental value of stakeholder participation and indigenous knowledge.

It was the reliance on stakeholder participation and their indigenous knowledge upon which this FTA focussed. The evidence indicates that this reliance was well-founded and should be incorporated into all FTAs and required in any systems-wide endeavour. While impossible to ensure participation of all members of a focal system, I highly recommend following this step in any FTA. In spite of the low rate of participation, the evidence indicates that including members of the focal system added considerable value to the FTA process. Validation of the failure events developed by the

FTA team lent credence to the process. Also, having the focal system respond to the technology use questions and attitude statements provided the FTA team with additional information they could use when implementing their plans to overcome the identified failure events.

Results summary

After having identified in the literature a significant gap between acquisition and use of technology, and examining the elements which diffusion of innovation literature indicates must be in place for successful diffusion to occur, I intended, in this research, to explore the applicability and utility of a modified version of Fault Tree Analysis as a potential solution to bridge this gap. Since part of the problem seemed to be a lack of involvement from members of the system for whom the innovation is intended to serve, I sought to find a way, to not only increase inclusion, but systemic understanding as well. Specifically, I conducted an FTA in a college environment currently considering the increased emphasis on, and use of, the internet as a teaching tool. The primary goal of this study was to explore whether or not such an analysis, according to the participants and the findings, was applicable and useful. FTA is a method of systematically improving the likelihood of success by examining the potential causes of failure when attempting to attain a pre-defined goal, in the diffusion of a technological innovation. FTA fosters communication and systemic understanding.

Research questions.

Based upon all of the information described in the Results and Discussion chapters, I offer the following answers to this study's main questions.

1) Is FTA an applicable and useful tool in the diffusion of innovation in an educational setting?

With certain simple modifications and a flexible attitude towards the process which accounts for the realities of the FTA team members and focal system, Fault Tree Analysis appears to be both applicable and useful in the diffusion of innovation in educational settings. Three of the four members of the FTA team who completed the entire process strongly agreed or agreed that the fault tree was useful (one member remained undecided). Interestingly though, when asked if they would use Fault Tree Analysis again, only one member agreed that they would while the other three remained undecided. Based on those responses, in addition to the comments the team members made in the group evaluation meeting, I believe that they would use the method again as long as certain methodological changes were made to it to make it more 'user-friendly'.

2) Can FTA be used in a timely and cost-effective manner?

The monetary costs of conducting an FTA, depending on the size of the focal system and mode of tree distribution, can be rather high. They would include audio cassette tapes, paper, pens and flip chart and the reproduction and distribution of survey and the fault tree. Addressing the issue of cost-effectiveness in terms of time and timeliness is more difficult to assess. Timeliness is objective when there is a deadline to

meet and in such cases an FTA team would be given a date by which their analysis has to be complete.

In the current case, the deadline, while important, was not fixed. I also feel that since the initiative for the analysis was externally driven and no internal deadline was set, a somewhat more lax adherence to time-lines was taken by the FTA team. This in no way implies that the team members did not take the process seriously and devote a tremendous amount of time and effort to its completion. They did. I believe, however, that with an internal deadline with consequences for missing it and without the need to fulfill academic requirements for the process itself, FTAs can be completed far more rapidly than was the one done for this research.

Even though the process spanned seven months and required approximately 25 hours from each of the four team members who completed the entire process, none of these team members felt that the FTA had taken too long to complete. On the evaluation questionnaire, all four members agreed with the statement that "The Fault Tree Analysis was completed in a length of time suitable to my needs". When asked to respond to the statement that "I feel that I have spent too much time on the project", one member strongly disagreed, two disagreed and one was undecided. Therefore, in terms of both personal expenditure of time and process time, FTA was seen as cost-effective.

3) Will the members of the focal system participate in the process?

Members of the focal system did participate in the process in greater numbers than were expected or previously experienced in similar situations. Also, almost half of those

who completed the survey indicated that they would be interested in participating further in the process. Participation may be increased by simplifying the presentation of the tree. The goal now, of course, is for the FTA team to sustain continued dialogue and participation with members of the focal system. As two of the main problems identified in this FTA related to issues of support and communication, such sustained interest may further increase participation.

I was told many times throughout the process that the faculty at the college can be somewhat hesitant when it comes to participating. Whether their hesitancy is due to previous lack of support and communication or the dearth of support and communication is due to lack of participation is difficult to know. What can be known, however, is that the feedback I received from both the FTA team and the focal system indicates that increased support and communication from *both* parties would be an excellent place to begin.

I have emphasized throughout that the inclusion of as many members of the focal system as possible was an essential element of this study since inclusion may be what is necessary to bridge the identified gap between the acquisition and use if technology. Accordingly, this study was specifically designed to be inclusive. While only 14% of the focal system chose to participate, this is a substantial amount for this particular system and indicates an openness to the goals. Providing this opportunity for faculty to be directly involved in and to voice their experience-based opinions may lead to further involvement. One of the FTA team members has told me that he is often approached by

other faculty members whose interest in the integration of technology was sparked by this study.

4) Will the participants find value in the process?

The results indicate that the FTA team and the focal system found value in the FTA process. Sixty-three percent of the focal system respondents, for example, indicated that they strongly agreed or agreed that the goal which was the focus of the FTA was worth achieving. Furthermore, 46% of the focal system felt that the survey and presentation of information was useful. These positive responses and the relatively high rate of response from a focal system not generally known for responding to questionnaires indicate that the members of the focal system found value in the process. Another finding which supports this is the high number of respondents who indicated their willingness to learn more about technology and its integration into their teaching practices.

Evidence also clearly suggests that the FTA team also found value in the process. Asked to evaluate FTA on the five criteria described by Rogers (1995) as influencing the rate of adoption, the majority (see Table 19) of team members agreed that: FTA has an advantage over other methods; practice and time (trialability) increased their understanding of FTA; and observing how FTA works in practice was helpful and provided them with ideas as to how else to use the method.

When asked to evaluate FTA as to its compatibility with their way of doing things, the system and the problem, only one member agreed that FTA was compatible, one was undecided and the remaining two disagreed or strongly disagreed. These results are not

surprising given the finding that issues of communication and support accounted for 60% of the failure events identified in the FTA. These findings do highlight the need for improvement in these areas and this FTA has provided the FTA team with ample evidence and incentive to do so.

The FTA team saw FTA as a good tool to gain insight into the current state of technology use in the college as well as the readiness of other faculty to learn more about the use of technology in their teaching. The FTA team has indicated that they will use the results of the FTA and, indeed, have already begun to do so.

5) Will the group of individuals responsible for implementing the innovation recognize the information obtained from the FTA and, if necessary, adjust their plans accordingly?

FTA team members have indicated that they recognize the importance of the information obtained from the focal system. Two of the team members have asked me to pursue some of the findings to further broaden their understanding. Additionally, team members have indicated that they will, or already have, changed their behaviour or some aspect of the system in order to address the issues raised by the FTA (e.g., increasing the number of available computers; setting up an initiative for lunchtime courses for faculty).

6) Will changes to the system (diffusion plan) be made according to the results of the FTA?

While it is too soon to tell if the Fault Tree Analysis will have long-term effects, I have highlighted throughout this discussion the positive and informative impact this FTA

has had on the FTA team members and focal system. There is increased awareness on the part of administration and faculty as to the existence and uses of technologies in education. A web-based course is currently in development for offer in September, 2001. Perhaps most importantly, however, for the long-term successful implementation of innovation is the awareness that lack of communication and support in the college is a problem that needs to be addressed.

Research assumptions.

Each of the eight assumptions (see page 10 - 11) under which I began this research proved, to varying degrees, to be well-founded. The FTA team was able to conduct a FTA. The team was able to adapt the process to suit their needs while safeguarding the integrity of the information they gathered. The FTA team formed a goal statement and was able to define successful accomplishment of the goal as well as the impediments they foresaw as hindering that accomplishment.

Limitations and Implications for Future Research

One of the more commonly discussed research limitations appears to be the ability to generalize the method or findings from one study to another. Throughout this chapter I have discussed certain process problems, and subsequent solutions, the FTA team and I encountered throughout the FTA (e.g., time constraints, changes in the FTA team, and focal system response rate). We did not view these situations as limitations but rather as opportunities we could use to adapt the FTA to the particular needs of the system. Furthermore, the solutions to these process problems resulted in making the FTA even

more contextually relevant than would have been the case had we rigidly followed the steps. Our study was context specific and systemically adaptive though, consequently, no less useful to others. The results of qualitative research are naturally attached to the context in which the research occurs. Separating the research in an attempt to generalize the findings strips the research of its context (Flick, 1998) and renders it less meaningful. The results of this study may be broadly generalizable to multiple contexts, regardless of the fact that no other context will ever be identical. The method, too, may be generalizable as long as the idiosyncratic needs of each context in which it is applied are addressed.

The evaluation of the FTA process was based primarily on the responses provided by the four member FTA team to the evaluation questionnaire and group interviews. While this is not a large group, in this context these are the only opinions upon which judgments about the applicability and utility of the FTA process can be based. In this context, these people are the entire population of decision-makers. It was the opinion of the team members – active participants in this FTA – that mattered when it came to assessing applicability and utility. While specific opinions of team members in another FTA may differ than those in this FTA, the process itself may still be reasonably transferred to other contexts.

I reiterate a portion of the discussion from the Introduction and remind the reader of Janesick's (1998) warning to beware of the constant obsession with the "trinity of validity, reliability, and generalizability" (p. 48) and "methodolatry" in which one becomes preoccupied with method to the exclusion of substance. In this instance, what little may have been lost in the ability to generalize without the need for adaptation was

made up for by the realistic nature in which this study was conducted. Adherence to the goals of the participants provided for much richer and more practicable findings than would otherwise have occurred. The method we used was sound and adaptable and the evidence suggests that this resulted in immediately available and useful information. An adaptable method also allows individuals in the study to become active participants rather than passive subjects and this, in turn, provides for a very rich study.

The purpose of this study was to conduct a process evaluation as to the applicability and utility of FTA as tool in the diffusion of innovation. The results of the study indicate that FTA is an applicable and useful tool to use in these circumstances. A natural next step, therefore, would be to conduct a longer term study in which an FTA is conducted and the innovation at its focus be followed through its various stages of implementation. While it will be never be entirely possible to attribute successful implementation directly to participation in the FTA, such a long term study will allow for a more systemic view of an entire process and not just its initial portion.

There are some objective measures which could be used to evaluate the stages of diffusion. As was the case in this FTA, it is likely that not all members of the focal system will participate in an FTA process though all will ultimately be affected by the innovation. In such a situation it would be possible to examine the differences in attitudes and use of the innovation. One such tool for assessing an individual's evolving attitudes to an innovation is the Stages of Concern questionnaire developed by Hall, George and Rutherford in 1977 and stems from research which led to the development of the Concerns-Based Adoption Model developed in 1973. Results obtained from having focal

system members complete the questionnaire (either before and after participation in the FTA or comparing responses from participants and non-participants) could be interpreted in light of the respondent's role in the FTA process.

Specifically, in addition to the Fault Tree Analysis, and as a means of providing additional information as regards to ultimate implementation of the innovation in question, the Stages of Concern could be administered to the members of the system under scrutiny. The developers of the questionnaire indicate that it can be used at multiple points in the implementation of an innovation without concern for testing effects. The stages of concern about the innovation delineated by Hall, George & Rutherford (1977) are: awareness; informational; personal; management; consequence, collaboration and refocusing. There are five items on the questionnaire which address each of these stages for a total of 35 items.

In the original questionnaire, the word "innovation" appears with the instruction to users to change replace the generic term "innovation" with the specific innovation they are examining thereby making the questionnaire flexible enough to apply to any innovation merely by substituting "innovation" for the actual innovation. For example, once the goal or mission has been identified, it will be substituted for "innovation". This questionnaire can be used as a unique adjunct to FTA as a means of indicating whether or not participation in the process of validating the fault tree (as produced by the expert committee) had any influence over the types of concerns participants have about the innovation in question. Furthermore, questionnaire results indicating areas of concern common to potential failure events identified in the FTA may add strength to the veracity

and applicability of the tree. Determining the actors' levels of concern (differentiated as external and internal) about the innovation and whether or not these areas of concern change as a result of participation in an FTA will add strength to the information gathered. The results of the questionnaire may also provide a profile of users that may help with the actual implementation and integration of the innovation under scrutiny.

This particular questionnaire was selected due to the fact that it can describe what a person is currently doing in relation to an innovation but, also, what they suppose they would do faced with the innovation. The questionnaire also allows for a picture of an individual's concern to emerge over time and exposure, either to the innovation itself or to information about the innovation. FTA can be used to analyze current instances but it can also be used as a predictive tool, much in the same way as the Stages of Concern questionnaire. As such, these two different methods of data collection will add to a developing profile of a particular system's readiness to adopt the innovation in question and how best to proceed with that implementation. The questionnaire is a tool meant to assess the "awareness and readiness" (Hall, 1976, p. 22) for an innovation. It examines these elements in terms of both an individual and organizational perspective. By administering the questionnaire before and after the participants participate in Fault Tree Analysis process, it may be possible to measure the contribution being involved in the process provides to the larger community (and not just those individuals on the expert committee who actually produced the tree). FTA is a tool meant to analyze potential trouble spots when implementing an innovation. Together, these two tools may serve to provide an overall picture of readiness and point out potential hindrances. The purpose then, is to provide a profile and easily referred to diagramme to which implementers

preparing to diffuse an innovation could refer in order to help make that implementation as successful as possible. This could be one manner in which FTA can contribute to the literature on the process of diffusing an innovation.

Other models worth investigating in conjunction with FTA are the Integration Technology Adoption and Diffusion Model developed by Sherry, Billig, Tavalin and Gibson (2000) and the Technology Acceptance Model developed by Davis (1989; 1996; 2000). The first model is an extension on the Concerns-Based Adoption Model and the work done by Rogers (1995) and avers that teachers pass through four distinct phases of adoption. The Technology Acceptance Model looks at the perceived usefulness and ease of use concerning a technological innovation and measures the effects these variables have on the ease and willingness with which users accept new technologies. The FTA process may help bring to light the issues both of these models rely upon and are worth investigating.

The consistency in the nature of impediments (support, perceived need, expertise. time, resources, and access) to the implementation of technology in educational systems over the last 50 years (e.g., Barrett, 1999; Cuban, 1996; Leggett and Persichitte, 1998; Sherry, Billig, Tavalin & Gibson, 2000; Sherwood, 1999) and the finding in this study that communication and support are major impediments as well, indicates that there is something lacking in the current approach taken to address and overcome them. On the one hand, it is encouraging that this FTA identified the same failure events that the literature discusses as impeding the integration of technology. On the other hand, however, if these events are consistently identified as impeding the integration of

technology, why has more not been done to address them? Future studies using FTA could focus specifically on these events and determine the effect participating in FTA has on them.

Another area open to further research stems from the finding in this study that barriers to communication exist. Surry (1998) discusses five areas in the diffusion of instructional innovations which remain to be explored. One of these areas concerns the interaction of adopter groups and how social structure influence adoption. He writes that, while some studies have been done to address the issues, they normally focus on a single adopter and "ignore the multi-level nature of most organizations (par. 14). Using FTA may allow for more insightful study into how different people in an organization or system influence adoption decisions.

Determining whether barriers to communication exist in other systems, as well as what their effects are on diffusion and adoption, could provide substantial information and help fill the gap between acquisition and use. Also, the FTA process itself fosters communication and future research could specifically examine FTA in terms of its ability to improve communication in systems.

Conclusion

Based on the identification in the literature of a significant gap between acquisition and use of technology, the intent of this research was to explore the applicability and utility of a modified version of Fault Tree Analysis as a potential means of bridging this gap. FTA is a method of systemically and systematically improving the likelihood of

success by examining the potential causes of failure when attempting to attain a pre-defined goal. Specifically, I conducted an FTA in a college environment currently considering the increased emphasis on, and use of, the internet as a teaching tool. The primary goal of this study was to explore whether or not such an analysis, according to the participants and the findings, was applicable and useful.

The evidence gathered in this study indicates that the FTA process we used is a better representation of practice and offers a more viable alternative than FTAs described in the literature that do not include focal system participation. I have also provided evidence that indicates that this process may subsequently serve to increase the amount of interest with which focal system members approach the diffusion of technology. The responding members of the focal system indicated an interest in the goal and a willingness to learn more about the integration of technology into their teaching. Including all members of the focal system in the FTA served to personalize a process – the diffusion of innovation – that all too frequently takes place with little or no input from anyone other than an administrative body.

The changes the FTA team, focal system and I made to the process resulted in it being even more suitable to the specific needs of their system (the college). Regardless, however, of the changes any one FTA team or focal system suggest when conducting an FTA in *their* system, it is important that the process remain flexible so that it can be adapted to *any* system in which it is used. As evidenced by the use the members of *this* FTA found in the process and the practicable means by which they are attempting to address some of the issues we discovered, the practicality and viability of the process

should be up to the stakeholders to define and determine. We were able to adapt the method to suit the needs of this particular system while maintaining the integrity of the method and obtaining practicable results. Based on the findings from this study that FTA is an applicable and useful tool in the diffusion of technological innovation in educational systems, I propose that such an analysis be done anytime one is contemplating the introduction of technology in an educational setting.

Solomon (1998) discusses the marriage of technology and education and highlights the importance that psychological factors play. Rather than the 'information age' or the 'postmodern age', Solomon sees our age as the "age of *active participation* whereby learning is seen as an active, intentional, and somewhat idiosyncratic process" (p. 4). This study qualifies as one in which the active participation of the stakeholders was both sought and encouraged. Then study also illuminates the idiosyncratic nature of the process and how those idiosyncrasies should be accounted for and nurtured in order to allow for a more comprehensive and realistic understanding of the particular system in which the FTA is being conducted. Anything we can do to gain a better, and more thorough, understanding of our surroundings is beneficial. Fault Tree Analysis, by virtue of its systemic reach and inclusive process, fosters just such an understanding and appears to be an applicable and useful tool.

The development of a fault tree may, by feeding into the systemic process of diffusion of innovation and as feedback and feedforward loops, help shape the way technology is integrated, implemented and perhaps even developed in the future. The premise of Fault Tree Analysis as an inclusive knowledge management and diffusion of

innovation tool is unique to this study and different from other methods which, as the evidence indicates, makes it worth pursuing.

The importance of this line of research in general, and in specific relation to the educational milieu, is clear. If we are to improve the impact technology has in higher education processes, providing a systemic approach to address the needs of the intended users will have strong sociological, economical, educational and policy-making benefits. If we know how to uncover, elicit and then systemically represent the knowledge that influences the acceptance and integration of technology, savings of time, effort and money can be had by overcoming the impediments before they have a chance to occur.

Epilogue

I played multiple, and often time contradictory, roles in this process. I was a student striving to fulfill academic requirements, a researcher looking to answer specific questions by following a proscribed path through a method and an active participant in the FTA itself. Keeping these roles separate while still maintaining the integrity and responsibilities for each required no small amount of skill. My need to fulfill certain academic requirements and adhere to the method often had me at odds with what the FTA team members wanted to do. While never compromising the integrity of the research, the needs and wishes of the FTA team took priority upon multiple occasions. The result of these compromises and lapses in strict adherence to method are, in my opinion, what made this study as successful and rich as it was. Rather than looking upon these departures as negative, I see them as a positive indication of the FTA team's

understanding of the process and a willingness to work to adapt the method to their specific needs.

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Appendix A – FTA team recruitment letter

Technology Study

Dear Faculty Member,

My name is Mandie Aaron and I am a doctoral candidate in the Educational Technology Programme at Concordia University. Please allow me to take a few moments of your time to introduce my research. I am currently working on my dissertation – the focus of which is on the diffusion of innovation in educational settings and a method by which diffusion and implementation can proceed more effectively. I have been working with a team of your fellow faculty members, technology experts and administrators for the last six months. I am now seeking your input.

By answering this questionnaire, you will have direct and concrete input into how the use of technology at the college evolves. Participating in my research will also help me a great deal in assessing the applicability of an analysis tool that may help to improve the process of implementing new technology into educational settings in general.

The analysis tool is called Fault Tree Analysis – the purpose of which is to improve the likelihood of success of a goal in any system by understanding potential areas and causes for failure, with the aim being to enhance the possibility of success.

The goal our team has been examining is that:

by the end of the next academic year (May, 2001), the college will:

1) develop and implement (in September, 2001) at least one, fully-contained, web-based credit course in each of the Core, Pre-University and Careers sectors which will serve as templates (guides) to the development of other such courses in the future; and

2) foster an increasing awareness amongst faculty members of the existence, potential and actual uses of the new technologies as applied to their teaching functions.

There are two sections to the questionnaire – the first looks at your current use of technology in your teaching and the second asks you to assess a branch of the tree. It should take you no more than 30 minutes to compete the entire questionnaire. I realize this is a very busy time for you but your input and participation will be greatly appreciated and beneficial.

Don't forget to write your ticket number on your returned questionnaire and to keep your ticket to be eligible for the $100 Indigo book certificate. To be eligible for the draw, you must return your completed questionnaire and diagram by Monday, September 25, 2000. The winning number will be posted in the next issue of The Web Support Line and on the answering machine at 848-2006. Contact me if you are the winner.

Appendix B – Focal system questionnaire

Technology Study

GIFT CERTIFICATE DRAW # _____

Section One

1. Please indicate the subject area(s) in which you teach.

2. How long have you been teaching?

a) _____0 to 1 years
b) _____2 to 5 years
c) _____6 to 15 years
d) _____16 to 24 years
e) _____25 years or more

Section Two

Using the scale provided below, please answer the following questions regarding your use of technology.

a) Always b) Almost always c) Sometimes d) Almost never e) Never

Do you use:

3. _____a computer to produce course materials (handouts, exams)?
4. _____the internet to research material for your course(s)?
5. _____information technologies to present material in your course(s)?
6. _____e-mail or FirstClass to correspond with other faculty?
7. _____e-mail or FirstClass to correspond with students?
8. _____the internet as an integral component of your class(es)?
9. _____FirstClass as an integral component of your class(es)?
10. _____e-mail to receive work from your students?
11. _____FirstClass to receive work from your students?
12. _____e-mail for group work and discussion?
13. _____FirstClass for group work and discussion?
14. _____Do you talk to other faculty members about the use of technology in teaching?

Section Three

Using the scale provided below, please rate the extent to which you agree or disagree with the following statements:

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

15. _____The internet is a valuable teaching tool.
16. _____FirstClass is a valuable teaching tool.
17. _____I am interested in learning more about the use of the internet as it applies to my teaching.
18. _____I am interested in learning more about the use of FirstClass as it applies to my teaching.

19. _____Web-based courses are an effective alternative to traditional (classroom-based) courses.
20. _____I am interested in learning more about developing web-based courses.
21. _____I am interested in becoming a 'technology mentor' to other faculty members.

Section Four **TREE ASSESSMENT**

In this section, you should refer to the diagrams with which you have been provided. The diagram(s) is(are) the branch(es) of the tree randomly selected for you to assess.

The tree works on a hierarchy – the lower events contribute to the ones above. The theory is that by anticipating the problems one may face while trying to achieve the goal, one can then prevent the problems before they occur and increase the likelihood of success.

The goal for you to consider when examining the tree, is that:

by the end of the next academic year (May, 2001), the college will:

develop and implement (in September, 2001) at least one, fully-contained, web-based credit course in each of the Core, Pre-University and Careers sectors which will serve as templates (guides) to the development of other such courses in the future; and

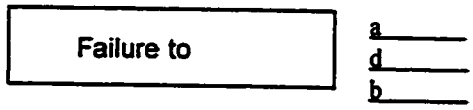
foster an increasing awareness amongst faculty members of the existence, potential and actual uses of the new technologies as applied to their teaching functions.

Using the scale provided, and marking your answers in the slots provided on the diagram(s), please rate the extent to which you agree or disagree with the following statements as they apply to the problem or failure event in each rectangle or diamond on the tree:

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

I. _____This event is relevant to the accomplishment of the stated goal.
II. _____This event is likely to effect my accomplishment of the stated goal.
III. _____This event is likely to occur.

Example:



Please add any items directly on the diagram(s) which you feel are impediments to the stated goal.

Section Five

Using the scale provided, rate the extent to which you agree or disagree with the following statement.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

a. _____The above-stated goal is worth achieving.
b. _____This survey and the presentation of information is a useful method for gathering my opinions about the use of the development of web-based courses and the use of the internet in my teaching.
c. Can you suggest any changes you think would improve the method?

THANK-YOU FOR YOUR PARTICIPATION!

Appendix C – Process evaluation questionnaire

1) The Fault Tree Analysis was completed in a length of time suitable to my needs.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

2) I feel that I have spent too much time on the project.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

3) Faced with a similar problem in the future, I would use Fault Tree Analysis again.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

4) Only 14% of the faculty completed the survey. Are you satisfied with this response rate? Explain.

YES NO

5) The fault tree is useful.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

6) Did you learn anything new about the system because of the FTA process? Explain.

7) I now feel better able to address the problems identified.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

8) Read the paragraph you wrote at the beginning of the study – how does it compare to what actually happened? Did the outcome meet your expectation?

9) What modifications do you feel should be made to the process?

10) The process valuable to me in terms of increased understanding, practical use, etc.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

11) I now feel better able to devise a concrete plan of action.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

12) Will you make any changes in how you proceed with the innovation because of what you learned in the FTA? Explain.

13) Will you try to find solutions to the failure events discovered during the Fault Tree Analysis? Explain.

14) Do you consider yourself more or less likely to participate in web-based course design or the increased use of technology in your teaching as result of participating in the process?

More likely Less likely No change

15) What actions will you take or anticipate taking because of participating in this study?

16) Participating in the Fault Tree Analysis process increased my understanding of the innovation.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

17) Participating in the Fault Tree Analysis process increased my understanding of the system in which I am operating.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

18) Participation in the Fault Tree Analysis process changed my view of the goal?

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

19) Reassess the paragraph you wrote at the start of the study and add or change it based on your participation in the FTA process.

20) Assess Fault Tree Analysis, as an innovation, on these six criteria.

The Fault Tree Analysis process takes too much time.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

The Fault Tree Analysis process required too much expertise.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

I had sufficient access to Fault Tree Analysis examples.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

I was provided with sufficient resources needed to accomplish the task.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

I received sufficient support throughout the Fault Tree Analysis process.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

Rate the perceived usefulness of Fault Tree Analysis as compared to other similar problem-solving techniques you have used.

a) Very useful b) useful c) Undecided d) Somewhat Useful e) Not useful

21) How do you rate the Fault Tree Analysis process in terms of the five criteria used when one examines the diffusion of innovation?

FTA has an advantage over other methods.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

FTA is compatible with our way of doing things, the system and the problem.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

FTA is too complex.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

Practice and time increased my understanding of the method.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

Observing how FTA works in practice was helpful and provided me with ideas as to how else to use the method.

a) Strongly agree b) Agree c) Undecided d) Disagree e) Strongly disagree

22) Our original goal was:

> By the end of the next academic year (May, 2001), the college will:
> develop and implement (in September, 2001) at least one, fully-contained, web-based credit course in each of the Core, Pre-University and Careers sectors which will serve as templates (guides) to the development of other such courses in the future; and
> foster an increasing awareness amongst faculty members of the existence, potential and actual uses of the new technologies as applied to their teaching functions.

Based on the results of the Fault Tree Analysis, would you modify this goal? How?

23) Write a brief statement as to your thoughts concerning the use of Fault Tree Analysis as a tool for the use of diffusion of innovation in educational settings.

Appendix D – Coding instructions

Coding instructions

The purpose of this exercise is to categorize the following items into only ONE of each of the following seven categories:

Support:	Administrative and technical leadership, and support
Perceived need:	Do "I" feel the need for this technology?
Expertise:	The development of expertise in technology – depends upon adequate and appropriate hands-on training. Knowledge of technology or concepts.
Communication:	Open lines of communication between administration, faculty, trainers, etc. Dissemination of information.
Time:	Including: time to plan, prepare, train, explore, etc.
Resources:	People, money.
Access:	Interpretations may vary but usually refers to access to equipment in private offices, labs and classrooms.

The items in your list may fit into more than one category, but please place it into only the best ONE. Place one initial (e.g., C, T, S) next to each item on your list.

Example:

R Failure to obtain adequate funding for training.

If you have any questions, please don't hesitate to contact me and thank-you again for helping.

Regards,
Mandie

Appendix E – Categorized and labeled list of the 228 failure events

1.	A	S	S	S	Failure of the Ministry of Education to support the college
2.	AA	R	R	R	Failure of the Ministry of Education to allocate funds to colleges other than Rosemont
3.	AAA	C	C	C	Failure of the College to demonstrate to the Ministry the interest and potential for supporting them
4.	AAAA	C	C	C	Failure of the College to establish a liaison with the Ministry of Education
5.	AAB	C	C	C	Failure of the College to demonstrate that it can provide good distance education courses
6.	AABA	C	C	C	Failure of the College to establish a liaison with the Ministry of Education
7.	B	S		S	Failure of the College to support web-based courses
8.	BA	S	S	S	Failure of the College to commit to offering the course
9.	BAA	C	C	C	Lack of collaboration between the Registrar and the Academic Dean
10.	BAB	E	C	E	Lack of understanding of the importance and credibility of web-based courses
11.	BAC	C	C	C	Lack of knowledge regarding web-based courses
12.	BB	S	S	S	Failure of the College to treat the web-based courses the same as traditional ones
13.	BBA	C	C	C	Lack of collaboration between the Registrar and the Academic Dean
14.	BBB	E	C	E	Lack of understanding of the importance and credibility of web-based courses
15.	BBC	C	C	C	Lack of knowledge regarding web-based courses
16.	C	S	S	S	Failure of the College to provide centralized system support for building and maintaining the distance education infrastructure
17.	CA	S	S	S	Failure of management to be committed to providing the infrastructure
18.	CAA	P	P	P	Failure to see the need for an infrastructure
19.	CAAA	C	C	C	Failure to be informed regarding the need
20.	CAAB	S	S	S	Failure to assign responsible body to oversee the infrastructure
21.	CAB	E	C	E	Failure to understand what an appropriate infrastructure is
22.	CABA	R	S	R	Failure to do the appropriate research
23.	CBAB	S	R	S	Failure to give someone authority to oversee the infrastructure
24.	CABC	C	C	C	Failure to listen to the advice of the FTA team
25.	CB	S	S	S	Failure of management (at the College) to support distance education
26.	CBA	T	T	T	Failure to allocate sufficient time
27.	CBB	R	R	R	Failure to allocate sufficient funds
28.	D	S		C	Failure to address issues related to access
29.	DA	A	A	A	Failure to provide adequate access to modern equipment
30.	DAA	P	P	P	Failure to perceive the need for modern equipment
31.	DAAA	T	T	T	Failure to keep up to date
32.	DAAB	C	P	P	Failure to understand needs
33.	DAB	E	E	E	Failure to understand that the existing equipment was inadequate
34.	DABA	C	C	C	Failure of faculty to inform regarding inadequacy
35.	DABB	S	S	S	Failure to make sure the equipment performs intended tasks
36.	DABBA	S	S	S	Failure to test equipment
37.	DAC	R	R	R	Lack of funds

38.	DACA	C	C	C	Failure to convince capital budget committee of importance of the project
39.	DACAA	E	R	E	Failure to prepare a convincing dossier
40.	DACB	C	C	C	Failure to ask for special grants from government
41.	DACC	C	C	C	Failure to ask for special grants from private sector
42.	DACD	S	A	S	Failure of College to make access a high priority
43.	DB	A	S	A	Failure to provide private space
44.	DBA	C	C	C	Failure to understand how people use the equipment
45.	DBAA	R	R	S	Failure to observe users
46.	DBAB	C	C	C	Failure to ask users' opinions on use
47.	DBB	P	P	P	Failure to perceive the need for private space
48.	DBBA	C	C	C	Failure of faculty to express the need for private space
49.	DBC	C	C	C	Failure to understand that existing space was not private
50.	DBCA	C	C	C	Failure of faculty to communicate needs
51.	DBD	R	R	R	Failure to provide funds to obtain space
52.	DBDA	C	C	P	Failure to understand the need for private space
53.	DC	S	S	S	Failure to provide sufficient and useful space
54.	DCA	T	R	A	Failure of faculty to use what exists
55.	DCAA	S	S	S	Failure to provide adequate support
56.	DCAAA	S	S	S	Failure to provide a 'toolbox' which could include an FAQ.
57.	DCAAAA	R	R	R	Failure to designate a person to do it
58.	DCAAB	P	P	P	Failure to perceive the need for support
59.	DCAABA	C	C	C	Failure to listen when faculty ask for support
60.	DCAABB	C	C	C	Failure to communicate the need for support
61.	DCAB	T	T	T	Failure to provide adequate time to learn and use the equipment
62.	DCABA	C	C	C	Failure to appreciate the amount of time required
63.	DCAC	C	C	C	Failure of faculty to feel comfortable with computers
64.	DCACA	S	S	S	Failure to provide a consistent desktop environment
65.	DCACB	R	S	S	Failure to support two platforms
66.	DCACBA	P	P	P	Failure to perceive the demand for two platforms
67.	DCACBB	R	R	R	Inadequate resources
68.	DCACC	S	R	S	Failure to provide adequate computer training to the faculty members
69.	DCACCA	E	E	E	Failure of trainers to perceive a changing need in the learners
70.	DCACCAA	S	R	S	Failure to evaluate needs
71.	DCAD	A	R	R	Failure to provide a convenient location in which to learn and use the equipment
72.	DCAE	P	P	P	Failure to see the benefit of using computers
73.	DCAEA	C	C	C	Failure to be shown the benefits
74.	DCAEAA	R	R	R	Failure to provide person to show benefits
75.	DCAEAAA	R	R	R	Inadequate resources
76.	DCAEB	S	C	C	Failure to provide a forum in which the benefits can be discussed and demonstrated
77.	DCAEBA	C	R	P	Perceived lack of interest
78.	DCAEBAA	C	C	C	Lack of communication between faculty and administration
79.	DCAEBAAA	C	C	C	Perceived lack of interest in message
80.	DCAEBAAAA	C	C	C	Lack of feedback
81.	DCAEBAAAB	C	C	C	Lack of confidence in message being heard
82.	DCAEBB	T	T	T	Lack of time
83.	DCAEBC	R	R	R	Lack of responsible person

84.	DCAEC	T	T	T	Failure to have sufficient time to explore the benefits
85.	E	E	S	E	Failure to use a minimum standard set of guidelines for course development, design and delivery
86.	EA	E	S	E	Failure to use a minimum standard set of guidelines for course development
87.	EAA	C	C	C	Failure to communicate the FTA team's strategies during the formative process
88.	EAB	C	C	C	Failure to operationally define the stages and critical points of the development process
89.	EABA	C	C	C	Failure to adequately document our thoughts for the target audience
90.	EABB	C	T	C	Failure to define a starting and ending point in the developmental process
91.	EABC	C	R	C	Failure to stop, retrench and consolidate our efforts before blazing along with more advanced features
92.	EABCA	C	C	C	Failure to recognize that the process is as important as the final product
93.	EABCB	C	C	C	Failure to identify each element that was necessary and sufficient
94.	EB	E	S	E	Failure to use a minimum standard set of guidelines for design.
95.	EBA	E	E	E	Failure to identify clear design criteria
96.	EBAA	S	S	S	Failure to break down criteria into small, attainable steps
97.	EBB	C	C	C	Failure to form a common set of objectives
98.	EBBA	T	T	T	Failure to pre-plan
99.	EBC	E	S	E	Failure to identify the tools that are needed
100.	EBD	S	S	S	Failure to develop a common teaching paradigm
101.	EBDA	P	P	S	Failure to focus on learning and not technology
102	.EBDB	C	S	C	Failure to work as a team
103.	EBE	C	C	C	Failure to define our pedagogical challenges in common terms that transcend disciplines
104.	EBF	E	S	E	Failure to recognize the importance of standard user interface in allowing the students to learn the skills only once. (i.e., Web CT or FirstClass, etc.)
105.	EC	E	S	E	Failure to use a minimum standard set of guidelines for delivery
106.	ECA	E	C	E	Failure to identify a common computer platform
107.	ECB	C	C	C	Failure to understand the needs, strengths and weaknesses of our target audience
108.	ECC	C	C	C	Failure to understand the importance of a standard user interface
109.	ECD	S	S	S	Failure to incorporate standing college and departmental policy differences governing our dealings with the students
110.	ECE	C	C	C	Failure to define our common objectives
111.	F	R	R	S	Failure to complete the mission because of failure to follow through
112.	FA	P	P	P	Failure of faculty members to buy-in to the necessity of the project
113.	FAA	C	C	C	Failure to involve faculty members in the development process
114.	FAAA	C	S	C	Failure to relinquish control
115.	FAAAA	C	C	C	Failure to recognize decentralized organization
116.	FAAB	C	C	C	Failure to understand that the project is a team effort

117	.FAABA	C	C	C	Tradition of doing things independently
118.	FAB	C	C	C	Failure to provide sufficient information to faculty members
119.	FABA	R	S	S	Lack of responsible body
120.	FABB	T	T	T	Lack of time
121.	FABC	P	S	S	Lack of interest in including faculty members
122.	FAC	C	E	C	Too much knowledge (pre-conceived ideas or prior experience)
123.	FB	C	C	C	Failure to see a common goal
124.	FBA	C	C	C	Failure to predefine the goal
125.	FBAA	T	T	T	Lack of planning
126.	FBAAA	T	T	T	Time constraints
127.	FBAAB	T	R	T	Failure of team-members to attend meetings
128.	FBAABA	T	T	T	Lack of time
129.	FBAABAA	T	C	C	Number of demands placed on team-members
130.	FBAB	T	R	T	Limited availability of the team members
131.	FBAC	T	T	T	Lack of planning time
132.	FBAD	C	C	C	Inability to reach consensus
133.	FBADA	C	S	S	Tradition of doing things independently
134.	FBADB	S	S	S	Failure to respond to requests for input
135.	FBAE	C	P	C	Failure to understand the need
136.	FBAEA	E	E	E	Lack of knowledge
137.	FBAEAA	T	T	T	Time constraints
138.	FBAEAB	C	C	C	Lack of informing body
139.	FBB	C	C	C	Failure to see where individual goals overlap
140.	FBBA	T	T	T	Failure to pre-plan
141.	FBBB	C	C	C	Failure to have an overall understanding of the mission
142.	FBC	C	C	C	Failure to see where the goals of the FTA team and the course developers overlap
143.	FBCA	C	C	C	Failure to communicate
144.	FBCAA	C	C	C	Failure to listen
145.	FBCAAA	C	C	C	Failure to understand others' perspectives
146.	FBCAAB	P	P	P	Lack of interest
147.	FBCAAC	T	T	T	Time constraints
148.	FBCAAD	P	P	P	Failure to perceive the need to listen
149.	FBCAB	C	C	C	Lack of community spirit
150.	FBCAC	T	C	T	Failure to be available for communication
151.	FBCACA	T	T	T	Lack of time
152.	FBCACAA	E	T	E	Failure to understand different modes of communication that exist
153.	FBCACAAA	E	E	E	Inadequate training
154.	FBCACAAAA	P	P	P	Failure to recognize the need for training
155.	FBCACAAAB	R	R	R	Lack of training personnel
156.	FBCACAAB	A	A	A	Lack of accessibility
157.	FBCACAB	T	R	T	Heavy workload
158.	FBCACB	C	C	C	Failure to find effective ways to convey information
159.	FBCACBA	E	R	R	Failure to evaluate effectiveness of tools available for communication
160.	FBCACBB	C	C	C	Failure to determine different levels of understanding
161.	FBCAD	C	C	C	Fear of a negative response
162.	FBD	C	C	C	"It's not my goal"
163.	FBDA	C	C	C	Lack of communication
164.	FBDAA	C	C	C	Lack of sense of community
165.	FBDAAA	C	C	C	Failure to share information
166.	FBDAAAA	S	C	S	Failure to organize information-sharing sessions

167.	FBDAAB	S	C	S	Failure to encourage a community of educators/learners
168.	FBDB	C	C	C	Goals of others are also my goals because it is a common project
169.	FBDC	C	C	C	Failure to be open-minded regarding other people's goals
170.	FC	C	S	C	Failure to anticipate workload
171.	FCA	C	C	C	Failure to understand what distance education courses entail
172.	FCB	C	C	C	Failure to be fully informed about the process
173.	FCBA	S	C	C	Lack of informing body
174.	FD	C	S	C	Failure to avoid reinventing the wheel
175.	FDA	C	R	C	Failure to work in teams
176.	FDAA	C	C	C	Lack of sense of community
177.	FDAB	C		C	Failure to be informed as to who else is interested
178.	FDB	T	S	C	Failure to organize tasks
179.	FDBA	C	S	C	Failure to define specific roles
180.	FDBB	E		E	Failure to know what tasks are required
181.	FDC	C	R	C	Failure to research other organizations/institutions for ready-made solutions to problems
182.	FDCA	T	T	T	Lack of time
183.	FDCB	E	E	E	Failure to know how to find solutions
184.	G	R	R	R	Failure to make technical assistance in course development available to faculty who are encouraged to use it
185.	GA	S	S	S	Failure to provide sufficient technical support.
186.	GAA	R	R	R	Failure to provide sufficient funds
187.	GAB	P	C	C	Failure to make it a high priority
188.	GABA	C	P	P	Failure to understand the need for teacher training
189.	GABAA	C	C	C	Failure of faculty to ask for help
190.	GABAAA	P	E	P	Failure of faculty to recognize that they need help
191.	GABAAB	C	C	C	Failure to realize that it is okay to ask for help
192.	GABAABA	S	C	S	Failure of technical staff to respond when help had been asked in the past
193.	GABAABB	C	C	C	Failure of technical staff to keep it simple
194.	GABAABC	S	C	S	Failure of technical staff to provide a safe place in which faculty can ask questions
195.	GABAB	E	S	E	Failure of technical staff to stay current with emerging technology
196.	GABABA	R	E	E	Failure to get outside training for the technical staff
197.	GAC	R	R	R	Failure to hire more personnel
198.	GB	C	S	S	Failure to find faculty who do not need technical support
199.	GBA	R	R	R	Failure to provide resources
200.	GBB	C	C	C	Failure to keep informed of faculty capabilities
201.	H	C	R	C	Failure of students to enroll in the course
202.	HA	R	R	R	Competition from other schools
203.	HAA	C	C	C	Failure of College to wrest DE from the clutches of College du Rosemont
204.	HAB	C	C	C	Failure of the College to demonstrate that it can provide competitive Distance Education courses
205.	HB	C	C	C	Failure to advertise
206.	HBA	P	P	P	Failure to see the need to stand out
207.	HBB	R	R	R	Failure to provide sufficient personnel
208.	HBC	R	R	R	Failure to provide sufficient funds
209.	HC	C	C	C	Failure to explain requirements
210.	HCA	C	C	C	Failure to adequately outline the course

211.	HD	E	C	E	Failure to offer an 'interesting' or relevant course
212.	I	E	C	E	Failure of the students to succeed in an web-based course
213.	IA	S	S	S	Failure to provide effective support and motivation
214.	IAA	R	R	R	Failure to have sufficient manpower to provide mentors and tutors
215.	IB	C	C	C	Failure of students to realize the course is serious and requires a lot of effort
216.	IBA	C	S	C	Failure to address student attitudes to distance education courses
217.	IBB	C	C	C	Failure to clearly state objectives and standards
218.	IC	P	P	S	Failure to focus on learning and not technology
219.	ID	S	C	E	Failure to keep the user-interface simple
220.	IDA	E	E	E	Failure to find appropriate pedagogical paradigms
221.	IDB	E	E	E	Failure to find suitable software
222.	IE	S	S	S	Failure to make tests and assignments flexible enough to accommodate student schedules
223.	IF	R	R	R	Failure to limit class sizes in order to keep students unified and motivated
224.	IFA	S	S	S	Failure to get the Registrar's office to cooperate
225.	IG	E	E	E	Failure of the students to have the skills
226.	IGA	S	S	S	Failure of the College to provide pre-requisite skills
227.	IGB	E	S	E	Failure of the College to know the required skills
228.	IH	C	E	C	Failure to have students who apply for the course demonstrate that they have the necessary skills