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Introducing the Failure Mode Effects Reflective Analysis Technique for the Field of Higher Education and Research

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INTRODUCING THE FAILURE MODE EFFECTS REFLECTIVE ANALYSIS TECHNIQUE FOR THE FIELD OF HIGHER EDUCATION AND RESEARCH

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Abstract

The Failure Mode and Effects Analysis (FMEA) technique is a well-established "key tool" [1] for risk assessment and management in the field of engineering that has been 'borrowed' extensively in recent years by other areas such as the field of medicine, chemical process industries, and the automotive industry, where it has been utilised as a quality improvement tool. In a very structured way the FMEA enables a team of individuals to assess and manage risk by clarifying potential failures or problems with the product, service or process under review, highlighting the effects or consequences of those failures, and agreeing procedures to be put in place to either eliminate the occurrence of those effects or mitigate the severity of their consequences.

In the absence of a standardised risk assessment strategy in the field of higher education (HE) and research, this paper details a study undertaken at a HE institute in Ireland that 'borrowed' the FMEA technique and modified it for use in the field of HE and research specifically, in order to evaluate its potential role and value for the field. Once modified in ways that supported the epistemological assumptions of the borrowing discipline, the technique was used to carry out a risk assessment of the strategies in place at the institute in question to implement its elearning initiative. Subsequently, how the research process itself ran, as well as the type and quality of the data the technique helped generate, were analysed in depth.

The key finding of the study emerged as the high level of reflection that the modified FMEA technique encouraged unexpectedly amongst the participants. It provided them with a rare and invaluable opportunity to reflectively analyse the strategies in question, which led to significant outcomes for them. This in turn led to the design of the Failure Mode Effects Reflective Analysis (FMERA) qualitative research technique for the field of HE and research, which holds huge potential for the field in this era of great change and need for continuous quality improvement. This paper will introduce the technique and provide practical recommendations for its use.

Keywords: Research methodologies, risk assessment.

1 INTRODUCTION

The implementation of effective risk management in higher education institutions (HEIs) has become an essential element in the drive towards quality improvement during these times of continual change, competition and growth. While risk management procedures have been embedded in the HE sector in the United Kingdom for many years now, it is only in recent times that risk management has been adopted and implemented in the Irish HE sector. Following the acceptance of the Code of Governance by the Irish Universities in 2007 there has been "...an increasing focus on ensuring effectiveness and on assurance based on identifying and managing risk" [2]. While the Irish Higher Education Authority (HEA) published a document to assist universities in ensuring that appropriate procedures and controls are implemented to manage the risks facing them, no practical guidelines as to how to undertake risk assessments are provided. In 2001 and 2005 the Higher Education Funding Council for England (HEFCE) published guidelines to aid English HEIs in embedding formal risk management processes in which 'risk' was defined as "the threat that an action or event will adversely affect the institution's ability to achieve its objectives" [3]. Although they state that there is no single correct approach to managing risk in institutions, their guidelines do provide a comprehensive overview of all of the elements that need to be addressed in order to undertake an assessment effectively. Such elements include a description of the risk type, the potential impacts of the risk, the risk rating by

impact and likelihood, the controls that are in place to mitigate the risk, and finally, actions for improvement. The guidelines also provide suggestions as to how to generate this data and include a desk top review of documents, interviews, group interviews, focus groups, and questionnaires with room for additional comments.

In the absence of a standardised approach to assessing and managing risk in the HE sector, I looked beyond the field at potentially viable methods well respected in their own disciplines, and chose to borrow the Failure Mode and Effects Analysis (FMEA) technique from the field of engineering and set out to establish if it held any potential value for the field of HE, and if so what that value might be. The following sections outline my study discussing it under the main headings of 'Method and Methodology', 'Key Finding', 'Introducing the FMERA', and 'Conclusion'.

2 METHOD AND METHODOLOGY

Borrowing methods across disciplinary boundaries raises many epistemological issues which must be addressed if the research outcomes are to be accepted in the borrowing field and contribute knowledge of any value to that field. The first of these issues relates to the researcher themselves and the absolute need for them to be explicit about their own epistemological foundations before reviewing the borrowed method and modifying it for use in its borrowing field. And so this section begins with a very brief statement of the assumptions with which I approached this study, followed by a description of the FMEA in its original context, an explanation of the context within which the modified FMEA was applied, the three ways in which the generated data was analysed, and the techniques employed to establish the trustworthiness of the findings.

2.1 Epistemological and Ontological Assumptions

I approached this study as a qualitative researcher believing in the importance of context in a qualitative study if the full meaning of the event in question is to be understood and appreciated. I also believe in the pivotal role that the researcher plays in the study and the consequential need to accept and value the role of the subjective rather than the objective. Furthermore I consider myself a social constructivist and advocate the benefits groups collaborating to construct knowledge and generate shared meanings can have for learning. I support also the notion that there is no one 'reality' to be discovered and disseminated because reality does not exist until it is constructed, in addition to which each individual constructs their own reality with no one reality any more valid than the next.

My role in this study as an insider researcher was "to help generate, give meaning to, and finally, present, the knowledge co-generated between the participants and myself from the multiple realities, feelings and interpretations proffered during the data generation meetings" [4]. But I was more than just an insider researcher, rather I was what I termed an 'insider-within'. To explain, I was a member of the team I chose to use in undertaking this study and so was a participant as well as the facilitator. This raised further epistemological, ontological and ethical concerns that needed to be addressed as the study progressed, particularly in relation to how I contributed as a participant, the impact or influence my contributions may have had on the other participants, and subsequently, how to handle my contributions when reviewing the generated data. I kept a reflexive journal throughout this study that charted my thoughts on these and other issues and all decisions finally taken.

2.2 The FMEA

I borrowed the FMEA from the field of engineering where it is held as a well-established "key tool" [5] for risk assessment and management as "it harnesses the insight and imagination of those concerned with product and service quality and it provides a structured approach to analysis" [6]. Borrowing methods from other disciplines is not without its challenges however and many modifications to the FMEA were necessary in order to make it of use in the HE sector. This section describes briefly the FMEA technique in its traditional context.

The FMEA is undertaken by a team of individuals, typically made up of those who could be called 'experts' in relation to the product/process/service under review and who set out, through analysis, to

document failures (errors, problems or concerns), their mode (how the failure occurs), and their effects (the failure's outcome on the product/process/service). Describing potential problems in this way provides the team with an opportunity to take actions that will either eliminate the effects of such problems or 'failures', or at the very least, reduce the severity of their impact.

The analysis begins with what is called a **review of the function**, meaning each and every component of a product, or each step of a process, is considered in depth and recorded on an FMEA worksheet, along with its intended function(s). Once completed, the team moves on to **identify potential failures and failure modes** of each of the functions listed, where a potential failure is understood as a potential problem, error or concern of any of the functions, and its failure mode is a description of the way in which that problem could fail to perform the intended functions. The next step is to list the **potential effects or consequences** associated with each of the potential failures listed. Given the type of knowledge this last step in the FMEA generated, the potential failures must then be prioritised or ranked in terms of the risk they hold for the organisation should they occur. Three individual rounds of **ranking** are undertaken as part of the process of prioritisation using ranking scales that usually range from 1 to 5. Firstly, the potential failures are ranked in terms of its **severity** (how severe it would be for the organisation should the failure occur), followed by **occurrence** (how likely it is to occur), and finally, **detection**, (how likely it would be that the failure would be detected before its occurrence). The **Risk Priority Number** (RPN) for each failure is then calculated by multiplying the results of the ranking process. **Actions** to mitigate or eliminate the failures and their consequences are then noted along with a timeframe for their implementation. Following an agreed period of time, those failures are reviewed once more, and their PRNs recalculated, in an effort to assess if the actions were effective or not, and to agree further actions if necessary.

The FMEA technique may have been developed by the United States Military as far back as 1949 to evaluate the reliability of their systems and equipment, but it has since been borrowed successfully by many other disciplines such as the aerospace industry and the automotive industry, as well as the health sector where it is used specifically to prevent product and instrument failures and medical process failures thereby improving patient safety and quality of care [7]. This paper describes how I borrowed and modified it for use in the field of higher education and research to assess risk and help inform decision making.

2.3 Context

In its traditional context, the FMEA is employed at the very early stages of product development so that potential failures can be identified and actions taken to either mitigate their effects or eliminate them, completely. In the HE context this could translate to a time in which a new policy is being formulated, a new project is being planned, or during a period of intense change.

In the context of this particular study, the FMEA was undertaken at a time of great change for the participants. The elearning team, of which each of the participants were all members, were in the process of merging with the more well established learning and teaching team at the institute. It was a merger that had been suggested by directorate and was proving difficult to implement. The participants were understandably very unsettled at that time and quite unsure of their changing identity and roles and how they as a group would fit within the newly merged team (NMT). The participants had also started to question if the strategies they had in place to implement elearning at the institute were as effective and efficient as they thought they were? If there were factors that could prevent those strategies from supporting fully their policies and being as effective as they could? And if there were such factors, could they mitigate their effects into the future? Did some of their processes and strategies need to be amended – how did they fit in within the context of the newly merged team (NMT)? And had the changes they had made to those strategies over the years been for the better? The following comments made by the participants during the data generation phase of the study give a sense of the uncertainty that they were feeling:

> **Speaker 1:** …as I say, there are other factors into the mix and why that is because, I suppose, we have been trying to find our identity as this [NMT]…

Speaker 2: That has been a big issue.

Speaker 3: Ya I think it's a big issue.

Speaker 1: …it's a major issue, and that is going to take time as well.[8]

"there's an ambiguity because of the whole [NMT] thing.…It's unclear as to where the whole thing is going to go". [9]

"There have been very few constraints on us in any shape or form. I mean maybe that's what's a little hard about the whole merger thing is that suddenly there are a few more constraints on us, that we can't just say 'ok let's do this or this', 'let's publicise it this way' or whatever, that we have to, you know, bend into a slightly different shape." [10]

"In terms of promotion, it's hard to promote ourselves within the context of the [NMT] and that's something we have to figure out. How are we going to promote the services we specifically do as a group of 6, 7 or 8 people as part of the [NMT]?" [11]

2.4 Data Analysis

The data was generated over a series of nine three-hour meetings spanning nine calendar months, where the participants (six in total) worked their way through each of the FMEA steps. The meetings were videoed to as to allow me to review each one and fill in the relevant information into the FMEA worksheet. The participants were assured that those DVDs would be destroyed once the study was complete. While neither the institute in question nor the participants were ever named in the study, the HE sector is Ireland is small enough that the contextualising data given meant that it was easily identifiable. So while I could not assure completely the participants' anonymity, I vowed to protect 'who said what', and so, instead of assigning each participant a letter or number, which could allow for a pattern of sorts to appear in the comments, I referenced each comment quoted in the study with the date of the meeting, the number of the DVD it came from, and the number of minutes into that DVD that the comment appeared.

The data generated was analysed three times. The first round of analysis involved reviewing the DVDs following each meeting drawing out the salient points relevant to what was being discussed at that meeting and filling in that data on the FMEA worksheet. However, this process also gave me the opportunity to begin reflecting in an initial way how the technique was running in the HE context. "In some instances, these reflections even prompted me to make some further modifications to the technique mid-study in an effort to make it even more effective." [12]

Once the team had ranked and prioritised each of the potential 'failures', which in the modified technique were referred to as potential 'risk events', the second round of analysis began whereby each of high priority potential risk events were reviewed closely in an attempt to determine which risk events the participants were most concerned with and why. A pattern of issues began to emerge that amounted to some very interesting findings from the team's perspective in relation to their work practices in general, and more specifically to their mutual unease concerning their training strategies for example and the changes made to those in recent times following the employment of a part-time trainer. Some further discoveries were made when those high priority risk events were reviewed against the changing context within which they had been generated, leading to some recommendations for the future use of the FMEA in the HE context. For further information please refer to the study itself. [13].

The third and final round of analysis was unplanned and arose from comments made by the participants during a short review session where they discussed the modified FMEA technique and

how they felt the study had run from their perspectives. Interestingly, it was this round of analysis that that revealed the most important finding of the study which led directly to the design and development of the Failure Mode Effects Reflective Analysis technique for the field of HE and research, and will be discussed in more depth in Section 3 below.

2.5 Establishing Trustworthiness

Boix Mansilla et al. [14] state that when undertaking interdisciplinary research one of the epistemological dimensions that must be addressed is the definition of standards of acceptability. According to Boix Mansilla et al., techniques, when borrowed, "adopt a different epistemological function" and so the criteria through which it is validated in its traditional context no longer apply in the borrowing discipline. To establish the trustworthiness of this particular study and its outcomes I looked to Lincoln and Guba [15] and the work they have done to design techniques constructivists can employ to evaluate their research and establish the trustworthiness of their findings. In determining which of their many techniques that I needed to employ, I considered the three distinct ways in which qualitative research is threatened, according to Padgett [16], and chose the techniques that best helped address those threats. See Table 1 below.

Table 1: Strategies Chosen to Mitigate the Threats to the Credibility and Trustworthiness of this Study Taken from [17]

	Threats to credibility and trustworthiness		
Strategies Employed	**Reactivity**	**Researcher's biases**	**Respondents' biases**
Prolonged Engagement	✓		✓
Reflexive Journal	✓	✓	
Persistent Observation			✓
Member Checking		✓	

Clearly these threats are problematic for researchers undertaking quantitative research as well as qualitative research, but Padgett does stress that qualitative research is more at risk because of the unique position held by the qualitative researcher in the study:

> the intensity of the research relationship and the pivotal role of the researcher-as-instrument place qualitative studies in "triple jeopardy" when it comes to these threats. [18]

3 KEY FINDING

Whilst discussing with the participants how the study had run and if they were happy with the actions noted during the final step of the technique, it transpired that they had viewed the FMEA as a *reflective* process. To quote the participants:

> It was good as it was a good reflective process, as a way of planning.

> I think it has been a hugely valuable exercise, quite independently of your research, just for us as a team just to happen on, you know, where we've come from and think we might be going.

> It's the whole reflective process…I found that hugely valuable. You know just reflecting back, because when you're on your day to day treadmill and you're having to adapt and change so quickly there's never much planning time, let's be honest. To be able to reflect back on what you have been doing. …You see what you've worked though, the changes that have occurred – it's brilliant.
>
> [19]

This revelation threw a different light completely on the study and prompted me to review the generated data a third time looking for instances of reflection on behalf of the participants and to see if themes began to emerge, and, for this purpose I took 'reflection' to be a technique that allows people to "recapture their experience, mull it over and evaluate it" [20]. The FMEA in its traditional sense is a systematic disciplined method of analysis within which there is no provision for personal or team reflection and development, and so, that the participants had seen it as such and moulded it to facilitate their specific needs in the HE context was very interesting, and unlocked, in my opinion, the ultimate value the technique holds for the field of HE and research.

The third review of the DVDs uncovered a whole new layer of data for analysis. "It transpired that not only did the participants reflect on their daily work practices thereby gaining valuable insights into how they operate as a team, but also on the changing context within which they work, and the effect of the merger and their changing roles and identities were having on their work practices and on the continued implementation of elearning at the institute" [21].

4 THE FMERA

Ultimately, this study led to the design of the Failure Mode Effects Reflective Technique (FMERA), tailored for the field of HE and research. This section gives a description of this technique and notes recommendations for its use in the field.

The technique has six steps and begins with a review of the process, procedure or work practice in question. It is essential that the team undertaking the FMERA has a shared understanding of what is being reviewed exactly so that all issues discussed are relevant to the task in hand before stating the objectives or policies that the process/procedure/work practice in question supports. The ultimate purpose of this review is to list each and every one of the individual steps within it or the elements that constitute it. It's important to be thorough at this stage and ensure that no step or element is left out as it is to these that the team will be returning in each of the subsequent FMERA meetings. Having undertaken the review it is important to asses if the task in hand is too big and if it needs to be broken down into a number of smaller FMERAs. Ideally FMERAs should be completed within the academic year as long gaps in time between meetings, given the rate at which contexts can change in the HE sector, could lead to outdated data being generated. Once this has been done, the team must revisit each step or element listed and discuss and identify potential risk events associated with it and list the potential impacts or effects of that risk event should it occur. This task should be approached as an *if-then* cause and effect type process, meaning, *if* a potential risk event happens, *then* what is/are the impact(s) of that, where 'potential risk event' refers to any factor that could effect in an adverse manner the institution's ability, or the ability of a specific team of people, to achieve the objectives or policies noted in step one of the FMERA.

Next, the team need to devise ranking scales. Qualitative ranking terms such as 'remote', 'low' 'moderate', high' and 'very high' can be used when ranking the 'severity', 'occurrence' and 'detection' of each potential risk event. The important issue here however is ensuring that the team have a shared understanding of what each of the ranking terms actually means. To do this, is it recommended that the ranking terms are contextualised, meaning the team spend time discussing one or two examples related to their work that for them represents each term adequately. In the case of this study the team listed a technical issue and a 'people' issue for each term before ranking 'severity', so for example, for them a 'remote' ranking was explained as "failover occurs and the user is logged out and has to log back in again", and "a team member takes one days annual leave in the summer time", while 'very high' was described as "the VLE is down for 24 hours", and "long term huge

staff cuts" [22]. Once devised, each potential risk event is revisited in turn and rankings are assigned for how severe it would be for the institution or the team in question should the risk event occur, the likelihood of it occurring, and the chance that it would be detected before its occurrence.

Once each potential risk event has been ranked in each of the three ways, they must be prioritised in order of importance. This is a two-fold step. Firstly, the risk events are assigned a risk score using a qualitative risk matrix such as that shown in Fig. 1 below.

	Occurence				
Severity	Remote	Low	Moderate	High	Very high
Very high	M	H	H	E	E
High	M	M	H	H	E
Moderate	L	M	M	H	E
Low	L	M	M	M	H
Remote	L	L	M	M	H

Key	**This risk event could…**
E = Extreme risk:	seriously disrupt the team and the services they provide. cause major disruption to the elearning initiative at TLI.
H = High risk:	significantly disrupt the team and the services they provide. considerably disrupt the elearning initiative at TLI.
M = Moderate risk:	cause a high degree of disruption to the team and the services they provide. cause a noticeable disruption to the elearning initiative at TLI.
L = Low risk:	have little to no effect on the team and the services they provide. have little to no effect on the continued successful implementation of the elearning initiative at the TLI.

Fig. 1: Qualitative Risk Analysis Matrix [23]

"This matrix acts as a screening tool that discriminates between the very high and the remote risks allowing the team to focus risk management attention. It should not be seen as a precise mathematical correlation of risks by severity and probability of occurrence" [24].

Secondly, the risk events risk score is cross-referenced with their 'detection' rankings and in doing so it is possible to reprioritise them in terms of their priority for attention. See Fig. 2 below.

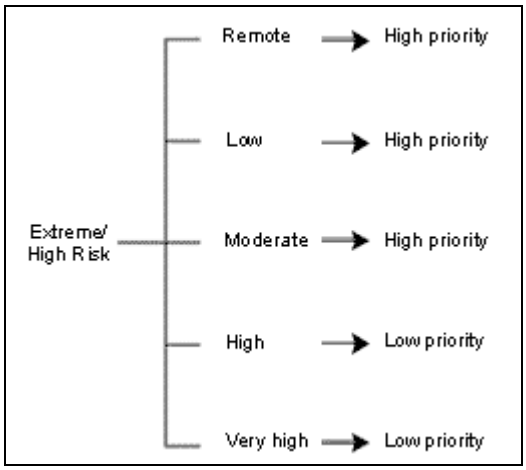

Fig. 2 Priority for Attention Flow Chart [25]

Fig. 2 shows that a potential risk event with an extreme and/or high risk score, coupled with a 'remote' ranking for detection, makes it a high priority risk event as it is very unlikely that it will be detected before its occurrence and so some action must be taken. However, a potential risk event with an extreme and/or high risk score, coupled with a 'very high' detection ranking is expected to be recognised before it occurs and so is not as high a priority as the former example.

Once prioritised, the FMERA team can then examine each one discussing risk to review risk mitigating measures. Once implemented for an agreed period of time the risk events can be reassessed and reprioritised in an effort to determine if the risk mitigating measures taken were effective or not.

5 CONCLUSION

Risk assessment and management is becoming more and more important in this time of continual change and pressure for quality assurance and improvement. In the absence of a standardised risk assessment technique for the field of HE and research, the FMERA provides a real alternative to institutions and project groups to help them get at salient issues and devise real actions for improvement. "Its presence certainly signals the potentially successful borrowing and modification of a technique across disciplinary boundaries, and a positive move forward for the field of HE and research as it embraces a new research technique" [26].

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