The Effectiveness and Impact of Risk Management Training on Supervisory Level within a Mining Organisation

by

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Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the authorship owner thereof (unless to the extent explicitly otherwise stated), and that I have not previously, in its entirety or in part, submitted it for obtaining any qualification.

March 2020

Abstract

South Africa has seen many accidents within the mining sector, leading to damage of natural resources, equipment and loss of lives, due to incidents occurring. Incidents can however be better controlled by implementing better management strategies to reduce the level of likelihood and consequence of incidents occurring, thus the level of risk of a specific job on mining sites. Currently, risk management training (RMT) programmes are presented to Supervisory level management with the goal to improve planning and scheduling around risk related mining activities to decrease mining related incidents.

Unplanned tasks and activities on Supervisory level increases operational risks, which raise the question on the effectiveness and impact of the Supervisory level training in the mining company being investigated. This study investigates the design and use of serious games (SGs) in RMT programmes to not only increase the impact of the training but also measure the effectiveness thereof.

Based on a review from literature, a SG is designed and developed to be played at an actual training programme for Supervisory level management in the mining organisation. The SG is designed with characteristics associated with better learning and cognitive knowledge uptake with the aim to improve implementation of principles learnt. The game is developed on Excel VBA with a points system framework to be played on a laptop or tablet by delegates to the programme. The four level Kirkpatrick model of training evaluation is followed (Reaction, Learning, Behaviour, Results) with the aim to compare theory test results, SG results and real on-site work improvement to track a behavioural change in delegates after attendance of the programme, thus the effectiveness and impact.

The SG was successfully designed, developed and implemented at an RMT programme for the collaborating mining organisation. A series of hypothesis tests were done to find statistical significance in the results obtained. From the delegates tested, all succeeded in improving their SG scores with a statistically significant increase within five rounds played of the game, proving that the SG game characteristics stimulates better learning, as found in literature. A statistically significant correlation was found between delegates' respective score increase and results from a theoretical test on the course content, indicating a correlation between knowledge gain and implementation of the principles learnt. Lastly, a statistically significant increase was found in real-world KPI's in the form of increase in work related outcomes of attendance of the programme, from before and after attendance. This indicates a positive behavioural change in delegates to the programme with the impact being an increase in planning and scheduling of work related to time and risk management.

The results indicated a positive uptake of the use of SGs in training programme as it can improve learning ability and knowledge retention, making the RMT programme more effective. On this basis, it is

recommended that SGs be implemented in RMT programmes to not only increase learning and application effectiveness, but also to use as possible effectiveness measurement tool on long- and short-term basis. The use of SGs have the possibility to improve the impact of training, and so creating a safer working environment in the mining sector.

Opsomming

Daar is baie ongelukke in die mynbousektor in Suid-Afrika, wat lei tot skade aan natuurlike hulpbronne, toerusting en lewensverlies as gevolg van voorvalle. Die beheer van voorvalle kan egter verbeter word deur die implementering van beter bestuurstrategieë gemik om die waarskynlikheid en gevolg daarvan, dus die risikobestuur van spesifieke take op myne. Tans word risikobestuur-opleidingsprogramme (RMT) aangebied aan bestuur op Toesighoudende vlak, met die doel om die beplanning en skedulering van risikoverwante mynaktiwiteite te verbeter om mynbou-voorvalle te verminder.

Onbeplande take en aktiwiteite op toesighoudende vlak verhoog die bedryfsrisiko's, wat die vraag laat ontstaan oor die doeltreffendheid en impak van die opleiding op Toesighoudende vlak in die mynmaatskappy wat ondersoek word. Hierdie studie ondersoek die ontwerp en gebruik van ernstige speletjies (SGs) in risikobestuur-opleidingsprogramme om nie net die impak van die opleiding te verhoog nie, maar ook om die effektiwiteit daarvan te meet.

Op grond van 'n literatuuroorsig, is 'n SG ontwerp en ontwikkel om gespeel te word tydens 'n werklike opleidingsprogram vir Toesighoudende bestuursvlak personeel in ‘n mynorganisasie. Die SG is ontwerp met eienskappe wat verband hou met beter leer ervarings en die gebruik van kognitiewe kennis met die doel om die implementering van geleerde beginsels te verbeter. Die speletjie is ontwikkel op Excel VBA met 'n raamwerk vir die puntestelsel wat deur afgevaardigdes na die program op 'n skootrekenaar of tablet gespeel kan word. Die vier-vlak Kirkpatrick-model van opleidingsevaluering word gevolg (Reaksie, Leer, Gedrag, Resultate) met die doel om teorie-toetsuitslae, SG-resultate en werklike werkverbetering te vergelyk om 'n gedragsverandering by afgevaardigdes na die bywoning van die program op te meet, dus die effektiwiteit en impak daarvan.

Die SG is suksesvol ontwerp, ontwikkel en geïmplementeer tydens 'n RMT-program vir die samewerkende mynbou-organisasie. ‘n Reeks hipotese-toetse is gedoen om statistiese betekenisvolheid in die resultate te vind. Van die afgevaardigdes wat getoets is, het almal daarin geslaag om hul SG-tellings te verbeter met 'n statisties beduidende toename na vyf rondes wat gespeel is, wat bewys het dat die SG-spelkenmerke beter leer vermoë stimuleer, soos gevind in die literatuur. ‘n Statisties beduidende korrelasie is gevind tussen afgevaardigdes se onderskeie SG tellingverhoging en resultate van 'n teoretiese toets oor die kursusinhoud, wat dui op 'n korrelasie tussen kennisverwerwing en implementering van die geleerde beginsels. Laastens is 'n statisties beduidende toename in werksbeginsels gevind in die vorm van toename in werkverwante uitkomste van die bywoning van die program, voor en na die bywoning. Dit dui op 'n positiewe gedragsverandering by afgevaardigdes na die

program, met die impak op 'n toename in beplanning en skedulering van werk wat verband hou met die tyd-en risikobestuur.

Die resultate dui daarop dat die gebruik van SGs in 'n opleidingsprogram positief is, aangesien dit leervermoë en kennisbehoud kan verbeter, wat die RMT-program meer effektief kan maak. Op grond hiervan word aanbeveel dat SGs in RMT-programme geïmplementeer word om nie net die leer- en toepassingseffektiwiteit te verhoog nie, maar ook om ‘n effektiwiteits maattinstrument te wees op lang- en korttermynbasis. Die gebruik van SG's het die moontlikheid om die impak van opleiding te verbeter, en sodoende 'n veiliger werksomgewing in die mynbousektor te skep.

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I would like to dedicate this project to my parents, Kobus and Magdaleen Uys, who continue to inspire me every day. Thank you for sharing your wisdom and providing me with the tools to carve the way forward, no matter the obstacles. Without you I would not be the person I am today.

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Terence Parker, thank you for the ongoing support and for going out of your way to help me wherever possible with the data collection process. Your passion for risk management and dedication to your work really inspired me and reignited my passion for working with people and processes, and continuous improvement.

Thank you to Anglo American for granting me the funding to complete this study, and also providing me with the necessary information and resources to gain first-hand experience in the field which forms an important part of this project.

Lastly and most importantly I want to thank the Lord for his grace throughout my studies and providing me with energy and persistence to complete my research.

'But those who trust in the Lord will find new strength. They will soar high on wings like eagles. They will run and not grow weary. They will walk and not faint' (Isaiah 40:31).

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Nomenclature

Acronyms & abbreviations	
ANOVA	Analysis of Variance
CEM	Critical Events Model
FLM	Front Line Manager
GDP	Gross Domestic Product
HRD	Human Resource Development
ICMM	International Council on Mining & Metals
JRA	Job Risk Assessment
KPI	Key Performance Indicators
LLC	Learning Life Cycle
LSD	Least Significant Difference
LTIFR	Lost Time Injury Frequency Rate
OP	Operational Performance
ORM	Operational Risk Management
PL	People & Leadership
PPE	Personal Protective Equipment
PUE	Priority Unwanted Event
RMT	Risk Management Training
SGs	Serious Games
SHE	Safety, Health and Environment
SHERM	Safety, Health and Environmental Risk Management
SHERMP	Safety, Health and Environmental Risk Management Programme
SOP	Safe Operating Procedure
SRM	Safety Risk Management
SRMP	Safety Risk Management Programme
TRCFR	Total Recordable Case Frequency Rate
TRIFR	Total Recordable Injury Frequency Rate
TRM	Task Risk Management
WED	Work Execution Document

1 INTRODUCTION

Chapter 1 key objectives:

- Provide the background and rationale of this study
- Give an overview of a typical Risk Management Training (RMT) programme
- Define important concepts and terminology
- Define the research problem and objectives
- Provide an outline of the research strategy

1.1 Background

The mining sector in South Africa forms an important part of the South African economy, contributing 7.10% to the annual Gross Domestic Product (GDP) of the country (Trading Economics, 2018). Over the years, South Africa has unfortunately seen many accidents within the mining sector, leading to damage of natural resources, equipment and loss of lives.

In 2008, a large mining company in South Africa implemented their A3 safety risk management programme (SRMP), which was based on the G3 course developed by the University of Queensland. This course expanded into a series of 'A-courses' during 2009 and 2010. The courses consisted of A4 for executives, A3 for managers, A2 for supervisors and A1 for shop floor levels (forming a foundation of good safety practices). It was seen that the same principles and techniques used in the ‘A-courses’ could be applied to manage health and environmental hazards, and therefore in 2010 the courses were expanded to include Safety, Health and Environmental Risk Management (SHERM).

After the mining company’s internal Global Risk and Change Management review in 2011, it was found that the responsibilities with respect to risk management were not specified, and methodologies were not always clearly established in terms of identifying the risk and managing critical controls. These concerns led to the implementation of group technical standards for integrated and operational risk management, and in 2013 the ‘A-courses’ were further expanded to incorporate Operational Risk Management (ORM) specifically focused on the scheduling and planning of work.

Mining companies deal with high risk activities every day on their mining sites, thus the correct implementation of ORM in terms of scheduling and planning is of high importance. The implementation of RMT programmes for supervisors and frontline managers (FLMs) has already shown improvements in risk and safety controls with a decrease in fatalities of 80% according to Anglo American’s sustainability report (Anglo American Sustainability Report, 2017). The extent of learning done through application of the RMT courses’ principles, however, is still uncertain and needs to be measured.

1.2 Overview of a typical risk management course

After Anglo American reviewed their approach to risk management, they found that their group of companies were lacking in formal processes for risk management. The series of A-courses as mentioned in Section 1.1 was designed, implemented and constantly improved in the group for the different management classes, with the aim to teach employees in different areas to identify risks and possible unwanted events and how to manage them. The A2 course, which is the focus of this study, focuses on the training of the front line managers (FLMs) and supervisors on site level.

1.2.1 Course objectives

The A2 course objectives are designed to assist the FLM/supervisor in implementing productive and safe task risk management systems in their everyday operations. The overall objective of the course is supported by the overarching aims to enable the FLM/supervisor to:

1. Understand the concepts of ORM;
2. Understand how their role is implemented in the company's approach to ORM;
3. Understand the techniques and tools used to manage operational risks in their area of operation, as well as assess the risks correctly.

The FLM/supervisor is usually in charge of a team to perform daily jobs/tasks. It is thus of high importance that they must be able to use the tools learnt in the course in everyday practice. Along with learning and applying these concepts, comes the tool to communicate this information to their team. After attending the course, the FLM/supervisor must be able to:

1. Explain the terms and concepts of ORM to their team;
2. Plan tasks and jobs using a Job Risk Assessment (JRA) form in the team;
3. Describe the actions and requirements to implement ORM at appropriate levels in their team.

1.2.2 Course modules

The course is divided into eight modules presented by certified professionals. The eight compulsory modules for the A2 course are as follows:

- Module 1: ORM context
- Module 2: Concepts and terminology
- Module 3: Human behaviour
- Module 4: Risk management during task planning
- Module 5: Treat the risks

- Module 6: Risk management at task execution
- Module 7: Monitor and review
- Module 8: Wrap-up, assessments and next steps

1.2.3 Delivery mechanism and duration

The A2 course is delivered by trained professionals who are acquainted in the process and modules of the course. The course is presented over two days at one of the company's training centres to groups of 10-20 FLMs and supervisors. The course is outlined to cover modules 1–4 on the first day and modules 5–8 on the second day. The mechanism for delivery is focused on being very interactive, making for a better learning environment through constructive comments, opinions and feedback. The training is supplemented by interactive team activities to test the understanding of concepts and processes. At the end of the course, an assessment in the form of a multiple-choice questionnaire is done by participants to test the level of understanding of the work. A mark of 70% must be attained in order to pass the course, otherwise a second attempt is allowed.

1.3 Introducing important concepts and terminology

Hazards in the mining sector are seen as sources of harm, and therefore the driving force behind the seriousness of incidents occurring. The likelihood of an event occurring is a function of control effectiveness. The likelihood and consequence of an event occurring is thus used to get a level of risk associated with an unwanted event. The uncontrolled release of energy is termed an incident, and if this incident causes harm it is considered to be an unwanted event. These incidents can, however, be better controlled by implementing better management strategies regarding the level of likelihood and consequence, and thus the risk of a specific job on mining sites.

As this project focuses on an ORM training course presented by Anglo American, it includes a variety of concepts and terminology unique to the mining and metals industry, especially from a risk management focus point. For anyone reading this document, it is thus very important to understand these concepts to gain a better context to the problem statement and further project proceedings. The important concepts and terminology are explained in the numbered headings below.

1. <u>Hazard</u>

A hazard is defined as the source of a risk, thus the source of potential harm. In order to find the hazard, a possible approach is to look for uncontrolled energies.

2. Unwanted Event

An unwanted event is the possibility of the hazard being exposed or released in an uncontrollable manner.

3. Incident

An incident is the case where the unwanted event does occur, and the hazard is released or exposed in an uncontrollable manner. An incident is therefore the uncontrolled release of energy.

4. Accident

An accident is defined as the case where an incident is realised and there is a resulting harm caused by the realisation of the unwanted event. Hazardous situations often occur where hazards are not completely controlled. These situations however do not always lead to an accident.

5. Risk and Risk Assessment

A risk is a function of the likelihood of an event occurring and the consequences should the event occur. It is the chance that something happens which will negatively affect and impact the objectives of an individual's task or work (Lameras, Dunwell, Stewart, Clarke, & Petridis, 2017). A risk assessment is then a process which involves evaluating risks which arise from the presence of a hazard. This process also considers the reliability of existing controls implemented to manage the hazards and based on this deciding whether the risks are acceptable or not.

6. Job Risk Assessment (JRA)

The JRA is a document completed on site by a team that is about to start with a specific task/job. It is a task-oriented assessment tool used in the Operational Risk Management process and is used as an integral part of task planning before scheduling, resourcing and execution of high-risk tasks. As a group, a team assesses the task at hand and discusses the possible hazards and risks associated with the task and the controls available before continuing with the job.

7. SLAM

SLAM (Stop, Look, Assess, and Manage) is a process associated with continuous risk assessment, especially considered when changes occur with a job or task. This process motivates the team to stop and think about the task at hand, look to identify the hazards involved in the task at hand, assess the effect these hazards may have, and manage the hazards so that they can be controlled.

1.4 Current state of unwanted events in the mining sector

Over the past decade, mining companies have started to invest significantly in the field of ORM, the main focus being to train managers and supervisors to plan jobs and daily tasks correctly, and by this create awareness for a team doing the tasks of the associated hazards and risks associated with those specific tasks, with the aim of decreasing injuries and fatalities on mining operations. This strategy has been adopted by many large mining companies.

One of the companies that has adopted this strategy is Anglo American, who started looking into formal risk management processes at an operational level, following their introduction of the SRMP in 2008. With this programme expanding into the Safety, Health and Environmental Risk Management Programme (SHERMP) and focusing on ORM the vision was for employees to recognise risk management as a vital part of daily decision-making.

The statistics shown from the past decade prove the implemented programmes to be working, as seen below in Figure 1-1. Lost time injury frequency rate (LTIFR) indicates the number of lost time injuries that occurred on a mining site for every 1 million hours worked. The lost time injury in this case refers to the loss of productive work time due to the injury of the employee. Total recordable case frequency rate (TRCFR) in Figure 1-1 refers to the sum of all the cases (fatalities, injuries, lost time) represented as a rate for the amount of hours worked.

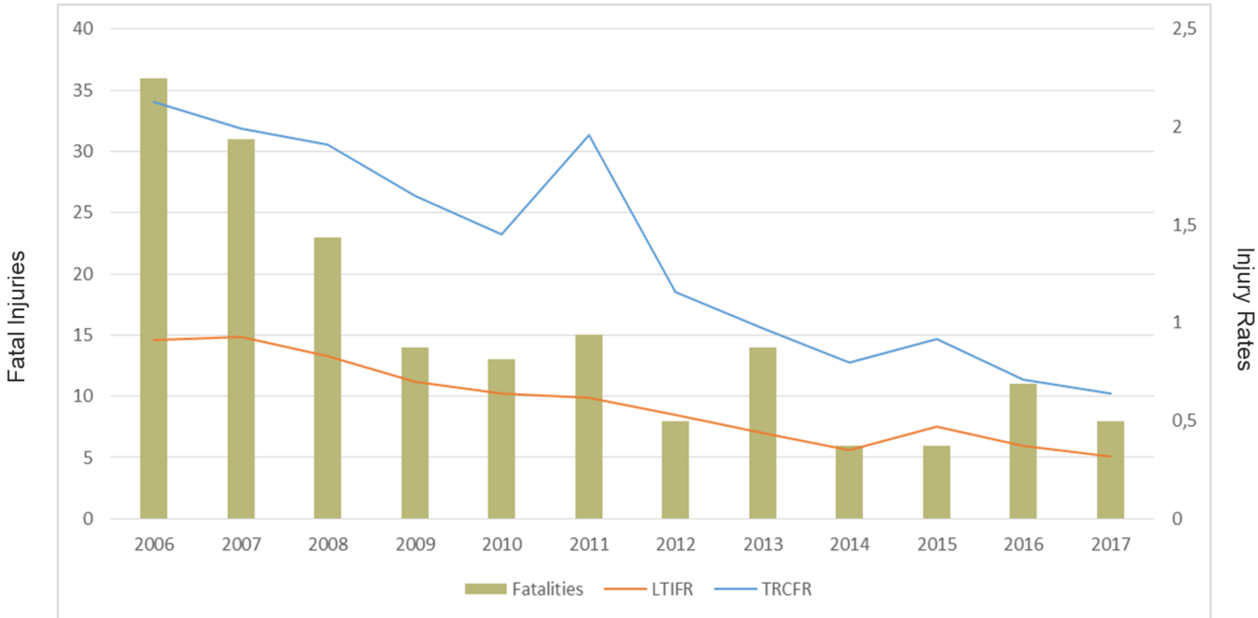

Figure 1-1: Anglo American fatalities and injuries statistics 2006-2017 (Anglo American, 2017)

It can be seen from Figure 1-1 that as a result of the organisation implementing systems that support the focus and awareness of safety on mines and emphasising their importance of management's importance in this implementation, the fatalities have decreased by 80%. With a work-related fatal injuries target of zero (as part of their zero harm campaign) and a total recordable case frequency rate year-on-year deduction target of 15% according the yearly Sustainability Report, it can be seen that the KPI targets have not yet been met as fatalities still occur every year. (Anglo American Sustainability Report, 2017)

It can also be seen that between 2008 and 2014 the lost time injury frequency rates (LTIFR) and fatalities have reduced significantly. Since 2014, these trends have however started to increase again. For this reason, Anglo American is investigating different methods of ORM.

The long-term plan of Anglo American with the new ORM A-courses is to link risk management to operational performance by the use of daily task risk management systems and correct daily planning and scheduling of tasks. Scheduled work in terms of ORM refers to the planning of tasks by completing a Safe Operating Procedure (SOP) document, a Job Risk Assessment (JRA) and a Work Execution Document (WED). The scheduled work thus refers the completion of these documents by a team who performs the tasks, informing each member of the task/job objective and the risks associated with the task, as well as the controls available. The correct scheduling of work by supervisors/FLMs is anticipated to deliver sustained performance in the decrease in injury frequency rates, as improvement in the past year can already be seen in Figure 1-2. From the data an increase in improved scheduling and work planning resulted in a 79% decrease in TRCFR (Anglo American Sustainability Report, 2017).

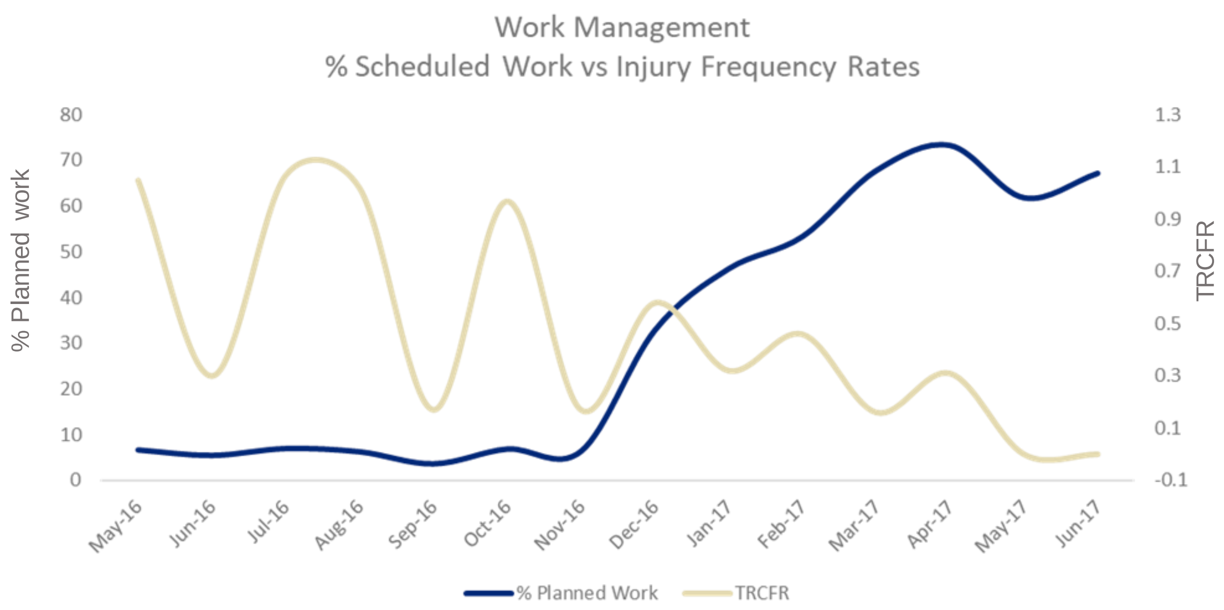

Figure 1-2: % Scheduled work vs injury frequency rate (Anglo American, 2017)

1.5 Problem statement

Most work done in the mining environment and on mining sites is unplanned on a daily basis, meaning that documents (SOP, JRA, WED) related to safety procedures of a job/task are not discussed and generated by teams before commencing with the tasks. The absence of these documents points to tasks that are unplanned before teams continue with the task, meaning that all members aren't fully aware of the possible hazards, risks and controls available for the tasks, increasing the chance of incidents occurring that might lead to serious injuries or even fatalities. This results in a culture of uncertainty towards daily operations and tasks a team has to complete.

An effective outcome of the A2 RMT programme would be for the supervisors that attended the programme to fulfil the main objective of the programme, which is to plan and schedule work effectively through the completion of procedural documents with their team before commencing with a task. The most important document to be generated being a JRA. These unplanned tasks/activities on supervisory level increase operational risks, which raises the question on the effectiveness and impact of the A2 training for supervisors in Anglo American. Generating actual in-training improvement data of participants' understanding of the course content will help course administrators identify modules that need more attention and explanation. The generation of this data for participants on a course might even lead to greater participation and eventually better learning and development in the field of ORM and apply the principles in practice better and more effectively.

1.6 Research objectives and questions

Following the background of this research project, the main objective is to propose and develop a measurement tool to measure the effectiveness and impact of the A2 training for supervisors within the Anglo American Group. The results obtained from the tool must be verified against actual key performance indicators (KPIs) of a sample group of supervisors. This overarching aim will be reached achieving the following sub-objectives:

1. Measure the effectiveness and impact of the A2 training for supervisors and FLMs within the Anglo American Group by developing an appropriate measurement tool/technique using serious games.

2. Correlate the measurement tool/technique with real-world performance indicators of a sample group of supervisors and FLMs within the group, especially in terms of routine and non-routine task planning.

The following questions will be used to develop a method to collect data and group-related concepts from literature, all with the aim of building a framework for reaching the research objectives:

1. What are the roles of front-line managers/supervisors on a mining site?
2. What are the methods used for risk management training programmes focused on better learning of concepts?
3. How can the implementation of better learning methods, like serious gaming in training programmes, be used to increase knowledge retention and ensure effective training?
4. What are different methods of measuring the effectiveness of training programmes in a corporate environment as well as in the mining sector?

1.7 Research strategy

To achieve the objectives of this study as described in Section 1.6, a research strategy was needed. A diagram showing the research strategy cycle adapted from Poddar (2014) can be seen in Figure 1-3. Firstly, a literature review process was decided on in the form of a systematic review, adapted from a typical study of this kind, in order to get a better perspective of the research already done on serious games and the effectiveness of learning, and their specific impact on RMT programmes in the mining sector. Thereafter, an appropriate design of a measurement tool was investigated through analysis of learning methods, serious games, coding platforms and effective delivery. Once the game was designed and coded, it was implemented at applicable RMT programmes in order to get results based on the effectiveness of learning through playing a serious game. Thereafter real-world KPI data was gathered, along with theoretical test scores, to measure if and how well the training influences the behaviour of delegates on the programme. The final step in the research strategy was to interpret the results by means of statistical analysis as well as to compare possible trends. Finally, to complete the cycle, the results would need to be compared to what was found in literature in order to come to a conclusion and share the outcomes of the study.

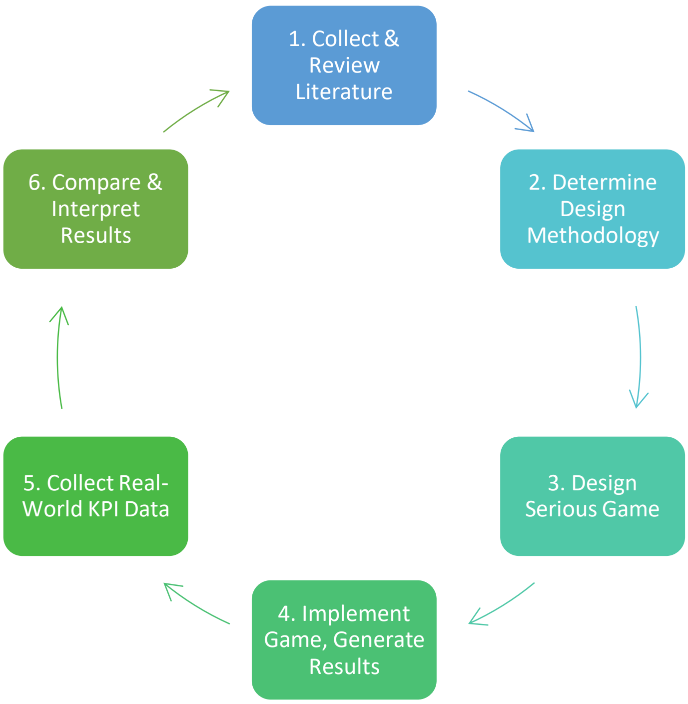

Figure 1-3: Research Strategy (adapted from Poddar, 2014)

1.8 Chapter Outline

The following outline describes and graphically indicates the planned chapter outline of the thesis.

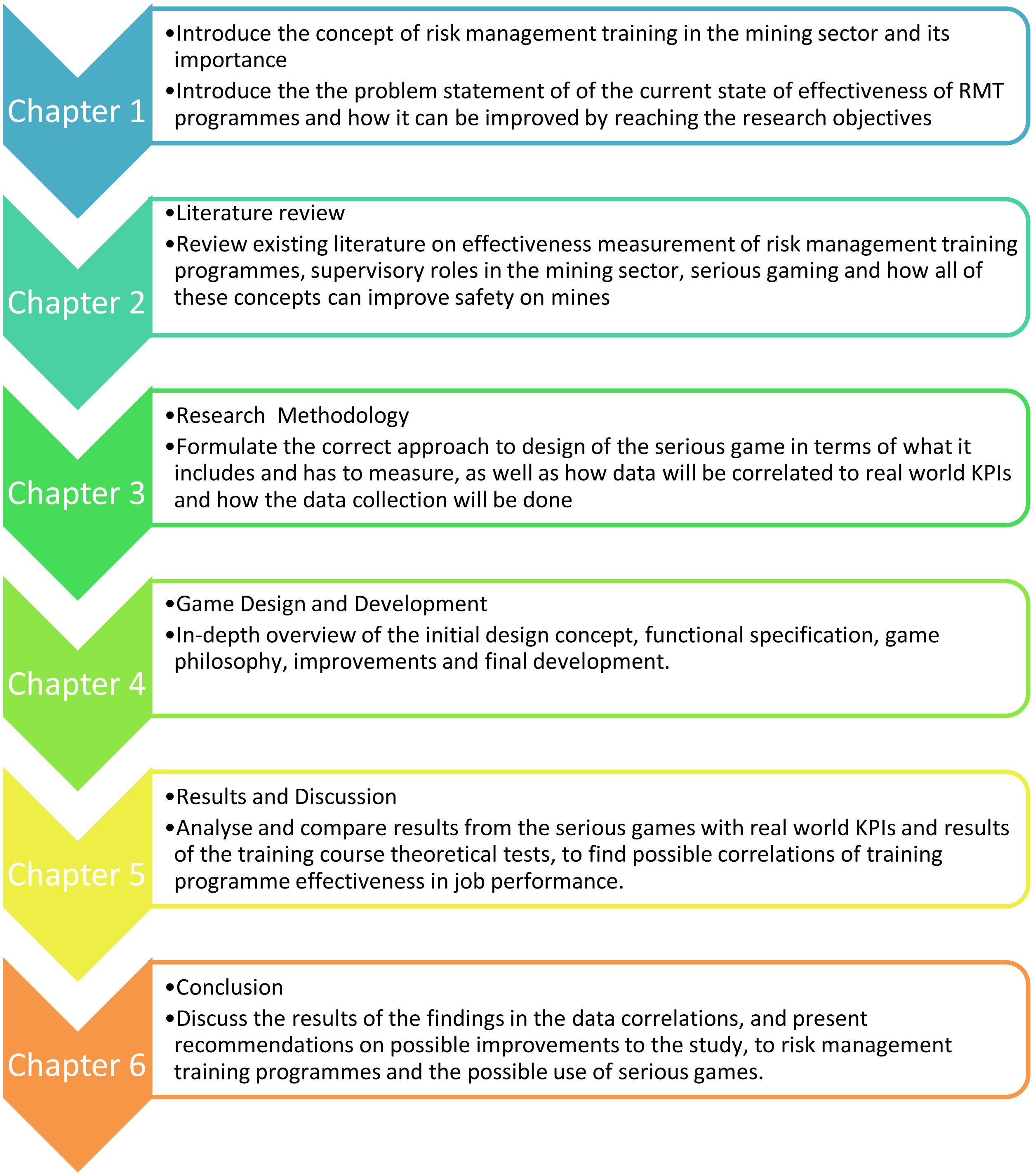

Figure 1-4: Thesis Chapter Outline

2 LITERATURE REVIEW

Chapter 2 key objectives:

- Provide a literature review methodology i.t.o. a systematic literature review procedure
- Investigation of training evaluation models and the measurement of effectiveness
- Investigation of RMT in the mining environment and its effectiveness
- Application of serious games in learning
- The leadership pipeline approach to management
- Investigation of game characteristics related to learning
- Investigation of game design platforms

A literature review was conducted to investigate previous research findings of corporate training programmes, more specifically risk management training programmes, and the techniques/models used to evaluate the effectiveness of such programmes. Furthermore, the use of serious games or gamification in training programmes was investigated, more specifically how they can increase effectiveness through application of learnt concepts in the workplace. The aim of conducting a literature review was to develop a better understanding of the research already done on these specific fields which would be essential in the development of an effective measurement tool to address the objectives of this study.

2.1 Review methodology

The literature review conducted included searches in two main parts. The first search strings included searches for *Risk Management* and *Risk Management Training* in the mining sector, but also risk management and risk management training in general. The effectiveness of these training programmes and specifically their measurement was investigated. The second string of searches included better *Learning Methods*, with specific reference to the use of *Serious Games* (SG) in general and in corporate training programmes which might increase learning ability, and better application of concepts learnt. The review was done by aiming to answer the research questions as mentioned in Section 1.6:

1. What are the roles of front-line managers/supervisors on a mining site?
2. What are the methods used for risk management training programmes focused on better learning of concepts?
3. How can serious gaming be used in training programmes to ensure effective learning?
4. What are different methods of measuring the effectiveness of training programmes in a corporate environment as well as in the mining sector?

2.1.1 Review procedure

The steps followed in performing a systematic search protocol are tabulated in Table 2-1. The procedure is adapted from Petticrew and Roberts (2009), and explains the steps followed to select the data sources to be used as well as how the specific sources used will be chosen.

Table 2-1: Systematic literature review procedure

Steps	Description
Step 1: Develop a search protocol	The research protocol will incorporate the whole literature review process in terms of the research objectives and the research questions. The objectives and research questions will help define search strings which will be used in different search engines. Relevant literature will be sorted according to inclusion and exclusion criteria which will be defined.
Step 2: Literature search	Data sources that are applicable to this research study will be identified and a literature search with appropriate search strings will be used to identify initial literature findings done on this topic. The literature obtained will be documented in specific files.
Step 3: Screen references	According to defined inclusion and exclusion criteria, the documents obtained from the initial search will be filtered to include only the relevant literature that will be useful to this study.
Step 4: Further screening of references	After an intensive study of the abstracts of the documents that remain, those which match the inclusion criteria are kept for further analysis.

2.1.2 Literature selection

Peer-reviewed literature, including conference papers, journal articles, master's and doctoral dissertations, and to a limited extent books, will be included in the search. As the main source of literature will consist of journal articles, and reviewed information from councils and societies related to the mining and metals industry as well as industrial engineering. The journals which will be used as databases were carefully selected according to applicability of the research.

Journals:

- International Journal of Training and Development (IJTD);
- Journal of Mining and Safety Engineering (JMSE);

Councils and societies:

- South African Institute for Industrial Engineering (SAIEE);
- The Southern African Institute for Mining and Metallurgy (SAIMM);
- International Council on Mining & Metals (ICMM);
- Society for Research in Higher Education (SRHE).

The research topic being investigated is made up of a combination of parts that combine to form the overall objective of measuring the effectiveness and impact of risk management training in a specifically mining organisation. The two concepts, risk management training and the use of SG to respectively enhance the training, have not been researched much in the past. For this reason, the literature or previous research done on this specific topic is very limited and the use of more easily accessible data forms a vital part of the research study. Examples of this data accessed and utilised are:

- Annual sustainability reports of different mining organisations;
- Mining-specific risk management training workbooks of leading mining organisations;
- Gaming internet sites that show data analysis of available SGs, applicable to the topic being investigated in terms of training programmes;
- Experiences and beliefs of industry experts working specifically in the mining sector.

Furthermore, valuable insight was gained from a book called *The Leadership Pipeline* (Charan et al. 2011), which addresses passages of leadership within an organisation. It articulates processes to be followed at different management levels within a company to improve management development, as well as defines the roles of different managerial levels within a company and how they interact with each other. These principles will be discussed further in the literature review. According to the book, leadership forms a critical part of management development within a company, especially on supervisory level within an organisation.

2.1.3 Search strings

From the data sources, a transparent and structured literature screening procedure was followed as proposed by Popay (2006). The procedure is structured in a way that it is transparent, rejects possible author bias, and reduces possible duplication.

As defined by Popay (2006), the 'building blocks' search string technique was used, which involves breaking the research topic down into three subject strings and searching for these strings in various science publications as mentioned in Section 2.1.2. In the different databases, the search strings were applied as shown in Table 2-2. As the research is a continuous process with finding new and relevant publications along the way, the literature search is an iterative process and keywords are often updated.

Table 2-2: Search terms used in different search string categories

	Category	**Search terms**		**Search position**
Search string 1	Risk management	"risk management"	"mining risk management"	Title, Abstract, Keywords
	Operational Risk Management	"operational risk management"	"mining sector"	Title, Abstract, Keywords
Search string 2	Training programmes	"corporate training programmes"	"risk management training programmes"	Title, Abstract, Keywords
	Training programme effectiveness	"training program effectiveness"	"training program effectiveness measurement"	Title, Abstract, Keywords
	Training programme evaluation	"evaluation of training programs"	"training evaluation models"	Title, Abstract, Keywords
		"risk management evaluation"	"training program evaluation methods"	
Search string 3	Mining safety training	"safety training in mines"	"mining safety training programs"	Title, Abstract, Keywords
	Serious gaming	"serious games in training programs"	"serious games in learning"	Title, Abstract, Keywords
	Gamification	"gamification platforms"	"gamification for learning"	Title, Abstract, Keywords

2.1.4 Review results

After using the search string methods a range of sources was discovered mostly consisting of journal articles, book chapters, conference papers, master's and doctoral dissertations and relevant gaming and mining industry-specific web pages, resulting in a corpus of 172 items as seen in Table 2-3. The search strings used in Table 2-2 resulted in 124 items. Using the filter criteria in Table 2-3, these articles were then refined. The remaining articles were filtered further using title search, based on how applicable it will be to the research project, which focuses specifically on the evaluation of the effectiveness of training programmes (more specifically risk management programmes in the mining sector) as well as how the use of serious games (gamification) can improve the effectiveness of knowledge uptake and behaviour of participants in the workplace. After this refinement, an abstract analysis was done on the remaining 87 sources. Ultimately, 65 sources were found to aid the research topic well in terms of risk management training, serious games design and training evaluation.

Table 2-3: Filter criteria with number of articles matched

Criteria	Included	Number of Articles
Search string matches	Yes	172
Period	2000-2019	124
Type	Articles	
Language	English	
Title Search	Relevant to study	87
Abstract Analysis	Useful to study	65

To summarise, the items were decided to be included in the review corpus if they:

- Contain the term risk management training in context of corporate programmes or in relevant mining organisations similar to the organisation that the study is done on.
- Contain information on the role of supervisors from a management perspective as well as from a risk management perspective unique to the mining sector.
- Discuss the levels of evaluation or measurement of training programme effectiveness and the tools available to measure the effectiveness.
- Discuss the use of games in a learning environment and how specific game characteristics can be linked to better learning.
- Discuss methods investigated to design a game that uses the investigated game characteristics that are unique to stimulating a learning environment.

2.2 Risk management training

When considering risk management in this study, operational risk management (ORM) is being referred to. Operational risks are the risks within a company that may lead to serious losses due to operational difficulties or issues. These operational risks may occur due to the company's policies, systems and/or everyday practices which are inadequate to prevent unwanted events from occurring, due to wrong internal control measures or operations (Chong, 2001). The objective of ORM training programmes is to initiate an understanding and way of thinking in participants' minds to consider all possible outcomes of their decisions in relation to company procedures, systems and policies. The training programme must effectively teach a participant how to best manage daily operations in order to minimise the risk of occurrences that may lead to unwanted events.

2.2.1 Training evaluation models

Corporate training evaluation models are the foundation of every training programme, as it is designed to engage with participants and set the algorithm of learning and development. These evaluation models are also used as measurement frameworks for the effectiveness of the training programme. Over the years many models have been developed for the assessment of training programmes or courses within businesses. The most widely used model for assessment of training in businesses is the Kirkpatrick model (Kirkpatrick D. , 1996), which consists of four levels as seen in Figure 2-1.

Figure 2-1: Four-level Kirkpatrick model for the assessment of training

<u>Level 1: Reaction</u>

As seen in Figure 2-1 the first level measures the reaction of the participants to the receiving of the training, in terms of their thoughts about it before the training, during the training, as well as after the training. Data for this level is usually gathered in the form of 'happy sheets' after the course where participants rate the training received regarding the location of the training programme presented, the course content, the trainer who presented the course as well as whether they think the course is necessary. The benefits of measuring this first level are that the organisation gets an idea how well the participants accepted the learning environment, and whether they feel that they have actually learnt something by the end of the course. This data the enables the organisation to identify gaps in the course training methods, which may include the training venue, the content of the course and how well the information was delivered (trainer). The results of the measurements of this level, however, do not ensure that participants learnt something as it is attendance-based but may determine how invested participants are in the course.

Level 2: Learning

It is important to measure the mindset of the participants in terms of acceptance of learning and material. Level 1 does not sufficiently measure the acceptance of learning material applicability. Level 2, however, aims to measure the amount of knowledge or capability gained by the participants during the training. This is usually measured by comparing the difference in average results between the pre- and post-course assessment. This level is thus very important, because it can give a detailed analysis of individual knowledge gained during the course, and how invested the participants were in obtaining knowledge on an individual level.

Level 3: Behaviour

The third level aims to measure or evaluate whether the behaviour of the participants has changed after and as result of the training received, and whether the knowledge gained through the training is actually applied and communicated in the workplace. This level of measurement is the most important as it evaluates the effectiveness of the specific training programme. Along with it being the most important, this is also the most difficult level to measure since it incorporates the most difficult measurement trait which is human behaviour. People differ in opinions, actions, acceptance of a new system, procedure or programme. Therefore, it is not possible to predict when participants will fully accept and utilise what they have learnt in the training and apply it in the workplace. Previously, organisations used self-assessments, feedback, surveys and observations from management to measure the change in behaviour of the participant after the training, but recently organisations are looking to add to the measurement of this levels and track a behavioural change of participants

Level 4: Results

The final stage aims to measure the return on investment (ROI) of the training, thus measuring the business side of the results obtained as a result of change in behaviour of participants. The biggest challenge in this level is causality and to identify which outcomes, results or benefits are most closely linked to the training. Measuring whether or not the training programme can be linked to business performance in the form of the return on investment is thus very difficult.

Kirkpatrick levels linked to research objective:

The current A2 course is focused on operational risk management with the participants being FLMs or supervisors, thus people working directly with a team performing technical work on a day-to-day basis, facing hazards and risks every day in the mining industry. The training thus focuses on understanding the hazards that exist and the risks involved in completing work in this hazardous environment and making sure the team understands the required controls by completing the necessary Job Risk Assessment (JRA) for every specific task.

The A2 course already measures Level 1 (Reaction) through a 'happy sheet' and Level 2 (Learning) through a post-course test. Level 2 knowledge uptake is unfortunately not measured as no pre-test is done. This research is therefore aimed at measuring Level 3 (Behaviour). It is proposed to develop a measurement tool in the form of an ORM game/simulation aimed specifically at this supervisory level. As part of the revised A3 and A4 courses, Anglo American has developed an Integrated Risk Management Simulation board game. It is proposed to expand the game to an A2-appropriate level and turn the game into an on-line game to be played on smartphones or tablets in an interactive environment. The data gathered from the game will then be used to measure the effectiveness and impact of the training on the supervisory level within the group by acting as a reflection of the behaviour change of the individual. It is thus anticipated that the game will provide insights into the application of Level 2 (Learning) and the Level 4 (Results), and by the results of the SG find a correlation between these two levels in order to estimate a degree of behavioural change (Level 3) in delegates to the programme.

2.3 Roles of the supervisor

Anglo American is one of the largest mining organisations in the world (Jacobs, 2018), working in mining operations that expose employees on mining sites to a variety of risks that could lead to injuries or fatalities on a daily basis. For this reason Operational Risk Management (ORM) processes are in place to prevent these incidents from occurring through correct planning, scheduling and implementation of safety procedures (ICMM, 2018). In order to design a measurement tool of the effectiveness of RMT, it is of high importance to understand the roles of the supervisors and their specific tasks, as discussed in the project objectives in Section 1.6.

The oversight and correct implementation of these safety procedures are thus of great importance to ensure that all the teams on a mining site understand their tasks and the risks associated with them, as well as the controls in place to prevent them. According to Anglo American ORM (2017) this implementation and oversight is dependent on the supervisor and the supervisor can make or break the ORM process (Anglo American ORM, 2017).

According to the International Council of Mining & Metals (ICMM) safety procedures on mining sites must adhere to the high standard set by them in order to be a member of ICMM (ICMM, 2018). Different companies might have different operational procedures, but when it comes to safety and the implementation of these procedures, the basic principles remain the same and are highly dependent on the role of the supervisor.

According to Anglo American the role of the supervisor in ORM can be seen as a continuous process (cycle) of management, as seen in Figure 2-2. The planning is done by the supervisor in terms of risk assessments with their team on the task they are about to do (Plan). Oversight is then given for that specific task (Direct) to ensure that safe operating procedures are followed. The job is then monitored (Check) and reviewed (Act) by the supervisor. These actions or roles of the supervisor on site thus play a critical role in the process of ORM and the maintenace thereof.

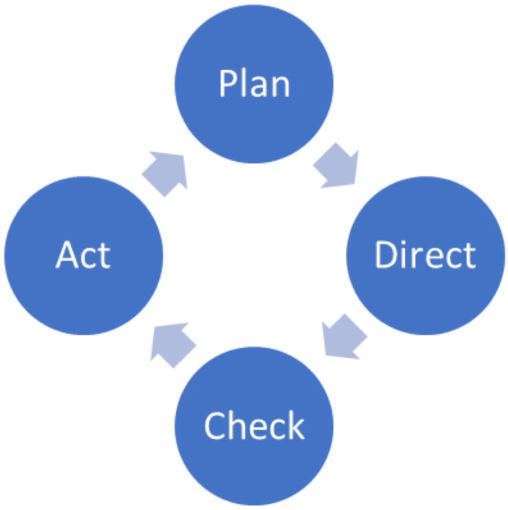

Figure 2-2: Supervisory role in Operational Risk Management on mining sites (Anglo American ORM, 2017)

ICMM (2018) states that after training the roles (duties) a supervisor will have to take are:

- To interact with their team directly through physical presence and communication;
- To understand their team in terms of their personalities and differences;
- To be familiar with the work on site and the hazards associated with different tasks;
- To enforce discipline in the work environment to ensure every team member does his/her job correctly;
- To be able to conduct on-the-spot risk assessments of a job/task to be completed.

2.4 Training effectiveness measurement

The objective of any training programme in a company is to improve in specific areas in the workplace, for example ROI of the business or performance improvements in terms of decrease in risk associated with incidents or fatalities. Various methods of evaluating the effectiveness and impact of the training programmes are used in industry (Downes, 4 Learning Evaluation Models You Can Use, 2016).

This section will discuss different possible evaluation methods to measure the effectiveness of the training. These assessment methods run in parallel with the four-level Kirkpatrick model as described in Section 2.2.1, with the different possible methods at each level as follows (Pham, 2017):

Level 1: Reaction

The evaluation of this level is done mainly by assessing how the participants react to the venue, course outline (modules) or even the presenter of the training course. Possible methods of evaluation could be: (Smith, 2017)

- Questionnaires on the applicability of the content.
- 'Happy' sheets, indicating the satisfactory level of the programme venue, presenter, location etc.
- Focus groups where sessions are held with all participants together.
- One-on-one interviews with participants.

Level 2: Learning

In terms of getting an idea of the level of understanding of the work and knowledge gained, this level is important, and data gathered will give an idea of knowledge gained by participants: The following evaluation methods can be used (Guerra-Lopez, 2008)**:**

- Pre-and-post training tests to measure knowledge gained.
- Evaluation of in-session learning projects.
- Influence of knowledge gained by participants on KPIs.

Level 3: Behaviour

This is probably one of the hardest levels to measure, as everybody differs, and it has to do with the psychology of the participant, and their willingness to learn and apply what they have learned into their working day routine in order to improve. Methods to measure this level include:

- Informal and formal feedback and reports from peers.
- Manager surveys, comments and possible complaints.
- Self-assessment questionnaires.
- On-the-job observation.

Level 4: Results

As businesses or projects strive towards success, being results orientated is of high importance. This level aims to measure the results of the knowledge gained by the training in the workplace. The causality of the problems or incidents that occur on mining sites can possibly be linked to performance of

FLMs/supervisors in terms of how they plan tasks and perform JRAs on site. The improvement on this performance will be linked to the training. This level can be measured by:

- Improved quality of work and productivity. For example, getting more work done on a daily basis due to better planning or scheduling.
- Improved business results.
- Higher morale.
- Specific to this research, a decrease of incidents and fatalities on mining sites, as well as the successful and sufficient completion of JRAs.

2.5 Use of 'games' in the training environment

Serious games (SGs) are defined as games used in corporate training programmes with the objective not of being fun or entertaining, but for the purpose of learning through using the principle of human reaction and participation in games (Laamarti, Aid, & El Saddik, 2014). The term was first coined by Abt (1987) with the idea to bring together the seriousness factor into important decisions, with the emotional and experimental freedom of play. In recent years, the uptake of the game-based learning method has been used in the fields of education, healthcare, engineering and emergency management. This section discusses the applicability of the use of SGs in these environments, as well as its applicability to this research.

2.5.1 Importance of games in training

The main idea behind the concept of incorporating SGs in corporate training programmes is well illustrated by Draeger (2014), where he gives main three reasons for incorporating these games.

1. **<u>Engagement of games:</u>**

   Interest level of participants in a training programme is of high importance in order for them to learn from it. Games have the ability to capture participants' attention through competition, surprise and reward. By playing a game, players (participants) are faced with a natural motivation, and best described by Draeger (2014) who speaks of a state of 'flow' participants reach which is equivalent to being highly focused. This principle of a 'flow' state is suggested by psychologist, Mihály Csíkszentmihályi, as a state between arousal, control, anxiety and relaxation, as shown in Figure 2-3. It can be seen that as a game increases gradually in the skill level required of the participant, as well as in difficulty level of the game, boredom is escaped, and the participant is engaged into a learning state. The idea explained by Draeger (2014) as seen in Figure 2-3 is that when a game is played and the difficulty level is increased (challenge level) the game requires a specific skill of a player. The engagement level of the player naturally increases into the state of 'flow' where the combination of focus and engagement increases a player's ability to learn and improve.

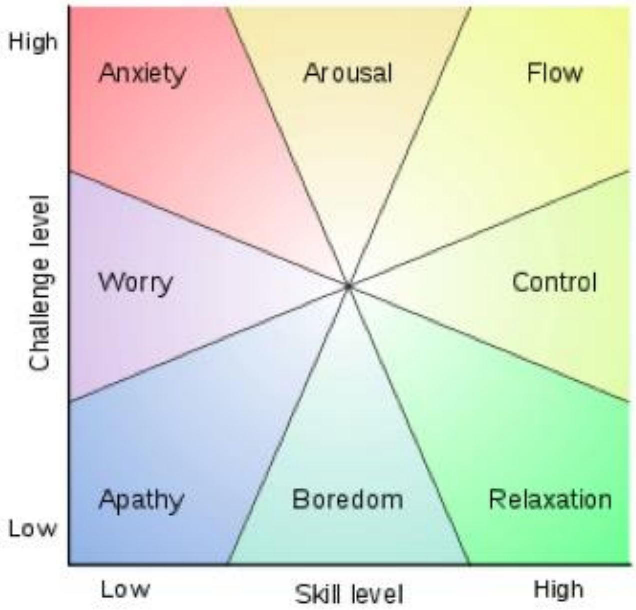

Figure 2-3: Mihály Csíkszentmihályi's graph (Draeger, 2014)

2. **Safe failure environment**

When working in companies that require employees to make high-risk decisions, the chances arise for critical mistakes to be made leading to failure. In real life, especially with regards to Anglo American and other mining industries, these failures may lead to serious injuries and even fatalities. When competing in a serious game based on a training programme, the game provides a safe environment in which to make a mistake but at the same time the participant recognises the impacts of that mistake, which helps them learn from it. In games, failure often lead to the opportunity to play the game or level again, to try succeeding. This reinforcement of repetition in a game is done in the forms of levels or stages. Repeating a whole level will take time and, in this way, decreases the possibility of the same mistake by repeatedly getting it correct in order to proceed with the game, and a definite way for the participant to learn from their mistake (Draeger, 2014). The implementation of levels along with the opportunity to play again and try to improve or succeed are thus of high importance in games in terms of stimulating learning.

3. **Stimulate cognitive and affective domains**

Important factors in human behaviour to consider when discussing the extent of learning is the cognitive domain. This includes human reactions like evaluation, comprehension and analysis, which are all important factors when learning, and thus highly applicable and necessary in SGs to ensure effective learning. Participants must make important decisions based on comprehension and analysis of the gaming interaction. The affective domain is reached in SGs by influencing participants' feelings, attitudes and values, which are domains which are triggered by human interaction and real-world situations. By triggering these domains through SGs, a better representation will be gained of how participants will respond in real-world risk-associated decisions.

2.5.2 Measuring the effectiveness of learning

As discussed in Section 2.5.1, from a psychological perspective there is a positive prediction towards the success or effectiveness of using SGs or SG principles as a learning method in corporate training. Bachvarova *et al.* (2012) investigated the metrics for the effectiveness of learning of SGs in corporate training, in order to understand and investigate which metrics of game features are most important for learning. The objective of this is for game builders or programme developers to benefit from metrics related to known game features.

After the study they identified the key metrics needed as features of such a game. These features or characteristics are essential to be included in a SG design in order to successfully stimulate learning within a training programme environment. The identified key metrics needed as features of such a game are:

- How well the employee knows what their job task is (job task efficiency).
- To measure changes in behaviour of a player.
- To measure task accomplishment of players.
- The number of tasks solved by players within the duration of the game.
- The losses and gains within the time frame of the game.
- The transfer of topic applicable knowledge to players by playing the game.
- The social interaction between players while playing the game in order to measure the knowledge flow.

2.5.3 Games as effectiveness measurement tool

The use of SGs is highlighted in the previous two sections, and through literature shows that it is theoretically a successful way of embedding knowledge through cognitive reactions humans experience while playing games (Vermeulen & Gain, 2017). These predictions of using SGs as learning tools, in correlation with the evaluation methods of the four levels of the Kirkpatrick model discussed in Section 2.2.1, can be used to generate data more easily. Important data like how well FLMs understand their job risk assessments (JRA) in terms of Anglo American's A2-course objectives will thus be generated and analysed more easily.

2.6 Serious game characteristics

This section forms an important part of this research project as it investigates the characteristics of games that make for better learning outcomes and knowledge outcomes, how to implement these characteristics in a practical environment like a training programme, and incorporate them into a game platform that will promote the reasons for using games in learning as discussed in Section 2.5.1. To do this, Lameras (2015) did a comprehensive mapping of different learning characteristics and how they correlate with gamification or serious games. His research, summarized in this section, investigates specific game characteristics that are unique to learning outcomes, and how these learning outcomes contribute to specific learning outcomes respectively.

This section also investigates findings from industry experts and specialists to form a critical approach to game design that offers optimal learning. This section thus connects a wide range of literature on serious gaming and its possible benefits with the game design and development in Chapter 4 of this study. As it stands, literature does not provide conclusive evidence of a perfect optimal structure for a serious game design as it may vary between delegates of the game (Beetham, 2008). The literature supporting the aspects of serious games and learning are, however, broken down in this section in terms of game mechanics (Lameras et al., 2014; Fabricatore, 2007; Charsky, 2010; Juul, 2005) and how learning characteristics are linked to game characteristics, forming an optimal learning environment (Arnab et al., 2014; Amory, 2007; Gunter et al., 2006).

2.6.1 Learning characteristics

Learning characteristics are widely researched, especially how these characteristics arise through playing a game. Connolly et al. (2012) suggest that while delegates use a game in a playful manner, they don't pay high attention to the actual learning outcomes, but more to the fun elements. With this they found that a form of incidental learning occurs where delegates still learn the set-out outcomes without really realising it. In an attempt to personalise in-game learning experiences to suit the target group, industry or specific concepts, researchers have created classifications of games' learning attributes in terms of learning activities; learning outcomes required in a learning experience. A review of the required learning characteristics follows:

1. **<u>Learning activities</u>**

A teacher or institution is the driving force for implementing learning activities which in effect support the learning outcomes of a training programme or subject. These learning activities are the same for game-based learning and the activities follow upon each other to create game-flow (Coursera, 2018). Learning activities in games of game design are in line with common practice learning activities as found in literature. An adapted framework from Lameras et al. (2015) can be seen in Table 2-4 , mapping general learning activities which are essential to learning and to be applied in serious game design, as found in the literature sources provided.

Table 2-4: Learning activities in games

Learning Activity	Source
Information: • Lecture • Lecture notes & slides • Diagrams and concepts • Listening	Gunter (2006); Beetham (2008)
Individual activities: • Exercises • Experiments • Reflections • Questions • Evidence and case study analysis • Role playing	(Bybee, Trowbridge, & Powell, 2008) (Crawford, 1999)
Collaborative activities: • Group projects/assignments • Brainstorming • Pair-problem solving • Group case study discussions • Group data analysis and reflection	(Bell, Urhahne, Schanze, & Ploetzner, 2010) (Gijlers, Saab, Joolingen, De Jong, & B.H.A.M, 2009)
Discussion and debating activities: • Open discussion/questions • Guided discussions/questions • Debates	(Beetham, 2008) (Laurillard, 2002) (Domínguez, et al., 2013)

2. Learning outcomes

As seen in Table 2-4, learning activities form a vital part of the learning cycle. Beetham (2008) suggests that the learning activities are the starting point to a learning design in serious games. Learning activities must, however, be mapped out to support specific learning outcomes, to ensure that learners utilise the specific activity to effectively learn a specific outcome in the work, through a good learning design (Lameras P. , 2015). Anderson et al., (2001) revised Bloom's Taxonomy of educational objectives which is a widely used framework that was developed by Benjamin Bloom in 1956 and categorises educational goals in terms of learning outcomes. Anderson et al., (2001) revised this framework and found that the learning outcomes consists of six main categories: Comprehension, Knowledge, Application, Analysis, Synthesis and Evaluation. The learning categories from Bloom's Taxonomy are linked to the specific learning outcomes that are focused on in game design as seen in Table 2-5.

Table 2-5: Bloom's categorisation of learning outcomes

Learning Category	Learning Outcome
Knowledge (Remembering)	Delegate can recall information
Comprehension (Understanding)	Delegate can use explained work through comprehension
Application	Delegate can use knowledge to solve problems and predict
Analysis	Delegate can use data to see patterns and concepts
Evaluation	Delegate can compare situations and scenarios and justify decisions through good evaluation of situations
Synthesis (Creation)	Delegate can use knowledge learned to design and plan and make the correct decisions

3. Assessments and feedback

In-training and in-game feedback form a key part of encouraging delegates/students and they promote learning through reflecting on concepts and possible mistakes, or even the correct understanding of the work (Swanson, et al., 2011). Feedback thus links up with the completion of learning activities as a sort of assessment on knowledge and comprehension of learnt concepts. Gee (2002) argues that the feedback from learning activities within a game forms an essential part of a learning activity and that assessments in games and the feedback should be formative and summative, encouraging learning and improvement of delegates. These findings are supported by Jones et al., (2014), where a group of leaders in the field of learning research defined Feedback Progress Indicators (FPIs) as responses indicating their effect on learning of delegates. They then developed a framework to review the feedback progress of delegates, called the SCAMP framework (Social, Cognitive, Affect, Motivational, Progress). Lameras et al., (2015) used this SCAMP model and contextualised in in the application of serious game designs as seen in Table 2-6.

Table 2-6: SCAMP model related to serious game design (adapted from Lameras et al., 2015)

FPI	In-game example	Game design
Social	'Liking' gaming progress through discussion	Visual feedback thread on screen
Cognitive	Choosing between different game situations/scenarios	Game levels; game hints; assessment tool
Affect	Visual indicators of making the correct game choices	Scoring system
Motivational	Winning coins for correct decisions of passing to a next level	Game levels; points gained; virtual currency
Progress	Game or scoring progress as visual feedback	Progress bars; dashboard scores; assessment feedback

From the SCAMP model related to game design, it is evident that the most important features to incorporate into a serious game for learning applications will be feedback through threads and progress bars, a scoring system, in-game hints, achievements and a dashboard with scores to initiate a competitive element between delegates.

2.6.2 Game characteristics

In Section 2.6.1 learning characteristics are discussed in terms of literature findings on specific learning categories, what motivation they create in learners/delegates, and how these characteristics and motivations relate to serious game design. In this section, game characteristics are investigated which are unique to games, as well as contributing to the promotion of learning through playing a serious game. Game characteristics are investigated from an educational perspective from various literature studies. The findings of these studies are listed in terms of the specific game characteristic associated with learning. This is done with the ultimate objective to apply these characteristics in the game design and development in Chapter 4 of this document.

1. **Game has rules**

A game's rules form the basis of a context of a game by providing players with goals, challenges and the option to perform actions to proceed in the game within the constriction of rules. Charsky (2010) suggests that rules in a game limit the actions of a delegate/player and create a platform for a level playing field. He suggests that the games are structures through 'emergence' and 'progression' in order to utilise rules and make games challenging for delegates. Juul (2005) suggests that the emergence part of using rules in games is that a game has to have a set of smaller rules which emerge into strategies a player of the game has to adapt to in order to proceed, for example using rules of a game to build strategy and actions. The progression part of using rules is suggested to be where a player uses the rules to perform actions in order to complete the game or proceed with the game. What is taken from these findings is that the rules of a game are essential for creating a level playing field, as well as to influence the actions of a player, giving the designer of the game the ability to influence player actions to an extent through applying game has rules.

2. **Goals and choices**

Evidence from literature suggests that a critical part of games should be that they are directed by an ultimate goal which a player works towards. Together with being goal-directed, it should be competitive and contain a set of rules, choices to be made by the players and feedback to the players for them to monitor their progress (Van der Spek et al., 2011). Goals of a game should be presented to the player through mechanisms such as scores, score improvement indicators, status/progress bars or threads of feedback. Juul (2005) found that these goals set out by the game to be achieved by players are driven by sets of choices a player needs to make. Choices players have to make are decisions within the game which will influence their progress towards the goal and must aim to be challenging for the player.

3. **Tasks, activities and challenges**

From previous research and literature, it is clear that the findings support the occurrence of learning improvements through task completion. (Gunter et al., 2006; Bedwell, 2012). This task completion goes hand-in-hand with the previous section (goals and choices), as the completion of a specific task may be one of the ultimate goals of a task which is driven by the choices a player must make. Juul (2005) suggests that a player is faced with task-relevant as well as task-redundant information which can be used to measure the difficulty level of the choices within a serious game. Van der Spek et al. (2011) found that the task-redundant information is an important part of learning as it arises in crisis management games and players are forced to make decisions based on what they feel are necessary and unnecessary (or relevant and irrelevant) decisions to complete the task. According to *Mihály Csíkszentmihályi's* framework of flow discussed in Section 2.5.1 of this study, these decisions a player must make involve an aspect of focus towards the task and challenge ahead in the game, which together with the enjoyment factor of playing a game, creates a state of 'flow'. This state of 'flow' is optimal for concentration and learning as can be seen in Figure 2-3 (Draeger, 2014).

Table 2-7 indicates the different learning categories discussed in this section and the in-game mechanics or characteristics associated with their respective learning categories. As literature points out, these game characteristics form important parts in the design of serious games to stimulate learning and performance while playing a game. With this mapping of learning categories to game characteristics it may help in the development and design of game-based training programmes in workplaces where risk management is important (Van der Spek et al., 2011), for example the mining industry.

Table 2-7: Game characteristics linked to learning categories (adapted from Lameras, 2015)

Learning Category	Game Characteristic
Game has rules	Game instructions before starting with conditions
Goals and choices	Game objectives, decision cards, storytelling
Task, activities and challenges	Game objectives with an end goal, progress bars, requirements, motivations for improvement
Competitiveness	Collaboration with other delegates, scoring, leader boards, points gained and lost
Feedback	Hints on how to improve scores, progress bars, progression to new levels

2.6.3 Learning through game characteristics

As discussed in Section 2.6.1 and Section 2.6.2, a lot of research supports the enhancement of learning and performance through gameplay, and thus provides the motivation for implementing serious games into education and training programmes. Arnab et al., (2014) investigated important requirements of game mechanics that reflect the relationship between learning ability and gameplay. Table 2-8 incorporates the learning game mechanics to be incorporated in serious games from Table 2-4, the learning outcomes to be achieved from specific learning characteristics from Table 2-5 and Table 2-6, and maps these aspects with the specific learning activities to be incorporated into serious games design.

Table 2-8: Linking learning characteristics and game characteristics to serious game learning outcomes

Learning Characteristic	Game Characteristic	Outcome	Feedback/Assessment
Information	Game and task descriptions. Scoring explanation.	Knowledge (remembering)	Progress bars; summative information
Individual activities	Game objectives with an end goal, progress bars, requirements, motivations for improvement	Comprehension (understanding), analysis, application	Formative and summative feedback on activities and work
Collaborative activities	Collaboration with other delegates, scoring, leader boards, points gained and lost	Evaluation, application, synthesis	Motivational, social
Discussion and debating	Hints on how to improve scores, progress bars, progression to new levels	Evaluation, understanding, analysing	Motivational, social, formative

2.7 Mining and metals companies

The International Council on Mining & Metals (ICMM) is an international organisation that brings together 26 of the largest mining and metals companies in the world to promote change and strengthen all the companies' vision and values in terms of safe, fair and sustainable mining. (ICMM, 2018)

In terms of safety and risk management training, this section takes a closer look into companies dealing with the same commodities as well as companies of larger scale to compare them with each other. These companies deal with large-scale operations on a daily basis, with risks and hazards that can lead to serious incidents. Risk management and risk management training is thus of great importance. The risk management strategies of these companies are compared, as well as their safety data and their approach to ORM and training effectiveness measurement. The goal with this comparison is to see if trends exist in results of safety data over a period of time and the companies' specific approach to ORM.

2.7.1 ICMM approach

ICMM brings together leading mining and metals companies in the world, where core issues related to sustainable development in the mining industry are faced together, with the goal to collaborate with each other to find better solutions to shared issues in industry. Prospective members have to go through an admission process to ensure that they meet high standards and prove that they can contribute to the goal of continuous improvement. The member companies commit to work together with other member companies as well as with governments to improve and encourage sustainable development. The member companies are listed in Table 2-9. The relevance of this lists lies therein that all of them operate under the same standards which is needed to be part of the ICMM, allowing the author to objectively measure their differences in risk management training approaches and how this might affect their safety performance. From this list, companies who deal with the same operations and on the same scale as the company being investigated will be identified, to compare from a similar perspective.

Table 2-9: International Council on Mining & Metals Members

ICMM Members			
Number	**Company**	**Number**	**Company**
1	African Rainbow Minerals	**14**	JX Nippon
2	Anglo American	**15**	Lonmin
3	AngloGold Ashanti	**16**	Minera San Cristobal
4	Antofagasta Minerals	**17**	Minsur
5	Areva3	**18**	MMG
6	Barrick	**19**	Mitsubishi Materials
7	BHP Billiton4	**20**	Newmont
8	Codelco	**21**	Polyus
9	Freeport-McMoRan	**22**	Rio Tinto
10	Glencore	**23**	South32
11	Goldcorp	**24**	Sumitomo Metal Mining Co
12	Gold Fields	**25**	Teck
13	Hydro	**26**	Vale

ICMM prides themselves in the fact that all of their members are in the process of adopting a critical control management approach to risk management, which will contribute to the overall awareness of workplace safety, as well as controls to implement in order to minimise risks and contribute towards a goal of zero harm in mining organisations. Member companies are thus encouraged to apply these critical controls in their risk management training programmes at all levels of management. The critical controls must be clearly defined in risk management training so that they are understood. The critical control management approach of ICMM is focused on the risk management of those controls and requires:

1. Clear indication of the most important controls.
2. Understanding of the controls available and what they need to do to prevent unwanted events from occurring.
3. Decisions on what validations are required to check if controls are working.
4. Knowledge of who is responsible for implementation of controls.

5. Performance reporting of all the critical controls.

2.7.2 Safety data

ICMM focuses on continuous progress in terms of health and safety performance of its members. They encourage better processes and a uniform approach to operational risk management, with a goal of reducing fatalities on mining sites to zero. The safety data of all 26 members of ICMM are shown in Figure 2-4 indicating the trend in total number of fatalities and fatality frequency rates between 2012–2018 (ICMM, 2018).

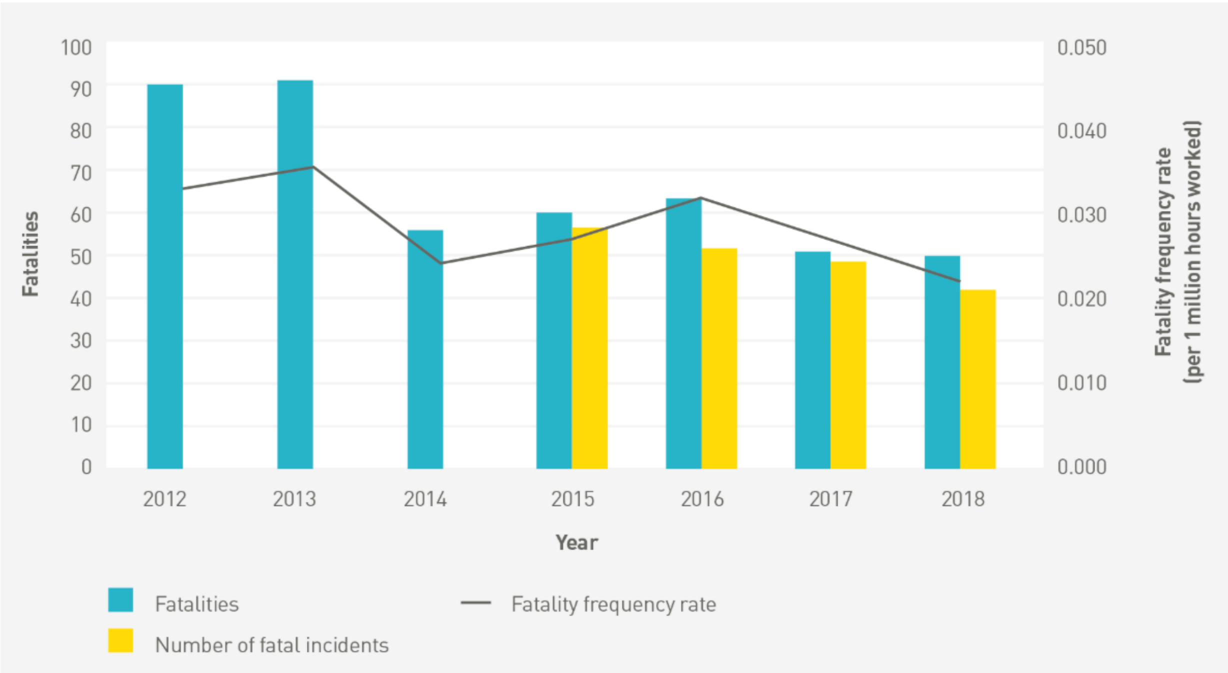

Figure 2-4: ICMM fatalities and fatality frequency rates (2012–2018)

It can be seen from Figure 2-4 that since the implementation of a zero harm policy and the implementation of a uniform risk management training strategy, fatalities and fatality frequency rates have decreased over the past seven years, indicating that the implementation of these processes and principles has had a positive effect in promoting change and safer workplace environments. The total number of fatalities and incidents are, however, not close to the goal of zero, indicating that there are still areas lacking in correct implementation of operational procedures, as well as implementation of risk management strategies.

In terms of demographics, it is also important to identify specific areas in the world that need improvement in terms of risk management strategies. Anglo American operates mostly in Africa and South America, meaning that safety data that correlates to specific regions is of high importance to identify areas for improvement as well as plan for the future in safety training and development, and possible changes to risk management strategies in these specific regions.

It can be seen in Table 2-10 that these figures are of great importance in terms of Africa and South America, having had the highest number of fatalities in 2018. Table 2-10 gives a context not only to the percentage's distribution of fatalities on different continents, but also the relationship of the number of fatalities to the number of hours worked by employees. It has to be noted that Africa and the Americas have the highest working hours, indicating larger amounts of mining activities and an increased chance of fatalities occurring, which can be a reason for the high number of fatalities for the year. Africa was the continent with the highest number of fatalities, accounting for 28% of the total fatalities (ICMM, 2018). This data contributes to the notion of the importance of risk management training to improve towards a goal of zero harm on mining sites, especially in an African context, and that although the data indicates a decrease in incidents and fatalities in the past seven years as seen in Figure 2-4, there is still room for improvement in achieving the goal of zero harm.

Table 2-10: 2018 fatalities per continent (ICMM, 2018)

Continent	Total hours worked	% of total hours per continent	Total recordable fatalities	Fatality frequency rate	% of fatalities per continent
Africa	629,469,336	27.7	22	0.035	44
Americas	1,016,033,984	44.7	17	0.017	34
Oceania	288,089,487	12.7	2	0.007	4
Asia	278,695,473	12.2	7	0.025	14
Europe	62,047,752	2.7	2	0.032	4
Other	1,174,157	0.1	0	0	0
TOTAL	2,275,510,188	100	50	0	100

2.7.3 Companies' approach to risk management training

In order to implement systems in measuring the effectiveness of risk management training, different leading mining companies' approaches to ORM and risk management training are considered. This information will give greater insight into the different approaches available, the implementation of these approaches as well as their results.

The companies used to compare RMT approaches were chosen in terms of the scale of their operations (hours worked per year) compared to Anglo American, as well as whether or not they are members of ICMM (to adhere to consistency in company safety and sustainability goals).

The companies identified for the comparison, along with their respective trading commodities are tabulated in Table 2-11. These companies all form part of the top ten largest mining companies in the world (Jacobs, 2018), as well as being members of the ICMM (ICMM, 2018).

Table 2-11: ICMM members chosen for RMT strategy comparison

Number	Company	Commodities	Total hours worked (2018)	Source
1	Glencore	Copper, Zinc, Lead, Nickel, Ferroalloys, Aluminium, Iron Ore	357,682,334	(Glencore, 2018)
2	Rio Tinto	Iron Ore, Aluminium, Copper, Diamonds, Energy and Minerals	170,314,514	(RioTinto, 2018)
3	BHP	Coal, Copper, Uranium, Nickel, Zinc, Potash	149,241,267	(BHP, 2018)
4	Anglo American	Base metals and minerals, Platinum, Copper, Diamonds, Coal	208,269,694	(Anglo American, 2018)
5	Freeport-McMoran	Smelting & Refining	129,998,149	(Freeport-McMoran, 2018)
6	Corporacion Nacional Del Cobre De Chile (CODELCO)	Copper	146,606,098	(ICMM, 2018)

Safety data and training and evaluation methods of the six companies tabulated in Table 2-11 are investigated by analysing their sustainability reports for the past five years. By analysing the sustainability reports over time, important insight can be gained in the improvement of the companies' health and safety, and their specific approach to training from a risk management perspective. Figure 2-5 shows the yearly fatalities of the discussed companies for the past five years (2014–2018). From Figure 2-5 it is seen that the measurement of number of fatalities can be very volatile which is typical of this high risk industry. It must also be considered that the type of mining operations differs between these companies, for example opencast vs. underground mining operations. Opencast operations are a lot less hazardous than underground operations. Volatility in data can also be due to a single event on an operation that can cause multiple fatalities, which could skew the data.

Reasons for the volatility can also be due to fluctuations in mining operations due to the market requirements and needs, variations between mining methods (opencast vs. underground) that are less hazardous than other mining activities, as well as the difference in scale of mining operations between companies. The scale of the mining operation can be seen in both the companies' net worth and total working hours for that specific year as indicated in Table 2-11. This scale of operations is evident when comparing Table 2-11 with the trend in Figure 2-5. Glencore has the largest operations and therefore a bigger likelihood of incidents occurring, which is evident in their high fatality rates. Anglo American and FreePort McMoran both indicate decreasing fatality trends from 2016–2018. Even though this statistic is very volatile, it is worthy of investigation into what companies dealing with the same daily safety risks are doing to mitigate any further incidents or fatalities.

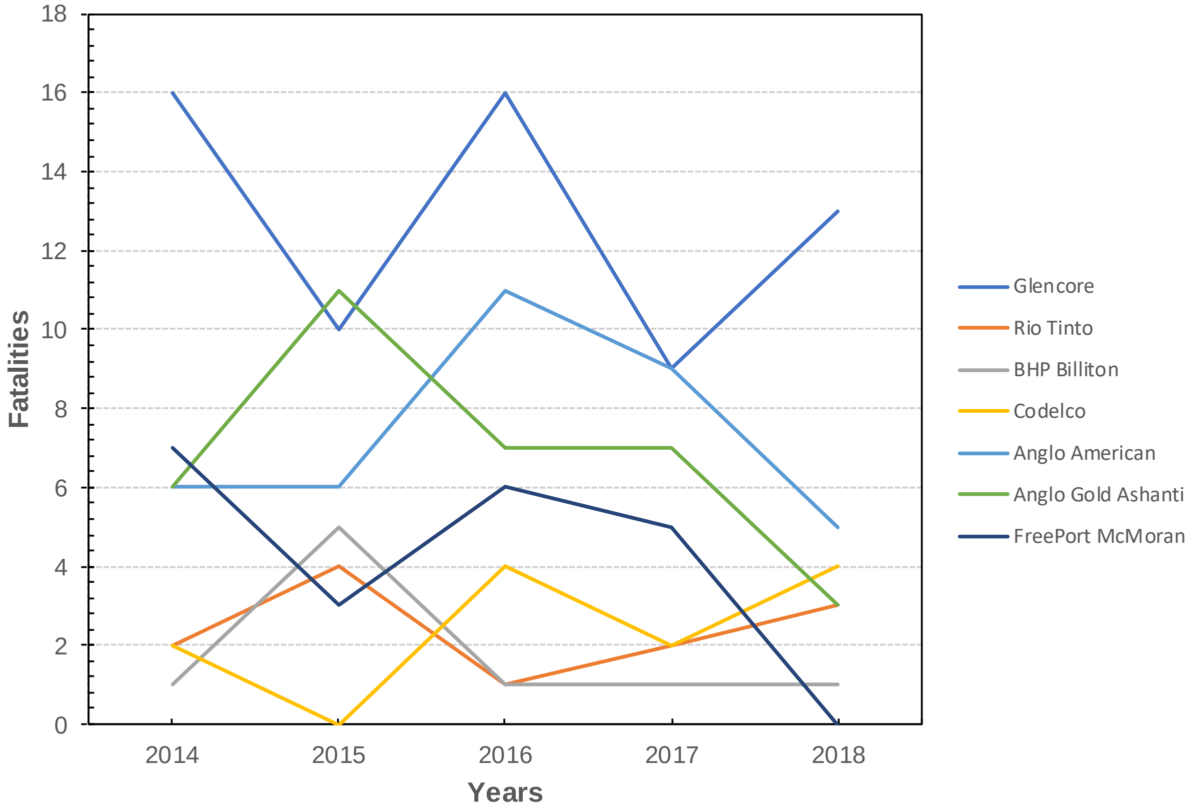

Figure 2-5: Yearly fatalities of investigated companies (2014–2018)

2.7.3.1 Glencore

With the largest operations and total working hours as seen in Table 2-11, Glencore is faced with a larger probability for incidents to occur on their mining sites that have the possibility to lead to a higher number of fatalities. The company strives to become a safety leader in their industry by following an approach of strong leadership on safety. By promoting and improving leadership on different management levels they believe they can create a safe workplace with less fatalities and injuries (Glencore Sustainability, 2018).

Glencore has implemented a model called *SafeWork*, which forms part of their approach to ORM and is designed to teach employees the tools to perform everyday tasks on mining sites safely. The goals with *SafeWork* is to empower supervisors (front-line supervisors) to be responsible for their team, their work areas and to motivate safe behaviours. The *SafeWork* model is implemented by training programmes across the group, where real-life hypothetical scenarios are used to learn how to treat risks and implement procedures.

2.7.3.2 Rio Tinto

From Figure 2-5 it is evident that RioTinto has some of the lowest fatalities over the last five years compared to the other companies. Their low fatalities may be owed to their specific mining operations, which are mostly opencast, which are a lot less hazardous than underground mining activities that other companies are subject to. Their approach to ORM considers the strategy of sharing learning across the group (RioTinto Health & Safety, 2018). In 2014 RioTinto reviewed their strategy and implemented a training programme called *Critical Risk Management* (CRM) to ensure that before tasks are commenced on mining sites, every individual on the team understands the risks associated with that activity. The supervisor of a team is thus responsible for ensuring that critical controls are implemented before a job starts.

RioTinto believed that the implementation of CRM training has played a critical role in their improvement and that training on this model has improved leadership, culture, systems and processes.

2.7.3.3 BHP

Along with RioTinto, BHP also has some of the lowest recorded fatalities in the past five years, and with a TRIFR of only 4.4 (per million hours worked) they pride themselves on promoting a safe work environment though the application of field leadership and leadership training (BHP Safety, 2018).

Through their *Field Leadership Program* all levels of management spend time on mining sites, engaging with employees and getting to know the mining activities and the risks associated with them. The aim with this engagement is to improve collaboration on ideas between different management levels about safety and the verification of safety risk controls. According to BHP (2018), this system helps to address at-risk behaviours in the field and improves critical risk controls, essentially improving the awareness and importance of implementing safe work procedures.

2.7.3.4 Anglo American

With some of the largest mining operations in the world, Anglo American is faced with high probabilities of incidents occurring, which is evident in the number of fatalities compared to the other companies, as seem in Figure 2-5. Anglo American does, however, have a very clear and structured approach to operational risk management. Their approach follows risk management training for all operational managers (all levels of the group). Each training programme caters for the specific tasks that management level will deal with in terms of identifying, controlling and prioritising risks in the field (Anglo American ORM, 2018).

The training programmes are based on providing the different levels of management with the tools to manage risks through the implementation of a four-level model (layered) to ensure that operational risk management procedures are applied correctly with the goal to minimise workplace incidents and fatalities. Table 2-12 shows the four layers of Anglo American ORM with an explanation of its application.

Table 2-12: Operational Risk Management Model (Anglo American ORM, 2018)

Layer	Component	Description
1	Baseline Risk Management	This forms the baseline of the ORM and identifies priority unwanted events (PUE) across all operations to plan and identify accountable parties.
2	Issue-based Risk Management	This layer addresses the PUE from the first layer by evaluating it using appropriate risk assessment methods that suits the specific risk.
3	Task-based Risk Management	Prior to beginning a task, a team along with their supervisor must complete documents supporting the effective task requirements and operating procedures. Job risk assessments are completed for that specific task in order to implement better controls for unwanted events.
4	Continuous Risk Management	Layer 4 promotes the continuous application of safe work procedures through ensuring that employees stop and think before attending to a task or job, only commencing once all the correct procedures have been followed.

By the end of 2018 Anglo American had implemented this model in the workplace and in training programmes across all management levels with the goal of zero harm to minimise fatalities and mining site incidents. A decrease in the number of fatalities can be seen in Figure 2-5 over the last three years, also being one fatality less than five years before.

2.7.3.5 FreePort-McMoran

Like Anglo American, as seen in Figure 2-5, FreePort-McMoran has shown a steady decrease in the number of fatalities in the last five years. The company claims that safety is a fundamental part of their operations and is indicated by the integration of safe practices into all areas of their operations (FreePort-McMoran OH&S, 2018).

According to the FreePort-McMoran sustainability report (2018) the company has an overall operational health and safety objective of zero workplace fatalities. They aim to achieve this by training employees from different management levels in their *Fatality Risk Management Initiative*. This initiative aims to train employees according to their Fatal Risk Management (FRM) programme, which ensures that potentially fatal risks are identified and that controls are applied effectively to mitigate the risks. The FRM process as designed and implemented by FreePort-McMoran can be seen in Figure 2-6.

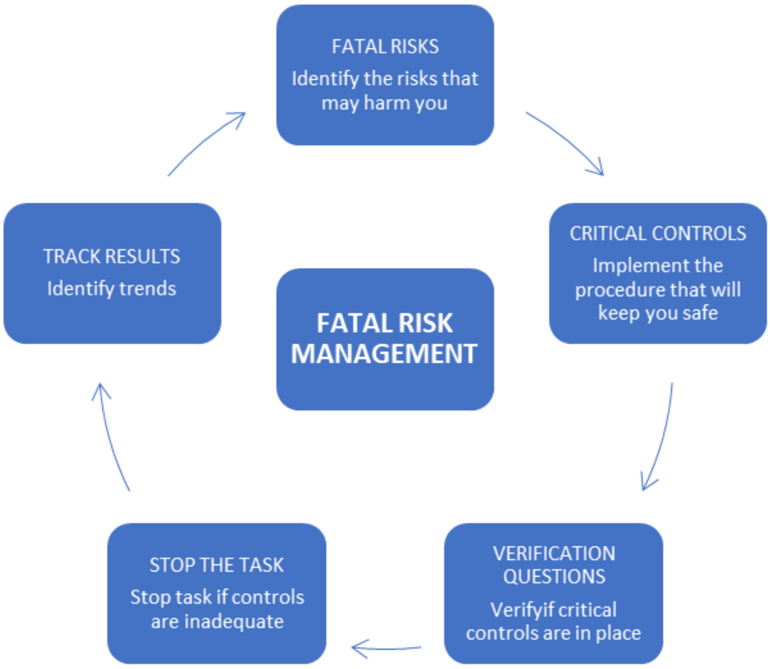

Figure 2-6: Fatal risk management process (FreePort-McMoran OH&S, 2018)

The management level appointed to oversee direct implementation of their FRM programme is the front-line supervisors. These supervisors use pre-task critical control checklists to identify potential hazards of specific tasks. This enforces conversation between the supervisor and the team members that perform the task, which assures that all potential risks are accounted for with appropriate controls and that everybody understands their role in the task and the risks involved. FreePort-McMoran manages these risks by the use of a mobile platform that guides supervisors and users through a checklist to validate fatal risks and critical controls. This system captures every possible scenario and creates prioritised tasks and controls for them (FreePort-McMoran OH&S, 2018).

2.7.3.6 CODELCO

CODELCO is a South American company who believe in a sustainable future in terms of safety on mines. Although the past three years have shown a slight upward trend in the number of fatalities as seen in Figure 2-5, the number of fatalities is still low compared to other mining companies. CODELCO has invested in a *Sustainability Master Plan* focusing on occupational health and safety to improve traceability of incidents and processes on mines (CODELCO Sustainability, 2016).

In terms of risk management and training, the company developed a leadership and behavioural safety programme which enforces the application of correct operating procedures on their mines. The programme entails monthly reporting of different management levels to their safety council and allows enhanced interaction between senior management levels and the workers. This interaction through leadership principles is believed to get perspectives from different levels on safety management, improving the understanding and implementation of operational procedures to create a safer work environment (CODELCO Sustainability, 2016).

2.7.4 ORM strategy overview

The aim of Section 2.7.3 was to find a relationship between the discussed companies' safety and incident reporting data and their approach to safety management. Sustainability reports of some of the largest mining and metals companies in the world were analysed and discussed to report on findings of their overall strategy regarding the approach to operational risk management.

From the six companies that were analysed it is evident that a common objective is a zero harm policy, which goes hand-in hand with the overall objective and mission statement of the ICMM for companies to implement systems that support the objective of reaching zero harm in all their operations (ICMM, 2018). All of the six discussed companies present risk management training programmes to employees and consulting companies that are structured towards learning the implementation of on-site methods and work procedures that are designed to create awareness of risks related to specific tasks and the controls available to prevent them. It has to be noted that some of the companies investigated have different methods of mining operations, which might be less hazardous than others, for example opencast operations vs. underground operations. Underground mining operations are subject to higher risks, meaning that a single event could lead to multiple fatalities which could skew the safety data between years, making the safety statistics very volatile and hard to compare to other companies.

An important aspect that is emphasised in all the above-mentioned companies is leadership and the role it plays in ORM. As outlined by the ICMM (2018), leadership and leadership development throughout the company and its management levels are of utmost importance when considering risk management training and on-site risk assessments. The implementation of correct work procedures and oversight of critical controls are some of the leading tasks of the front line managers and supervisors on site (Anglo American ORM, 2017). Leadership strategies in terms of leadership roles at different management levels are thus of high importance to understand and implement when designing risk management strategies and operational procedure implementation to create a safer mining environment. Leadership applications will be discussed further in the following section, as outlined by (Charan, Drotter, & Noel, 2011).

2.8 Leadership in operational risk management

Charan *et al,* (2011) outlined a model called *The Leadership Pipeline* containing six critical leadership passages (Figure 2-7) for the development of different management levels within a large company and how their roles as leaders change. This model is of high importance to the understanding of the roles of supervisory levels within a mining organisation as their leadership in their teams provides the baseline for ORM in the oversight of application of safe work procedures.

From the outline of roles of a supervisor on mining sites discussed in Section 2.3, it can be seen to relate to *Passage 1* and *Passage 2* shown in Figure 2-7. For supervisory level management, supervisors are first expected to fulfil the competencies of managing themselves through their own time management. From there they proceed to use the skills and experience they have gained in the previous passage to apply to others. From Section 2.3 it is evident that supervisory level goes hand-in hand with the process of where employees are equipped with professional and technical skills but in the process developing their leadership and broadening their skills in order to use it to manage others (thus the transition from *Passage 1* to *Passage 2*).

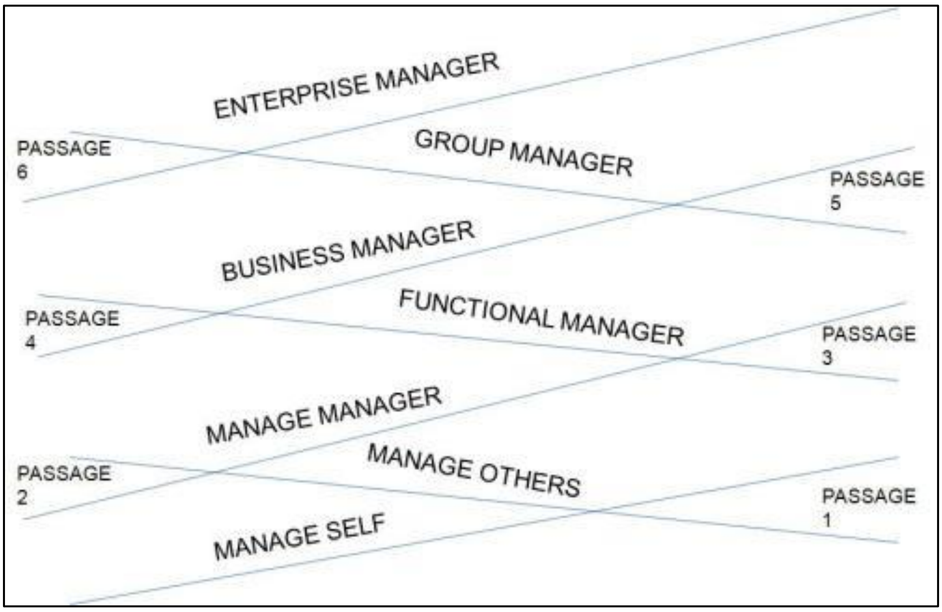

Figure 2-7: The six leadership passages (Charan et al, 2011)

Charan, Dotter and Noel (2011) explain that during passage 1 the employee will progress in various management skills through leadership development and move towards the role of front-line manager (supervisory level). This transition is the most important as it involves a behavioural shift as the employee develops skills in planning of work, assigning of work, oversight of implementation of operational procedures and the ability to motivate a team. Shifting to the management of others, the supervisory level thus takes on the main responsibility of time and resource management of a team, which is the basic function of management according to Charan et al. (2011).

Considering the importance of *Leadership Passages*, it can be seen that leadership forms a critical role of not only the development of supervisors but also their implementation of operational risk management systems in a team, with the objective of creating a safer working environment on mines, and so reducing the number of annual incidents and fatalities.

2.9 Possible game development platforms

2.9.1 Engines

Development of SGs can be very technical when it comes down to their architecture and engines, which are the platforms in which they are coded. Söbke & Streicher (2015) did a comprehensive study specifically on the design and architecture of these games according to their objectives and characteristics, as well as the possible platforms on which to create them.

Söbke & Streicher (2015) suggest that due to the fact that a part of the degree of freedom is removed from SGs in comparison to other digital games, the hardware required to develop such a game is less than normal games meant only for pleasure. They then investigated the different hardware that could possibly be used for such games so far as possible using corresponding platforms:

Computer (Desktop):

It was found that from a development point of view, the engine required that the game can be run without a network connection. Easier engines and languages to use for the coding of the games are C++ and Java programming environments.

Mobile Games:

Mobile games would be the preferred option for development when considering the user platform. When looking at simulation and gaming software development tools there is already designated software available making it easy to design your own game (Eurosis, 2018). One of these engines is *DX Studio*, which features a development platform for creating 3D graphics into the game. Using this tool, one can build interactive applications, simulations or games. Another engine is *ITyStudio*, which is a software application for development of SGs where users can create their own content, with interactive cards, software and technical training.

2.9.2 Platforms

One of the key objectives for implementation of SGs on digital platforms is to make them easily accessible and user friendly, which will also increase the communication of the learning material. Zhang & Lu (2014) investigated useful mobile platforms for serious gaming applications and divided them into three categories as shown in Table 2-13. They are divided into Tablets, Computers and Phones, with each one given a rating of their important characteristics associated with serious gaming.

Table 2-13: Possible serious games development platforms (Zhang & Lu, 2014)

	Tablet	Computer	Phone
Storage	Medium	High	Medium
Processing Capacity	Medium	Strong	Medium
Operation	Simplicity	Complexity	Simplicity
Interface Size	Medium	Large	Small
Game Effect	Medium	Good	Low Quality
Mobility	Strong	Bad	Very strong

The objective of Anglo American (2017) when it comes to design and aesthetics is simplicity and transportability. From Table 2-13 it is evident that a phone or tablet will be a good fit, as the interface size is fairly low, but the storage capacity and processing capacity is still reasonable. With this reasoning, a laptop assigned to the participant would also be a good fit, as it has enough storage capacity, is easily accessible to the participant, as well as portable. When not wanting to deal with the expense of devices, websites are also good platforms for game development.

2.10 Conclusion

This section concludes the findings of the literature review (Chapter 2) and discusses how the findings from the literature review contribute to the achievement of the objectives of this project. By doing this, it forms a vital part of the understanding of concepts and builds the foundation of the development and design of a serious game within a mining organisation to test the effectiveness and impact of risk management training on supervisory level within a mining organisation.

Risk management training in a mining organisation is important as the procedures and principles learnt can lead to serious injuries and even fatalities if not implemented correctly. These training programmes are compulsory for different management levels as stipulated by the ICMM (2018) for their members. From analysis of fatality and injury frequency rates investigated in this chapter, it is evident that even though the implementation of these programmes has raised awareness about the importance of risk management the number of fatalities has decreased; the targets of zero harm on mining sites is not yet met. All the companies do, however, invest in training programmes across the management levels with the focus on implementation of unique risk management systems and hazard and control identification.

The majority of work done in the mining environment and on mining sites is, however, still unplanned on a daily basis and as a result creates uncertainty towards daily operations and tasks of a team. This uncertainty is a result of unplanned activities from supervisory level and thus increases operational risks, which raises the question on the effectiveness and impact of risk management training courses at supervisory level. The evaluation of the effectiveness of the training programme was chosen to be related to the Kirkpatrick four-level model of training evaluation, namely reaction (level 1), learning (level 2), behaviour (level 3) and results (level 4). Where levels 1, 2 and 4 are more easily measurable, level 3 is, however, harder to measure as it deals with the motivation of delegates to use the knowledge gained from a programme and apply it in the workplace. The literature study thus investigates possible designs for tools to increase learning ability and motivation of delegates and at the same time measure the effectiveness of the training (level 3: behaviour).

The findings from the literature review in terms of the research objectives to find supporting literature and information to answer overarching questions that will help achieve objective 1 of this research. By completing this and gaining an understanding of the literature it enables the second objective to be met through completion and implementation of the first objective.

2.10.1 Objective 1 conclusion

Using a systematic literature review procedure, the roles of a supervisors on mining sites were identified in terms of risk management. Together with this, training evaluation models were investigated in line with how serious games can be used for better learning and application in training programmes to improve knowledge retention and so the effectiveness of a training programme of this nature.

Through investigation of the sustainability reports of members of the ICMM it is established that the main roles of supervisors are to promote safety in their teams through leadership principles by:

- Interacting with their team directly;
- Understanding their team;
- Being familiar with the work on site and the hazards associated with different tasks;
- Enforcing discipline in the work environment;
- Being able to conduct on-the-spot risk assessments of a job/task to be completed.

The content of the Anglo American ORM programme for supervisors was investigated and attended by the author. These decisions/tasks were then aligned with the content of the ORM programme which was then used in the design and development of a serious game to be used as measurement tool within the training programme.

The applicability of serious games from literature studies was investigated, together with the characteristics of games that are connected to better learning characteristics through cognitive reactions. The most important aspects of games to incorporate for better learning were found to be:

- A game must have rules;
- Goals and choices;
- Tasks, activities and challenges;
- Have a competitive nature;

- Have feedback.

It was found that the best practical way to incorporate a serious game into a training programme of this sort is via a digital platform (phone, tablet or a laptop). This enables the author/designer to create the SG on a coding platform, as well as make the user interface more accessible, transportable and user-friendly. For practical purposes the author did a course on both Serious Game Development and Excel Visual Basic.

A SG containing the investigated and abovementioned principles was designed in collaboration with well-known mining organisation, in the form of a desktop application. The SG also includes principles and characteristics that are unique to Anglo American's RMT programme that is tested in this study. A preliminary design specification was developed by the author, in collaboration with Anglo American, at Stellenbosch University. After approval of the design specification by the organisation, the SG was coded by the author using Excel VBA at Stellenbosch University. This design and development phase are discussed in Chapter 4 in detail.

To conclude, an approved serious game was designed and developed by:

- Using the principles and characteristics of games related to learning;
- Using serious games design tools;
- Using the roles of supervisors on mining sites;
- Using the content of the A2 ORM programme of Anglo American;
- Coding the game on Excel VBA.

Through completion of this, the first objective of the study is met, and the second objective could be achieved through application of the serious games as effectiveness measurement tool of the A2 ORM programme.

3 PROJECT METHODOLOGY

Chapter 3 key objectives:

- Provide an overview of research methods used
- Provide the approach and motivation to the game design
- Provide the source of data chosen and its analysis
- Evaluate the methodology chosen

3.1 Introduction

The Kirkpatrick model for training programme evaluation, as discussed in the literature review, has a third level which involves measuring the 'behaviour' of participants in a training programme. In the case of RMT training courses on supervisory level in a mining organisation, the behavioural element represents the extent to which a participant is willing to learn and apply the concepts learnt in the work environment. Whereas measurement of the other three levels of the Kirkpatrick model (Reaction, Learning and Results) are physical aspects that can be measured, the behavioural level is influenced by factors like emotion and psychological aspects which have no measurable feature.

The aim is thus to develop a method by which a correlation can be found between the extent of learning achieved in a training programme and the actual results of work performance measured by KPIs in the workplace on mining sites. This chapter discusses how the project objectives will be met by the chosen methodology.

Chapter 3 also considers different research approaches in order to form a baseline for the research design. The research for this project is of a design nature and will thus consist of both qualitative and quantitative research methods.

3.2 Meeting the objectives

In order to meet the objectives intended for the research project, extensive planning and research needs to occur. To meet the first objective, the author needed to get acquainted with the principles of ORM in the mining sector, and how mining companies' vision impacts the structure of their training programmes for different levels of management, as well as how they intend to measure the effectiveness of these training programmes within their company. This was done by the author by attending one of the ORM A2 training courses at Anglo American. The measurement tool chosen to conduct the study is in the form of a digital SG and the author successfully completed an on-line course on Serious Gaming, which teaches the most important aspects a SG should contain to promote better learning and knowledge uptake, as well as motivation to play the game. Furthermore, different platforms need to be investigated to select which will best suit the SG development on which the game will be coded.

The second objective will be met by collecting data from the company on which the study will be done. This data will consist of three sets; namely the results of a post-training course test (which measured the extent of theoretical learning or knowledge gain), results from the SG that is designed and tested, and real world KPI data which measured the performance of supervisory level management on site. 'Happy sheets' will also be considered and analysed in terms of scores obtained by specific delegates according to how they experienced the training programme.

3.3 Quantitative and qualitative research

Quantitative and qualitative research approaches are both widely used and are approaches that differ with respects to their epistemology, ontology, and how they connect theory and research with each other. Bryman *et al*. (2000) describes the relationship between theory and research design to be either inductive or deductive. They describe inductive approaches to be where theory is the outcome of research, whilst deductive approaches are where theory guides the research to form a research design.

Creswell (2009) explains that inductive approaches refer to theoretical understanding that is developed through data based on observations, interviews and focus groups and they are thus usually associated with qualitative research methods. By contrast, deductive methods are characterised by involving some sort of hypothesis that is tested based on research findings. Deductive methods are thus associated with quantitative research methods and emphasise the quantification by collection and analysis of data. Research can be done using quantitative methods, qualitative methods, or a manner that contains both methods, called mixed methods analysis.

Fundamental differences between the quantitative methods and qualitative methods are described in Table 3-1, relating to the area of research associated with them.

Table 3-1: Considerations of research: differences between quantitative and qualitative methods (Bryman, et al., 2000)

Area of research consideration	Quantitative	Qualitative
Role of theory in relation to research	Empirical, deductive testing of theory	Generation of theory by the inductive nature of data
Epistemological orientation	Natural science methods: Positivism	Researching differences between objects and people, e.g. natural science and social science
Ontological orientation	Objectivism	Constructionist

In order to design a research strategy, the research approach needs to be decided on in order to gather all the necessary information and data required to meet the objectives. The above-mentioned research methods, both quantitative and qualitative, have differences in research areas according to the collection of data, the purpose of the data collection and the approach to gathering the data (Bryman, et al., 2000), (Creswell, 2009). Table 3-2 shows the differences in the research methods of the two discussed research approaches in terms of their characteristic components (Creswell, 2009).

Table 3-2: Quantitative and qualitative research approach comparison (Bryman, et al., 2000), (Creswell, 2009)

Characteristic component	Quantitative	Qualitative
Approach	Measuring and testing	Observation or interpretation
Type of research used for	Descriptive research designs	Exploratory research designs
General approach	Numbers and measurement or tests	Words and descriptions, either observed or interpreted
Purpose of method	Test a stated hypothesis or specific research questions using statistical analysis or evidence	Understanding of a phenomenon through observation or interpretation. Discovering ideas
Data collection	Structured collection of data	Unstructured collection of data

The advantage of using a combination of these two research approaches exists, called the mixed methods research approach (Bryman, et al., 2000). This method entails the collection of both quantitative and qualitative data for analysis for the research objectives. By using this method, a broader insight can be gained into the research topic and the results.

Considering the above-mentioned research methods and their characteristics, the researcher must thus decide on his or her epistemological and ontological orientation in terms of the research objectives, in order to formulate a successful research design. The choice of the method used will influence the method of data collection as well as the data analysis methods.

3.4 Approach

Following the first project objective which is the design and development of a measurement tool to measure the effectiveness and impact of RMT programmes on supervisory level participants in a mining organisation, the source of data will be both quantitative and qualitative in nature; thus a mixed methods research approach will be followed.

The first part of the research will be based on theoretical approaches to aspects which affect the training and development in RMT programmes as well as which of these aspects is more likely to promote better learning to improve the effectiveness of the RMT programme through learning and application of procedures and principles in the workplace. These theoretical approaches will be compared with data from the author’s and field experts’ observations during the A2 programme at Anglo American, as well as the state of mind and motivation of participants of the relevant RMT programme.

The second part of the research will be based on the data gathered from the designed measurement tool and will thus be quantitative in nature. By conducting research on the specific aspects and requirements for training programmes which promote better knowledge uptake and retention of programme-specific concepts (cognitive ability), the author will gain thorough knowledge and understanding to develop a successful serious game (SG) as a measurement tool. As Bryman *et al.* (2000) explain, adopting both quantitative and qualitative research methods will result in better understanding to contribute to more valuable research conclusions in specific research projects, as is the case with this project.

3.5 Source of data

This study uses the outline for data generation from the four levels of training evaluation as described by Kirkpatrick (2006); being Reaction (Level 1), Learning (Level 2), Behaviour (Level 3) and Result (Level 4). In this study the aim is to measure the effectiveness of the application of SG in training programmes by estimating the behavioural change of participants. In order to do this, data from the surrounding levels was used and compared to the knowledge gain through playing a SG in a training programme.

The designed serious game (measurement tool) was played at an Anglo American training facility for participants in the A2 Operational risk management training programme. The data that was collected from playing the game was from the respective training programme where the game is played.

The data that was required was:

- 'Happy sheets' from the participants that attended the A2 RMT programme that the SG was tested at, which gives insight into the overall attitude of the participant during the training (Level 1).
- Theoretical test scores of a test that was written after the A2 RMT programme to test the level understanding of theoretical concepts, assuming that they had no previous knowledge thereof. (Level 2).
- Results from the *Time Risk Manager* game, which was designed, testing an overall score as well as subcategory scores:
    - Operational Performance
    - Safety, Health and Environment
    - People and Leadership
- Real-world KPI data which is an indication of application of principles and procedures learnt in the A2 RMT programme (Level 4). This data is correlated with the previous data measures, especially the results and trends of the playing of the SG to serve as an effectiveness measurement tool. The effectiveness of the RMT programme is a thus seen as a part of a behavioural change in participants due to their attendance of the A2 RMT programme and the knowledge gain and concepts and procedures learnt. The behavioural change or attitude towards learning is a pivotal part of training programme effectiveness. The real world KPI data gathered was:
    - Completion of Job Risk Assessments (JRA) to a quality approved by Anglo American;
    - Frequency reporting of incidents, accidents and fatalities.

Another important aspect is the time frame of this data. The correlations are done in terms of the influence of attendance of the A2 programme on the behavioral change in delegates. The progress is thus measured on a timeline of analysis of real-world KPIs before and after attendance of the A2 programme. This progress in terms of real world KPIs will be measured for the weeks leading up to the A2 programmes (of the respective sites the delegates are from) and the weeks following their attendance. The collecting of this KPIs are done by either the data gathered from Enablon on the completion of JRAs on mining sites, or from physical documented completion of JRAs on sites where Enablon Is not active yet. Enablon is a software that uses cloud-based systems to manage health and safety data on mining sites and improves the management of these data through easier documentation and resource planning. These results were then correlated with those of the theoretical tests and results of the SG.

3.6 Data analysis

Before analysing the data in terms of a time frame to consider the possible behavioural change of delegates, it was necessary to investigate the use of a serious game in a training programme and whether an increase in learning is achieved through the cognitive effects of a gaming and competitive environment. The game is played in rounds, and the possibility of learning and improvement is thus investigated by means of statistical analysis, mostly using hypothesis testing related to an ANOVA to measure the extent of variances between respective delegates' SG scores over five rounds played.

To measure a behavioural change in delegates that are linked to attendance of the RMT programme, correlations are investigated between the scores achieved from a theoretical test and the scores achieved in the SG. These correlations are statistically tested with a hypothesis test using Pearson and Spearman correlations using the *Statistica* software. Thereafter another hypothesis test is done using ANOVA in statistically testing if the uptake of work procedures by delegates increase after their attendance to the RMT programme.

3.7 Project Methodology Conclusion

This chapter discussed how the research objectives are used along with a literature review to propose a methodology for the research approach to use and for a SG design to not only enhance learning ability within a RMT programme, but also be used as measurement tool to measure the effectiveness of the RMT programme in a mining organisation.

Due to the nature of the type of research, being of both design and development as well as data collection, the author decided on a mixed methods approach. By using the knowledge gained from a literature review a design and development approach for a SG is followed using characteristics associated with better learning in games, as well as associating these characteristics with the four-level Kirkpatrick model of training evaluation discussed in section 2.2.1. The SG will be designed in line with requirements of Anglo American in terms of expectations of a supervisor on a mining site and the outcomes of their RMT programme for supervisors.

After the design and development phase, the author will analyse data by means of hypothesis testing using ANOVA to measure an increase in knowledge gain and delegates' ability to improve SG scores, as well as to test for statistically significant increase in improvement of work procedures associated with the outcomes of the RMT programme. Furthermore, the author will use hypothesis tests using Spearman and Pearson correlations to test for statistical correlations between delegates' theoretical knowledge gain and ability to improve SG scores. This method of data analysis will together give insight in a possible behavioural change in delegates due to attendance to the RMT programme.

4 GAME DESIGN AND DEVELOPMENT

Chapter 4 key objectives:

- Use a software development life cycle to approach the game design
- Perform an initial game design
- Research and apply relevant RMT concepts in the game
- Design a game points system
- Test the game and make continuous improvements
- Present the final design of the game

4.1 Introduction

This chapter provides insight into the functional specification of the Serious Game (SG) designed to be played in the risk management training course. For the game development phase, it is important to follow a predetermined process that is already available to ensure that the process is repeatable. Figure 4-1 shows the six steps in a general software development life cycle as described by DDI Development (2017). For the author, the design phase of this methodology will take the most time, as the author will have to get acquainted with a software development language on which to build the platform, as well as investigate different techniques to be used for more effective cognitive stimulation for learning effectiveness of the subjects tested.

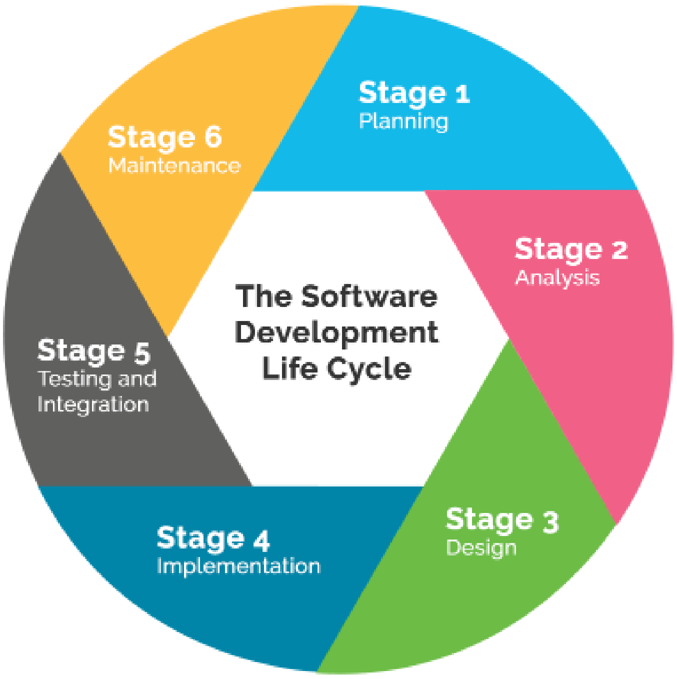

Figure 4-1: Software Development Methodology (DDI Development, 2017)

4.2 Planning

The planning of the development of the measurement tool will form an integral part of the process, as it will incorporate research on previous SG development, the use of SG in other corporate learning environments and the measurement of the effectiveness of training programmes. It will also have to incorporate research on specific high-risk mining activities and correct procedures and decisions to be made on mining sites. Together with the high-risk mining activities, research must be done on the roles of an FLM/supervisor on mining sites and how their decisions affect the mining safety environment. It is important that all these aspects are considered to ensure that the design phase completes the development life cycle so that final game design is as realistic as possible and meeting the requirements.

4.2.1 Analysis of the problem

As mentioned, and discussed in Chapters 1 and 2, different evaluation models for the extent of training received do exist, and the model focused on in this study is the four-level Kirkpatrick model. In corporate training programmes, these evaluation models are used to measure the understanding of the programme content, the way it is delivered, as well as the effectiveness of the training programme. The effectiveness of the delivery of the training programme would thus be measured in the form of real-world KPIs such as an operational improvement.

The four levels of the Kirkpatrick Evaluation Model are:

- Level 1: Reaction;
- Level 2: Learning;
- Level 3: Behaviour;
- Level 4: Results.

The problem with this is that all the levels are easily measurable, except *Level 3: Behaviour* and *Level 4: Results*, which is tough to measure as it has to consider the emotional and psychological state of participants, and most importantly their willingness to learn from a training programme, and apply the concepts they have learnt to their everyday work procedures and planning. The problem is thus to design and develop a tool which will be easily accessible to the participates of the RMT programme, and generate usable data linking the knowledge uptake of the RMT programme and the concepts learnt in the programme, with real-world KPIs, to evaluate if what the participants have learnt is applied in the workplace (i.e. their *Behaviour*). The measurement of the levels thus becomes more difficult to as you go up the levels. In a sense *Level 3: Behaviour* will then be evaluated by finding a link between its surrounding levels (*Level 2 & 4*), where the higher levels will be more difficult to measure, and thus require a larger effort or series of events in order to measure.

4.2.2 Criteria for an acceptable solution

To qualify as a Serious Game (SG), the gamified measurement tool needs to adhere to specific requirements and features to be deemed successful. The author has completed a certificate course (Coursera, 2018) on Serious Gaming (SG), where the key features of SGs were analysed as well as how to apply them in game design and development. This course identified four key features of SGs and these four features are investigated further. Lameras (2015) also performed extensive research in his book *Essential Features of Serious Games Design in Higher Education*, and found that games may have several attributes which all contribute to educational learning. He focused on the four most important ones, which also correlate with the findings of the author. These features are discussed in more depth in the literature review (Chapter 2), and are:

1. Game has rules;
2. Goals and choices;
3. Tasks, activities and challenges;
4. Feedback.

The measurement tool thus needs to:

- Be engaging for participants, encouraging them to participate in a collaborative environment and discussing and comparing their results.
- Incorporate the four aspects of gamification as mentioned above.
- Be able to store the results data to be compared to real world KPIs.
- Be able to run on a desktop or laptop, which is accessible to the participants, as well as be sent as a file via email or transferred to a hard drive.

The success of the applicability of this type of gamification on corporate learning programmes will be dependent on the willingness to participate in a training programme, game results in favour of the theory that knowledge uptake increase with repetition and on a gamified platform, as well as the participants' accessibility to a laptop or desktop to play the game on.

4.2.3 Gathering of necessary information

The information required for the development of an applicable measurement tool is gathered through a literature study (Chapter 2) including investigation into previous training course evaluation methods. In terms of the information required for the content of the measurement tool/game, the following are required:

- Attendance of the author at an actual A2 ORM programme presented by Anglo American.
- Interview with ORM professionals at the applicable mine about everyday mining activities and

possible risks.

- Completion of a short course on 'Serious Gaming' by the author.
- Completion of a short course on an applicable programming language by the author.
- Consultation with programmers to determine the best suited platform to build the programme on, considering the limitations of the author as well as the requirements of participants playing the game.

4.2.4 Required engineering tools and other knowledge

The engineering tools required from the author to design and develop an applicable engineering tool in the form of a SG include:

- The learning and application of a coding language in order to develop a user interface that generates scenarios using calculations (points system) and randomness to give a result as well as feedback to the participants.
- The ability to conduct a thorough literature review using a systematic approach, in order to gather the necessary information and knowledge from previous academic studies.
- The ability to communicate with participants and others involved in the generation of data for this project.
- The ability to analyse the data and interpret it in terms of the objectives of this study.

Other applicable skills:

- The understanding of the principles of operational risk management in the context of the mining environment.
- The understanding of the role of the FLM/supervisor in a mining organisation.
- The knowledge and understanding of RMT programmes and the different evaluation methods available for different training programme evaluation models.
- The understanding of Serious Games and how to apply their principles in the design and development of an applicable measurement tool for evaluation of the third level of the Kirkpatrick evaluation model.

4.2.5 Possible approaches

This section considers the different possible approaches to handle the problems around the design and development of the measurement tool, considering the design criteria and required information and knowledge.

4.2.5.1 Type of tool to develop

- A board game exists which relates to the Anglo American A3 Risk Management Training programme (for executives) which focuses on the financial aspects of risk management behind the daily mining activities. The game is a decision-making board game, where players are presented with a range of different daily work scenarios they may encounter in their field of work. The scenarios all have specific consequences and likelihood of happening associated with them, as well as a price per activity if that specific activity is done. With a tight budget, players must decide whether to treat a scenario/decision *now* or *later* which all then add up to different dashboard scores in terms of the business unit. A similar approach to this board game will work for the measurement tool, but with a different approach to the type of risks encountered, as the participants of the A3 RMT course have different job descriptions and objectives compared to the A2 RMT course.
- The second possible approach is an online game which is based on a board game approach, including leader boards and scores to compare to others. The on-line game can also give feedback and keep better track of score increases and decreases of respective participants.

4.2.5.2 Type of platform to develop the tool on

The decision for the type of platform to use for the development phase is based on the ability of the author to develop the game himself, thus limited to the authors coding ability and skillset.

- Design a physical board game to be played by participants.
- Code the measurement tool/game using a Microsoft SQL Server.
- Code the measurement tool/game using Excel VBA.

4.3 Analysis

This section describes the thought process behind analysing the possible approaches in the design development cycle and concludes with which design will be most applicable and necessary for successful execution of this study.

4.3.1 Choice of measurement tool to develop

The choice for the design of the measurement tool is a digital board game. The reason for the digital board game is that it is easily understandable by delegates to the programme as Anglo American already uses a board game system for other activities. The board game concept also makes the implementation of SG principles and characteristics easier. The game will resemble the existing physical board game of the Anglo American A3 RMT programme for executives. The game will thus have a different scope than the A3 game, as the daily work objectives of the participants will differ. In the case of the A2 RMT programme, the FLMs/supervisors deal with decisions every day on site which have different risks associated with them. These FLMs/supervisors have tight schedules and therefore their 'currency' in which they deal with is not money, but time. The decisions they make daily influence the outcomes of how well their team on site handles situations and this influences the overall operational performance and safety on site.

The players will play the game, which then generates a score which will be comparable to other participants in the same RMT programme and gives the players the opportunity to improve on their previous score through feedback from the game. These features will stimulate motivation for the user in a competitive environment to help them learn faster and achieve better results (Munoz-Merino, Molina, Munoz-Organero, & Kloos, 2014).

4.3.2 Choice of platform to develop measurement tool

With the objective of creating a game which can be played by participants in a training programme on their respective laptops, as well as capture the resulting scores data and be aesthetically pleasing, it is clear that the game has to be coded. The choice made for the use of Excel VBA is based on the accessibility for participants to play it (just by opening the Excel file on their laptops), the objective of this project (which isn't a coding project, so it can still be basic) and the coding ability and knowledge of the author. The author has completed a course on Excel VBA. The Excel VBA platform is well suited for the creation of 'UserForms' and will incorporate a points system framework associated with different decisions made in the game, as well as capture the scores as usable data.

4.4 Initial design of measurement tool

This section describes in more detail the initial thought process of the game layout and important game elements associated with what the player sees. This was created in relation to an existing board game played by participants of the A3 RMT programme presented by Anglo American for higher levels of management. The game designed for this project, however, is focused more on the safety and risk aspects of daily decision-making and scheduling of tasks, which are common difficulties that participants of the A2 RMT programme struggle with (FLMs/supervisors).

4.4.1 Gameplay

The players/participants move within a two-dimensional (2D) plane on the device they play on. The players/participants are easily guided through the first part of engagement until the point where the actual game starts. The actual game is based on frontline managers'/supervisors' decision-making on a daily basis. In the game they are dealt a set of scenario cards, each of which contains an everyday scenario where they have to decide if they are going to treat the scenario/activity *now* or *later*. These decisions are based on possible outcomes (negative or positive) associated with the decision to treat it *now* or *later*. As the game only assumes a 55-hour (45 normal hours + 10 hours overtime) work week, each card has an associated time to complete, which limits the number of scenarios allowed to treat *now*.

Participants are shown a set of 20 scenario decision cards which give information about the event/job/activity as well as the possible consequences if the event were to occur. According to the time limit of the summed activity times, they can only choose a few to attend to on a short-term basis.

4.4.2 Game-flow

Actions that the participants/players can perform are:

1. Read Risk and Opportunity card and drag the card to the *Treat Now* box. Cards that are left in their positions are automatically chosen to *Treat Later*. Once the 45-hour normal work week time is filled, decisions might be dragged to the *Overtime* box. In the event of an activity/consequence happening that is chosen in the *Overtime* box, the points penalty is greater (as this should have been handled in *Normal Time*) and if the event doesn't occur, the points gain is not as big as it would have been in the *Normal Time* box.
2. As the players move tasks between T*reat Now* and *Treat Later*, they should be able to see the remaining time available in the week in 'real time'. Players are warned if the number of hours is going to be exceeded.
3. Players are allowed to leave 'spare time' for unexpected events. It is thus an interactive environment where the player can move the cards between the 'bins'.
4. Once the player is happy, they can press the 'compile' button to generate a score.
5. They then see new dashboard scores with comments and advice on choices for the next round.
6. Players see their scores compared to others that have completed that round on their site, division and in the whole company.
7. Repeat the next rounds in the same manner (the number of rounds necessary will be dependent on the time availability within the RMT programme).

4.4.3 Game scoring and levels

Scoring:

The scoring system is linked to which task/activities scenario the player decides to attend to first (with limited available time to complete activities), and which activities they attend to later. These decisions increase or decrease the players' dashboard indexes which comprise of the following aspects:

- Operational Performance;
- Safety, Health & Environment;
- People & Leadership.

It should be noted that each of the scenario activity cards will have different weightings with respect to each of the above-mentioned dashboard aspects. The scoring system with increase and decrease of dashboard scores will be based on risk decisions front line managers/supervisors have to make. The player is faced with a set of cards displaying different work scenarios. The player must decide to attend to the activity/task *Now* or *Later*. Each card holds its own level of likelihood and consequences that will affect the dashboard scores. Each scenario, however, has an associated time to complete, and with only limited time available the player can only choose *Now* to attend to the activity/task which the player thinks is of highest importance.

The player must thus base decisions on a trade-off between the amount of time available and the level of significance that the player associates with an activity/task according to its importance and time it will take to complete. Decisions made are also subject to a level of randomness of the likelihood of the events actually taking place. Once players have made their decisions, the game determines which events/opportunities actually occurred. In order to compare scores on a course-by-course basis, the randomness assigned to each activity/task is the same from player to player. However, the randomness changes between courses and between rounds. If an event was prevented from happening the player is given points. However, if an event happens which was not actioned, the player is penalised. The points gained/penalised will be weighted per category for each task, which impacts the overall dashboard scores.

Rounds:

For both the purpose of better learning and the measurement of improvement data, the decision game will be played in three rounds. After each round the player would be given feedback from the system on how to improve decisions, in terms of the order of decisions made from the previous rounds. The players are thus allowed to review their decisions in the second and third rounds in order to increase their dashboard scores.

All players start the first round with exactly the same dashboard scores. After each round, a player ranking is displayed for the participants, showing their accumulated points after that round. This enables a competitive side to the game, contributing to a cognitive need for improvement. Through this, better learning is assured through repetition.

4.4.4 Card options

Examples of typical scenario cards that will be displayed for the players to rank according to their risk association, can be seen in Appendix A. Each card has an associated time required to complete the task, and a decision on whether to complete the job now or to treat it later. The tasks treated now may not exceed the limit of a summed number of hours which is 55 hours, to make it realistic – assuming a normal work week is 45 hours + 10 hours overtime. In the real world, time costs money. In this game the supervisor/frontline manager's 'currency' by which they make decisions is *time*. In the game, a player is thus rewarded or penalised for using overtime for specific events:

- If the player uses overtime to treat an activity/task which does not happen, then they get penalised.
- If the players have overtime left but chose not to treat a task which then happens, then they are penalised (but less severely).
- If the players used overtime to treat a task and it happens, then they are rewarded. However, the reward is less if some of the tasks did not happen in 'normal time'.

4.4.5 User interface

The purpose of the user interface section is to clarify the means by which the user will interact with the game. These systematic interactions can be seen in the flowchart in Figure 4-2. Each heading represents the interface that will be displayed on the data screen as seen by the user. From there the users will decide the path they would take on the platform.

Flowchart:

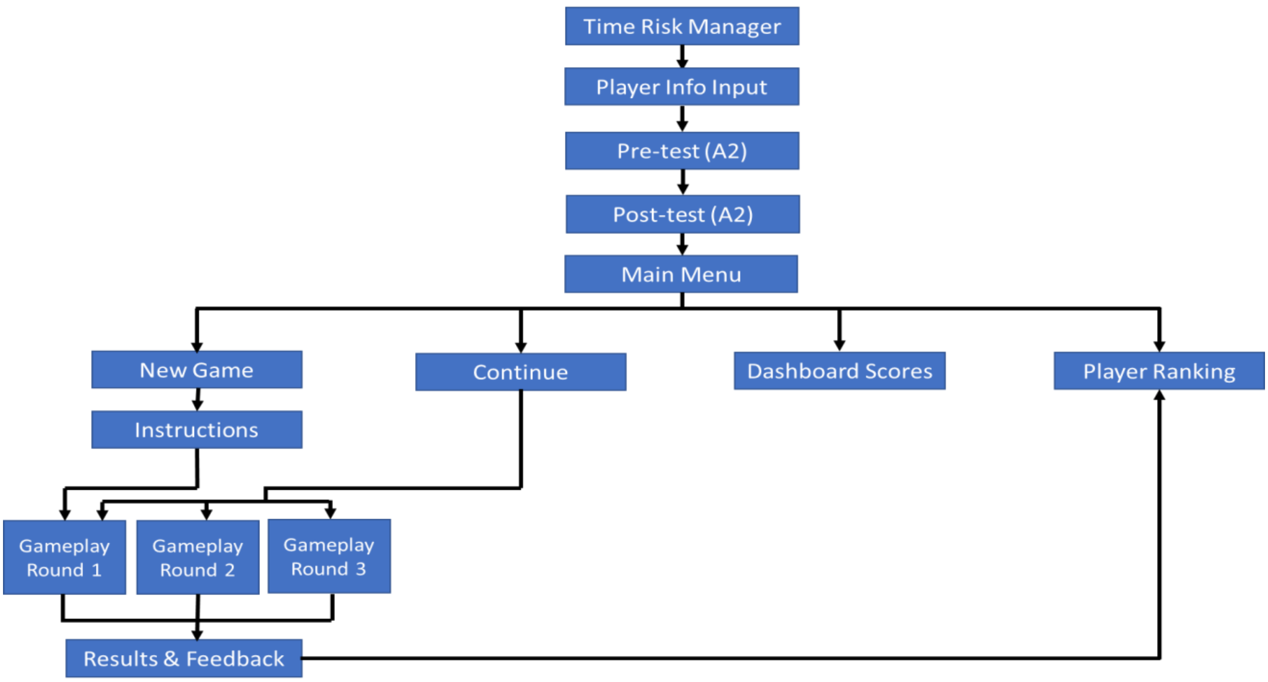

Figure 4-2: User interface flowchart

Functional requirements:

- *Time Risk Manager:* Initial landing page showing the game logo and introduces the player to the game.

- *Player Info Input*: Screen that presents the player with the screen to input details such as their names (or alias), work site location, their division and employee number. The work location and division they work at is presented in the form of a drop-down list with all the specific possible work locations and divisions. The reason for this gives continuity in options selected instead of participants possibly misspelling, making referencing difficult.
- *Pre-test (A2):* After completing the Player Info Input, the player is presented with a compulsory *Pre-test*. The *Pre-test* must be completed before the A2 course at the course venue. Only when this test is complete will the player be able to access the *Main Menu* of the game. A pre-test will enable the author to form a baseline of the theoretical knowledge that the delegates have of the concepts discussed and learnt in the A2 programme.
- *Post-test (A2):* This option is unlocked for players once the *Pre-test* is complete, the A2 ORM course has been completed and all the content covered. By doing a post-test, the author will gain insight to the theoretical knowledge of the delegates who completed the A2 programme and compare this to their knowledge before their attendance.
- *Main Menu:* Presents the player with the different options to view aspects of the game, as well as a graphic background to introduce the theme of the game. The *Main Menu* option only becomes available or unlocked once the player has completed the *Pre-test* (which is done at the start of the A2 course).
- *New Game:* Screen which leaves the player the option to proceed to a new game.
- *Instructions:* After New Game on the Main Menu is selected, the player is given instructions on what to do in the gameplay modes to come.
- *Gameplay (1,2,3):* The main part of the game consisting of players playing a minimum of three rounds, where players must choose decision cards based on what they think are the best tasks to complete this week and which tasks to leave for the next week, based on the possible risks associated with leaving tasks for later. These decisions are also based on time availability in the week and tasks having specific times for completion. The gameplay is, however, open-ended, so that players can decide to repeat the game as many times as they want, to try to improve scores.
- *Results & Feedback:* The game will analyse in what section of the dashboard (*Operational Performance*; *Safety, Health & Environment*; *People & Leadership*) the players attained the lowest score. Based on the lowest dashboard score, the user gets feedback tips on how to improve their decisions in the next round. After each round, only that round's score is shown to the player, thus they start from a 'blank sheet' each time.
- *Player Ranking:* When selecting this option, the players can see their ranking of the game compared to people from their division, work area, job sector and even the whole company. The

ranking is based on the sum of the scores of the three dashboard areas. This feature promotes the idea of a competitive game where players might want to improve their ranking.

- *Dashboard Scores:* Displays the player's dashboard scores after each round. This can be accessed from the *Main Menu* just for reference.
- *Continue*: Displays the options for the user to continue to the next round of the game which will lead the player to *Gameplay (1,2,3).*

Interface Mock-Ups:

1. **Time Risk Manager**

This screen will display a colourful mining safety associated background, with the title of the game superimposed over it.

Figure 4-3: Time Risk Manager home screen mock-up

2. **Player Info Input**

At the start of the game the *Time Risk Manager* screen appears briefly, followed by the Player Info Input screen allowing players to enter their information. The *Player Info Input* has five inputs including *Player Name*, *Employee Number*, *Division (e.g. Iron Ore)*, *Work Area (e.g. Sishen)* and *Job Sector (e.g. Mining, Plant, Engineering, or Services)*. The last three inputs can be selected from a drop-down list to ensure easy reference and no loss of data due to possible misspelling or incorrect name. When a player finishes entering their details, they press the 'Save details and continue' button to continue to the *Pre-test*.

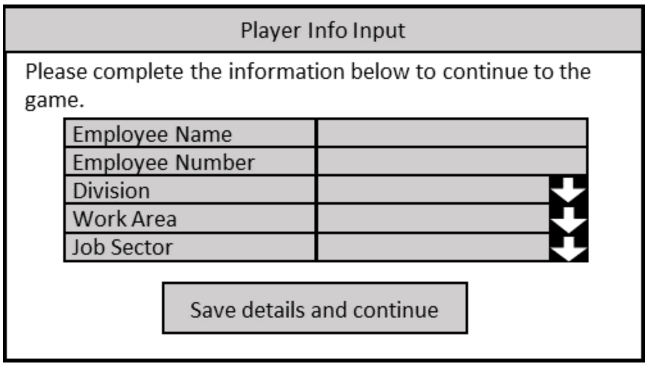

Figure 4-4: Player info input mock-up

3. Pre-test (A2)

Before unlocking the *Main Menu* leading to the gameplay options, players/participants are presented with the compulsory Pre-test that contains works which are covered in the A2 ORM course. Once the *Pre-test* is completed, the *Main Menu* is unlocked and the A2 course commences whereafter players/participants are allowed to continue to the *Main Menu* for gameplay.

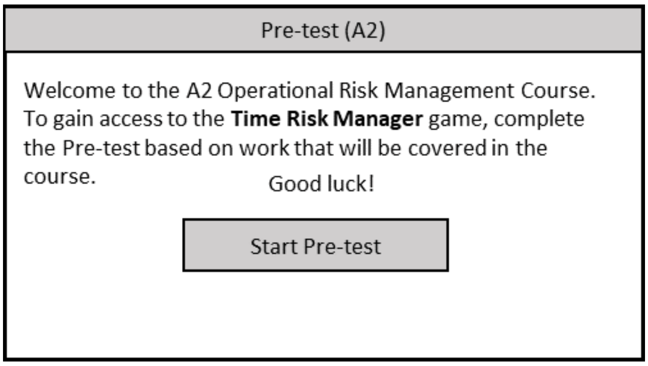

Figure 4-5: Pre-test start button mock-up

4. Main Menu

The *Main Menu* is the landing page the player sees after completing the *Pre-test*. This leaves them with several options including; seeing their current *Dashboard Scores*, seeing their current ranking with respect to other divisions and work areas in the company, or continuing to the next round of the game.

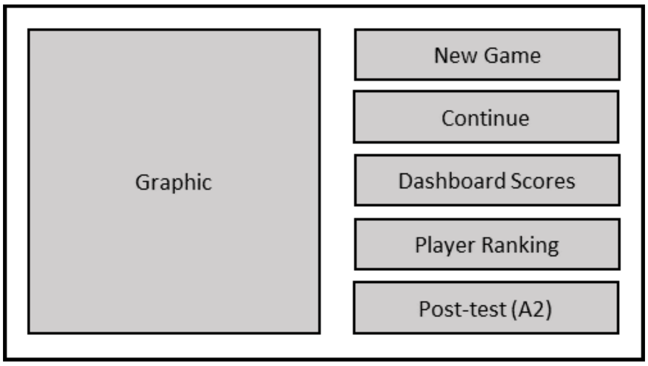

Figure 4-6: Main menu with game choices mock-up

5. Instructions

Before playing the first round of the game, an instructions page appears after *New Game* is selected on the previous screen. This gives the player a brief explanation of how to play the game. Once the player is done reading the instructions, the *Continue to round 1* button is selected to start with round 1 of the game.

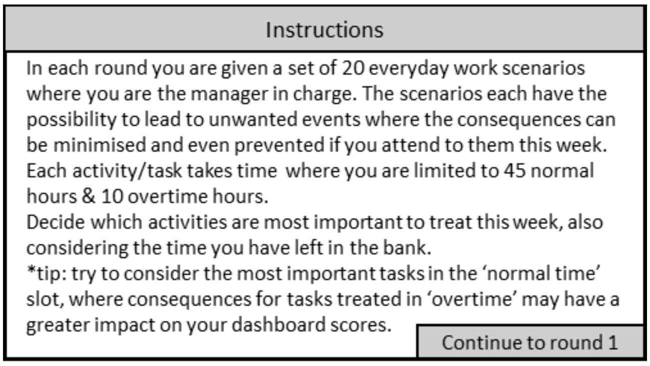

Figure 4-7: Game instructions page mock-up

6. Gameplay (1,2,3)

In the 'Mock-up' below it can be seen that the scenario cards are numbered. This is the setup for the actual gameplay mode, and involves the player dragging the task cards selected to be Treated now (this week) to the *Treat now* bin. The numbered decision cards are small, but when panned over or clicked on, they enlarge to show the scenario details as can be seen in an example in Appendix A. The time associated with each card (task) is subtracted from the *Time remaining* indicator as the card is dragged into that bin. Once the time limit is reached in the *Normal Time* bin, a player has the option to drag cards into the *Overtime* bin (which holds higher consequences i.t.o. dashboard scores). Once decisions are final, the player can click the *Compile* button which will generate dashboard scores. This 'Mock-up' will look the same in all three rounds of the game.

Figure 4-8: Gameplay with decision cards mock-up

7. Results & Feedback

After selecting the *Compile* button, the game generates scores for the different dashboard scores. It will assess in which areas the player was lacking or attained the lowest score in the specific round and give a tip or feedback advice on possible reasons for the low score and how to improve it. After the player has read the advice, they can either select *See ranking* which shows the player's ranking with respect to other people on their division, work area, job sector or even the whole company. The other option is for the player to select *Back to Main Menu* and head back to the *Main Menu* page to start the next round.

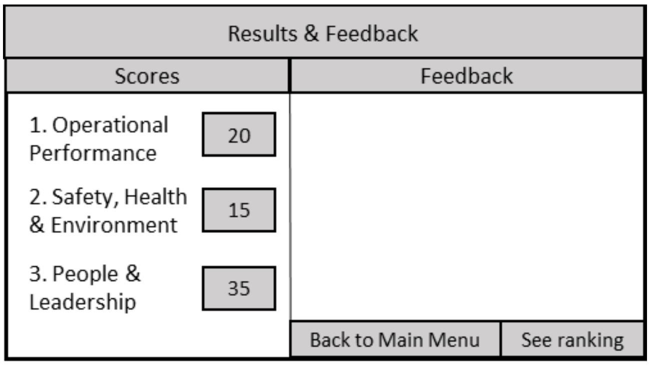

Figure 4-9: Results with feedback page mock-up

8. Player Ranking

This is where the players can view their overall score compared to other people who have completed the game at that point. The ranking is listed i.t.o the player's division, work area, job sector and even the whole company. After the player has viewed this option, they can select Back to Main Menu to go to the Main Menu where other game options are available, and where they can continue to the next rounds of the game.

Figure 4-10: Player score and ranking page mock-up

9. Dashboard scores

The dashboard displays the current scores the player has on the various fields including *Operational Performance*, Safety, *Health & Environment*, and *People & Leadership*. After each round these scores change, which also changes the player's ranking accordingly. The ranking is shaped by the sum of the dashboard scores. The higher the better.

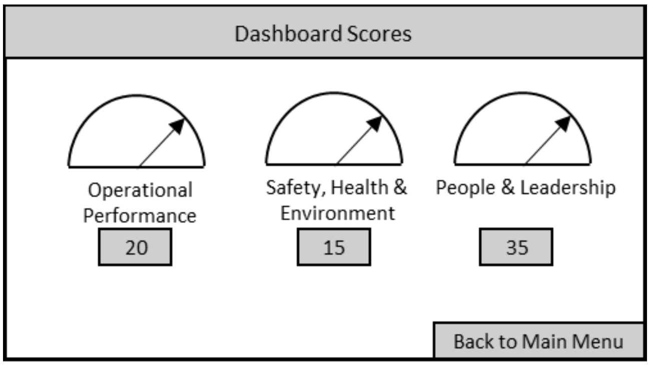

Figure 4-11: Player dashboard scores mock-up

10. Post-test (A2)

Once the player has completed the game, this option unlocks and leaves them to complete the Post-test. The pre- and post-tests are the same for all participants, although the two tests differ from each other in order of questions as well as some of the questions. The two tests are on the same difficulty level.

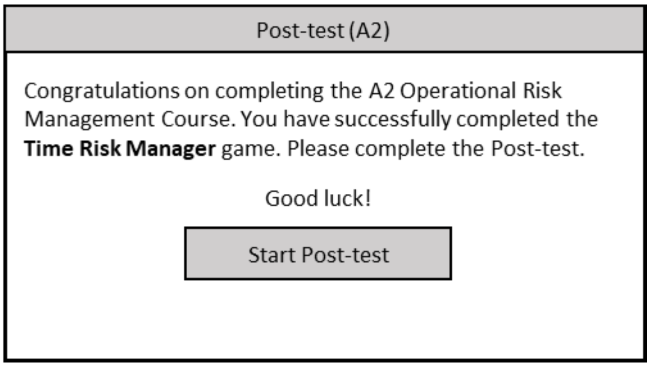

Figure 4-12: Post-test button mock-up

4.5 Changes from initial design

<u>Pre- and post-tests</u>

It was decided that the pre-test (written before the training programme) and the post-test (written after the programme) in order to measure the knowledge uptake of procedures and principles of the programme, will be written separately from the *Time Risk Manager* game, and not connected to the game. The data of the two tests will be gathered separately along with observational data of collaborative in-programme activities.

<u>Gameplay:</u>

The game cards were changed from the initial design in terms of the duration of a task/activity and the time available in a week. The assumption was made that a typical work week includes 40 normal hours + 10 overtime hours. From the random 20 scenario cards presented each round, the time constraint is designed to reach a maximum availability after picking 10/11 scenarios to treat in the present week.

Player Ranking:

At this stage of the design and to enhance the applicability to this level of management, it was decided that instead of showing the player's/participant's rankings in terms of the player's division, work area, job sector and even the company, a more collaborative environment should be created while playing the game. Participants will be encouraged after each round to share their respective dashboard scores and their calculated dashboard average scores. With this collaborative environment, the competitive aspect will still be a factor as the highest-ranked player in each dashboard category would be named and asked opinions about their strategies. The same will go for the player with the highest-ranked average score.

4.6 Final design

4.6.1 Game philosophy

The game philosophy of on-site decision-making is based on factors which influence the dashboard scores of the player (Operational Performance; Safety, Health & Environment; People & Leadership). These factors in daily on-site decision-making are adopted from the workplace model, also referred to as the Nertney Wheel (Bullock, 1979).

For safe productivity in a controlled work environment, the four main components of the Nertney wheel were considered when looking at daily operating decisions a front-line manager must make on site. These four components, as can be seen in Figure 4-13, are:

1. People/competency;
2. Equipment integrity;
3. Work methods/operating procedure;
4. Controlled work environment/supervision.

Figure 4-13: Nertney Wheel (Bullock, 1979)

When it comes to the role of the supervisor/FLM on site, the decisions made are sometimes of the nature where their outcomes may have consequences if not handled correctly or on time. Safety in the long run of decision-making is thus of highest importance to the team on site, with time being one of the main constraints. The nature of the decisions to be made in the *Time Risk Manager* game are designed to be categorised into the four components of the Nertney wheel, as these components need to be addressed to maintain a sustainable and safe work environment.

On a daily basis, the FLM on a mining site will come across questions/decisions which all hold a certain degree of risk and possible consequences. These questions/decisions have time constraints which also need to be considered in the process of task planning and scheduling. These decisions typically relate to the four components of the Nertney Wheel as listed in Table 4-1 (Anglo American ORM, 2017).

Table 4-1: Typical scenarios a supervisor/FLM faces i.t.o. The Nertney wheel

People/ competency	Equipment integrity	Work methods	Supervision
Do my team members have the right knowledge/ skills to complete the task as designed?	Do we have the right tools/ equipment for the task?	Are the task steps clearly defined? Are we clear about the scope of the task?	Have I communicated the objectives of the task effectively?

People/ competency	Equipment integrity	Work methods	Supervision
Can team members apply the SLAM tool effectively to manage unplanned changes?	Are the tools/ equipment performing as designed?	Does every member of the team know the procedure to be followed to complete the task?	Does each member of the team know their roles/responsibilities?
Do they understand the hazards associated with the task?	For tools/ equipment that have broken down, can I complete the task with defective equipment? Or do I need to stop the work until the equipment is fixed/replacement equipment in place?	Have we completed adequate task risk assessment to ensure that all hazards have been identified, and controls in place to mitigate all unwanted events?	Are procedures being followed, controls being implemented as per design? (JRA/ WED)
Do any team members require special on-the-job training before we begin the task?	Can I afford to keep this equipment operating beyond the scheduled service interval?		Am I aware of issues among team members that affect their ability to do their work? (e.g. personal issues)
If competency issues have been identified during the task, should I keep the person on the team? If so, in what capacity?			Can I afford to exclude a key team member due to personal challenges? (e.g. arrived at work intoxicated)

The decisions made by the FLM are based on the four pillars of the Nertney Wheel. By considering the possible consequences versus the likelihood of events occurring, these four pillars then translate to the three dashboard score levels of the game, as seen in Figure 4-14.

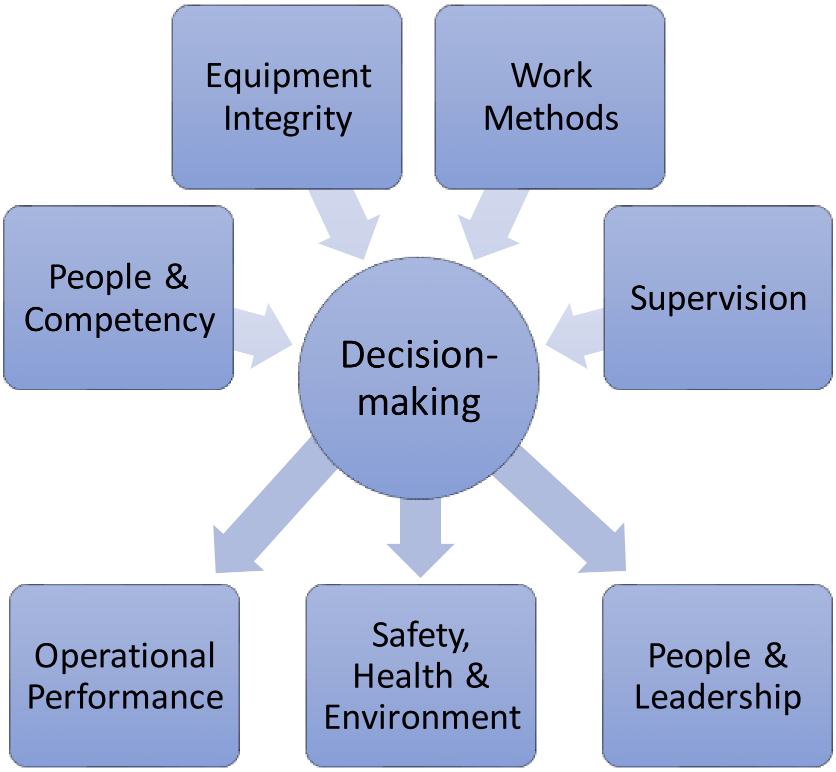

Figure 4-14: Nertney wheel concepts translated to game scoring system

4.6.2 Points system framework

The 'points system framework', or more simply put, the system followed for awarding points for scenarios decided to 'treat now' or 'treat later', is related to the four management principles of the Nertney Wheel as seen in Figure 4-14. The 20 randomly picked scenario cards a player is dealt at the start of each playable round, are picked from a pack of 32 possible cards, which are derived from the four Nertney wheel categories (thus eight possible cards per category). In each category, the eight scenarios are ranked with an importance factor (1 being of highest importance and 8 being of lowest importance) in terms of seriousness of an event occurring due to treating or not treating the scenario. According to these importance factors, time estimations are made for how much time is spent on the problem. The time spent is essentially the FLM's 'currency'. The process explained can be seen in Figure 4-15.

Each of the possible scenarios influences the three dashboard scores (*Operational Performance; Safety, Health & Environment; People & Leadership)* with respective scores added or subtracted in each category for a scenario decided to 'treat now' or to 'treat later'. The total number of hours available in the four Nertney wheel categories are 40 hours and the total points available in each of the three dashboard score categories is 160 points. A table with the explained points system framework can be seen in **Appendix C.**

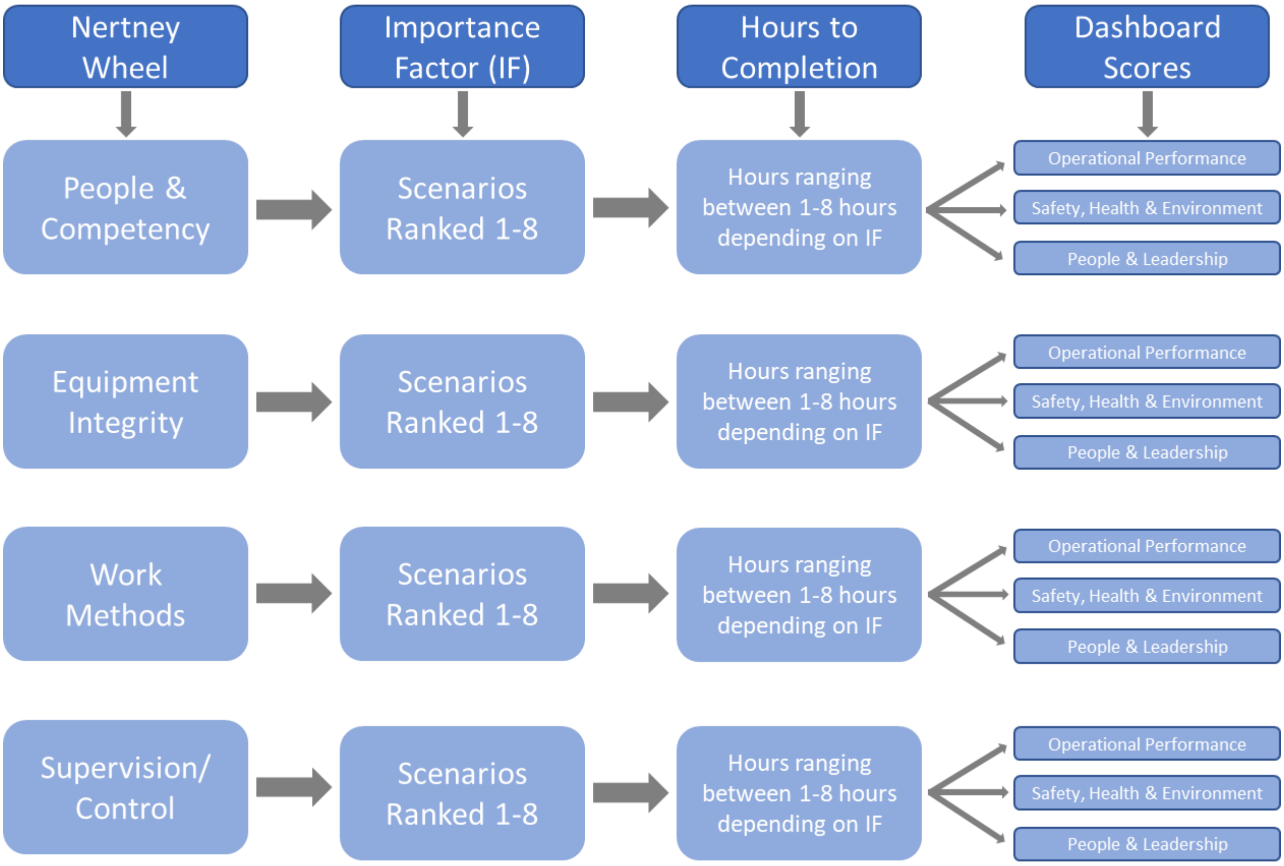

Figure 4-15: Flow diagram explaining the points system

Of the eight scenario cards created in each of the *Nertney Wheel* categories, each has a different importance and impacts associated with them which influences the dashboard scores. Each round that is played presents the player/participants with a randomised selection of these scenarios in a random order.

4.6.3 Final user interface

After the decision to develop the game on Excel VBA and all the information and skills required were gathered, the user forms were programmed to provide a user-friendly platform which gives the players/participants a chance to play and improve their dashboard scores, as well as capture the scores data in the background. A visual representation of the final user interfaces is as follows:

4.6.3.1 Excel landing page

Once the Excel file is opened, this is the first interaction the player will have. Once this button is clicked on, the Time Risk Manager home page will pop up.

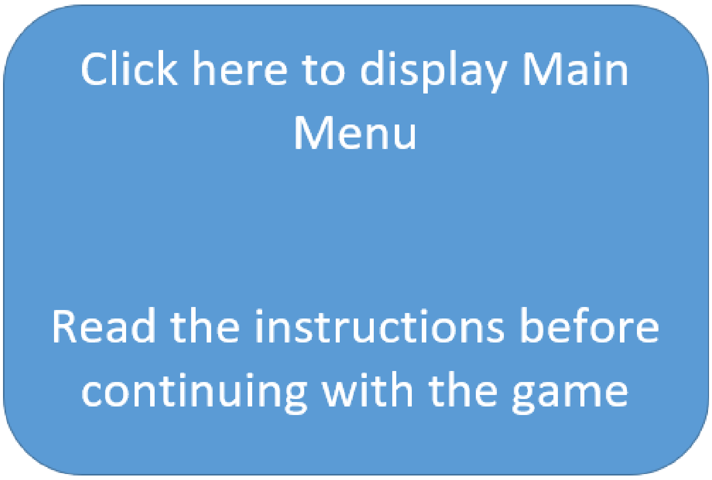

Figure 4-16: Excel sheet 'start' button

4.6.3.2 Time Risk Manager home page

The home page also serves as the *Main Menu* for the game and is the visual that the player sees after selecting the Start button on the Excel file. From here the player/participant can choose to start a *New Game*, whether it is the first time they're playing or after that. The players are encouraged to first read the game instructions by clicking on the *Show Instructions* button. The player can also choose to view their current *Dashboard Scores* from this page.

Figure 4-17: Time Risk Manager home page

4.6.3.3 *Game Instructions*

This page opens after clicking the *Show Instructions* page from the Home page. The player gets a chance to read the game philosophy, game objectives and a game tip. Once done reading, the player exits this page by clicking on the cross in the top right corner, which then takes them back to the home page where they can start a *New Game*.

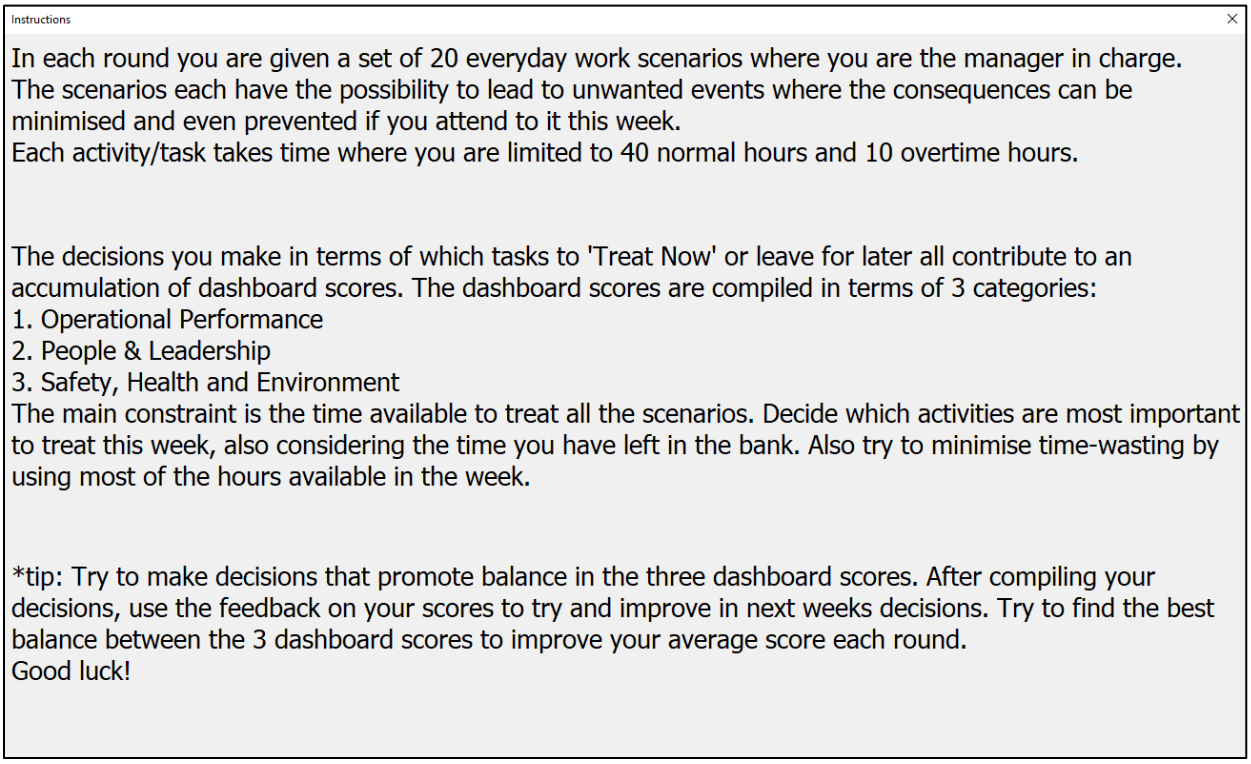

Figure 4-18: Game instructions window

4.6.3.4 *Gameplay*

The description for this part can be visually seen in Figure 4-19. After selecting the *New Game* button in Figure 4-17, this is the gameplay window the players see. The numbered decision cards on the left are a set of randomly generated scenario cards as explained in the design philosophy. When a card is clicked on, its description with possible task treatment is shown below it. Using the arrows to the right-hand side of the cards, players have a choice to either put the selected card in the *Normal Time* or *Overtime* box, until the number of hours left are done. The time associated with each card (task) is subtracted from the *Time remaining* indicator as the card is dragged into that bin. Once decisions are final, the players can click the *Compile* button which will generate dashboard scores along with relevant feedback. If players are not satisfied with their decisions, they may choose the *Start Over* button, which will reset the scores as well as generate a new set of randomly generated scenario cards. If players decide to quit and go back to the home page, the *Done* button can be clicked.

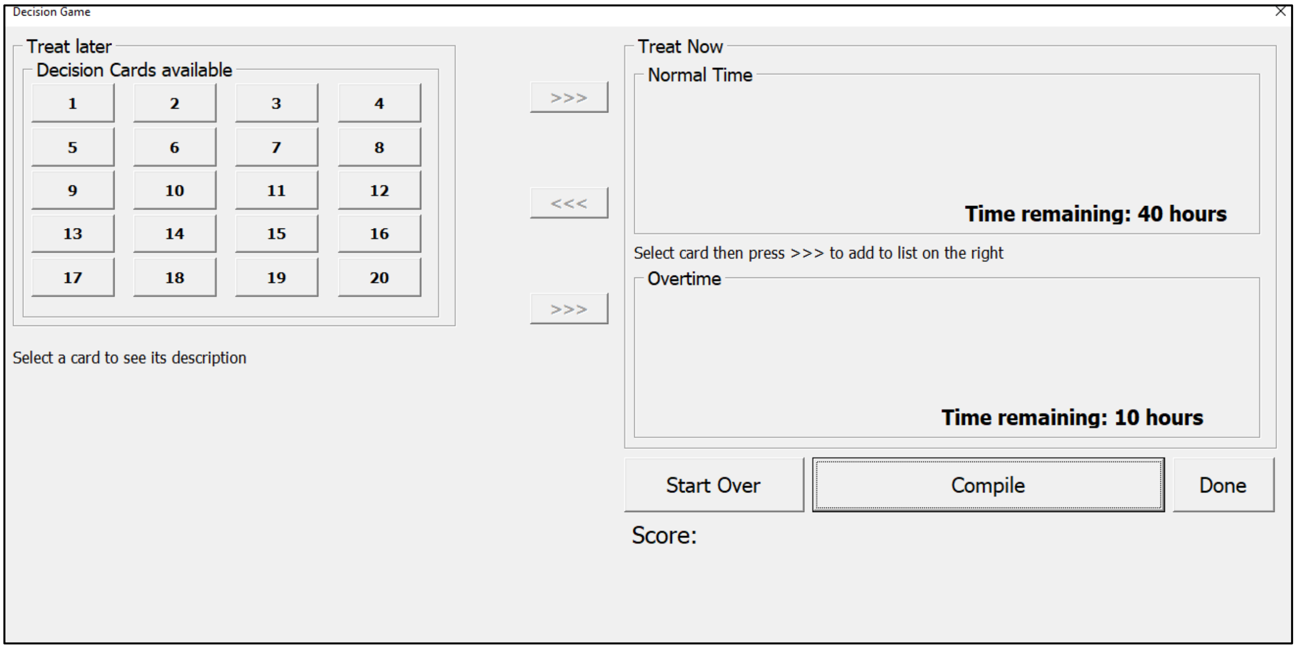

Figure 4-19: Gameplay decision window

4.6.3.5 Gameplay when a card is clicked on

Figure 4-20 illustrates what the gameplay window looks like when a card is clicked on. As explained above, the respective scenario card's description (Risk identification) pops up along with a possible risk treatment, as well as the number of hours associated with the treatment of the risk. Once all decisions are made, and there is no time left for the week, the Compile button is clicked on and the dashboard scores are shown.

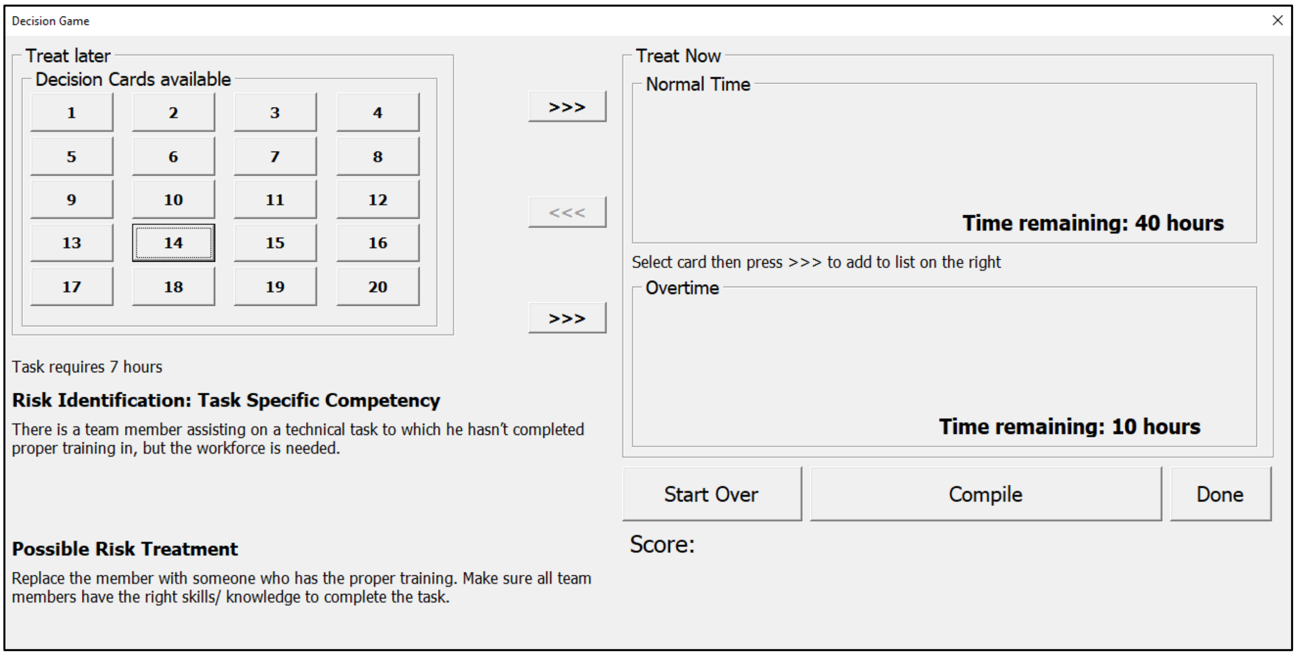

Figure 4-20: Gameplay illustration

4.6.3.6 Gameplay with time availability restriction

When a player reaches the point as seen in Figure 4-21, where there is insufficient time left to treat any more scenarios/tasks, the player will be unable to click on the Compile button and generate dashboard scores. If the time limit is reached, the players can click on the selected cards again respectively and decide to remove them from the *Treat Now* block by selecting the cards and clicking on the arrows pointing to the left.

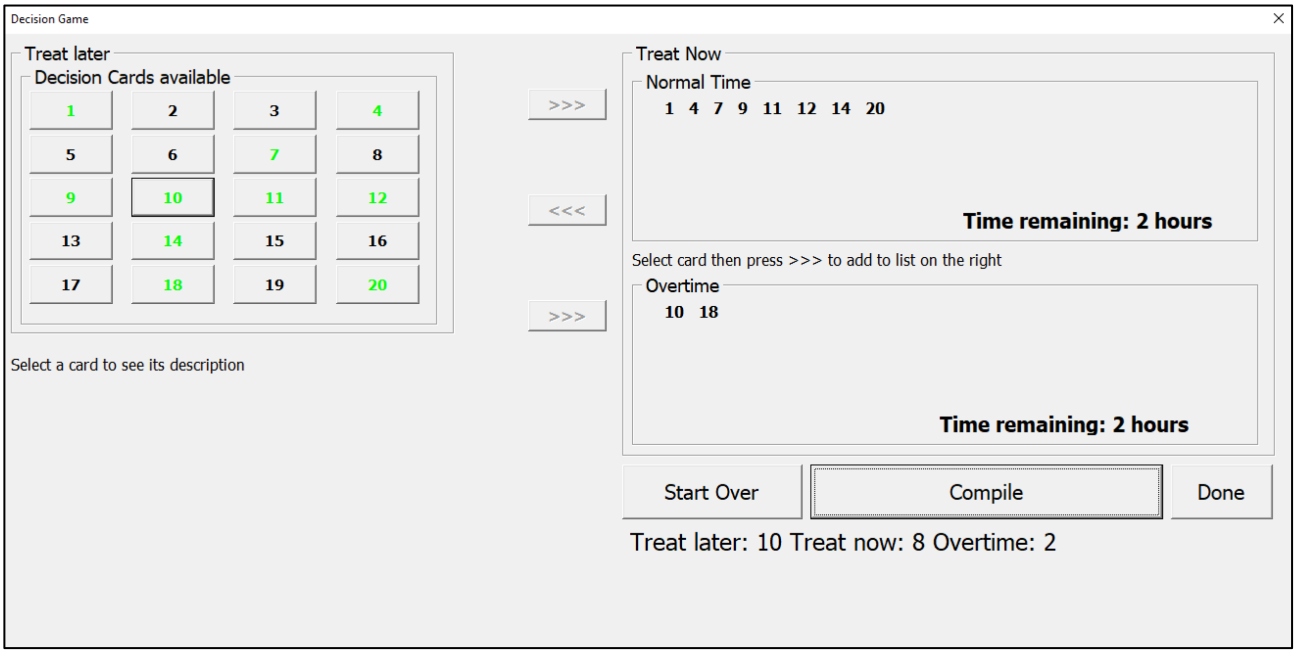

Figure 4-21: Gameplay illustration

4.6.3.7 Dashboard score and feedback

Once the Compile button is selected after the decisions have been made, a UserForm looking like Figure 4-22 will appear showing the player's score achieved in each dashboard category, as well as the average score. Feedback is also given to the player on what they should focus on in the next round in order to improve their scores. Once the *Return* button is selected the player is faced again with a UserForm similar to Figure 4-19 and left to play and try and improve their scores, and ultimately improve their average score.

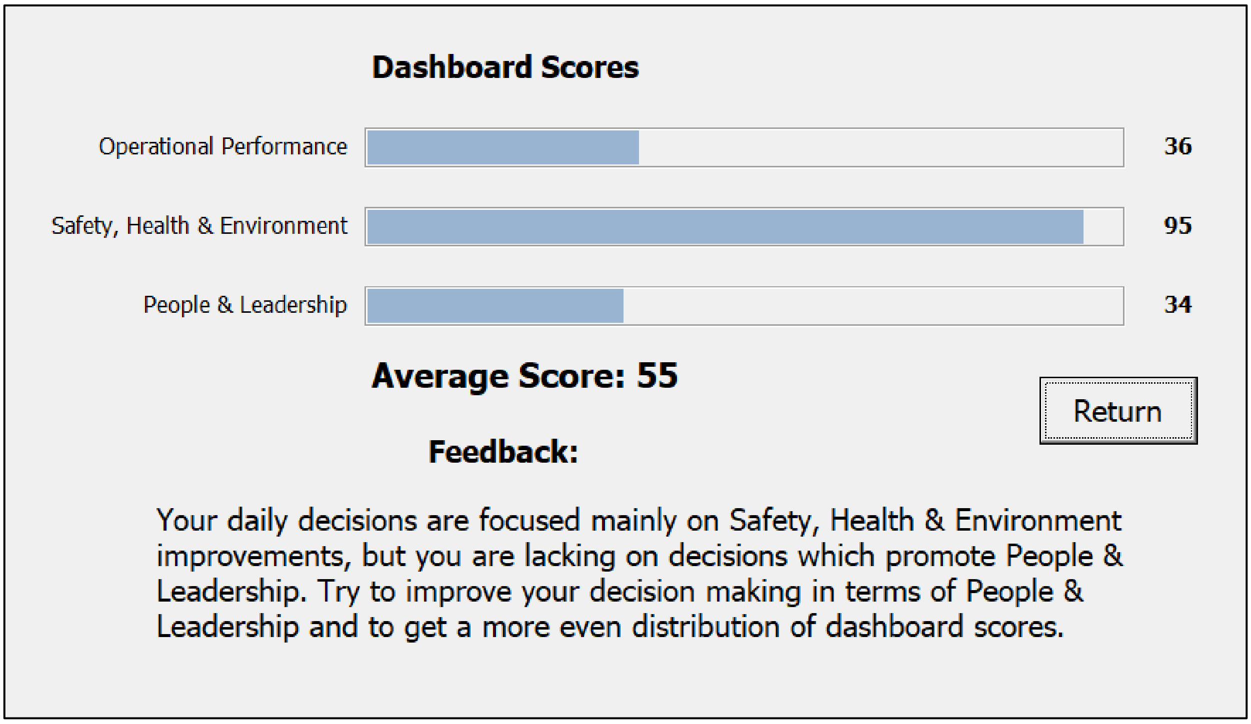

Figure 4-22: Dashboard score window after compilation (1st round)

4.6.3.8 Dashboard improvement

The players can play as many times as they like to try and get the highest possible average score. Figure 4-23 is an example of an improved average score after playing another round. Although Safety, Health & Environment has decreased, the other two scores have improved, as well as the average score. The player can thus decide on which aspect of decision risk management they want to focus, while still improving their average score.

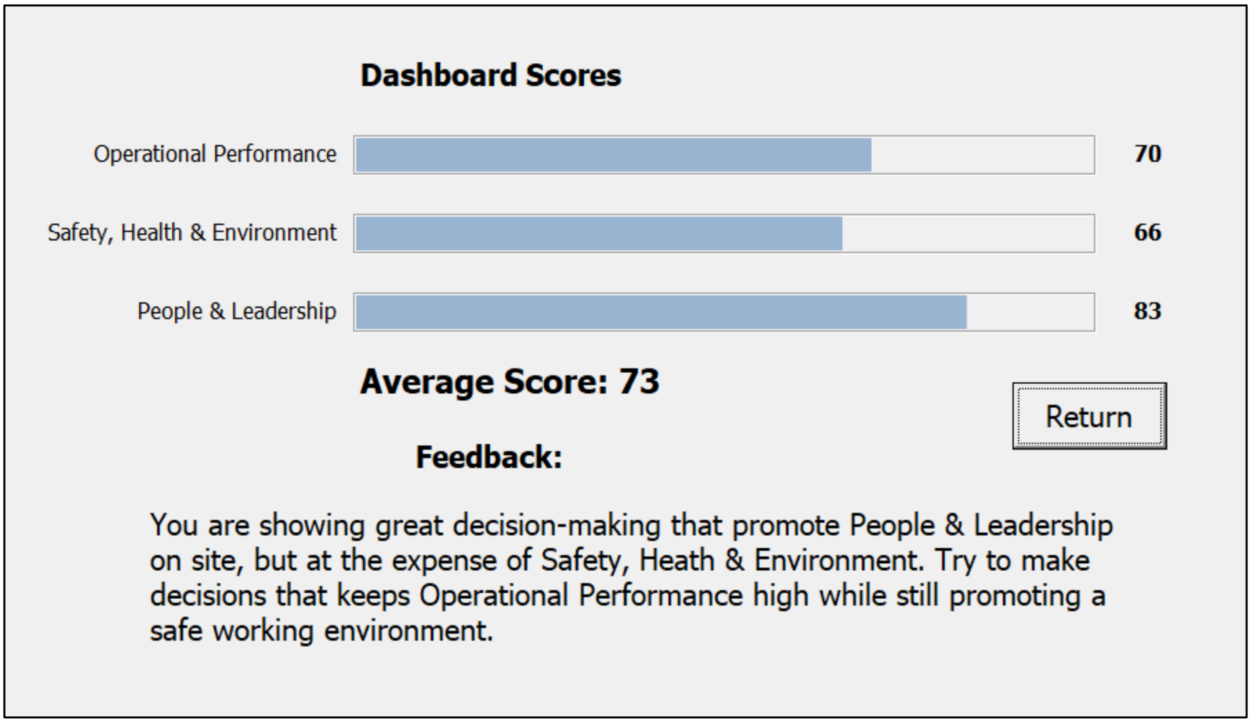

Figure 4-23: Dashboard score window after compilation (last round)

4.6.3.9 Background data collection

A code running in the background of the programmed file, saves the score of each round on a separate Excel page, allowing the capture of the data of different players and to use it for analysis, seeing if and how players improve their dashboard scores and decision-making, as well as which dashboard categories they favour the most or pay most attention to. Figure 4-24 is an example of points data generation after five rounds of playing.

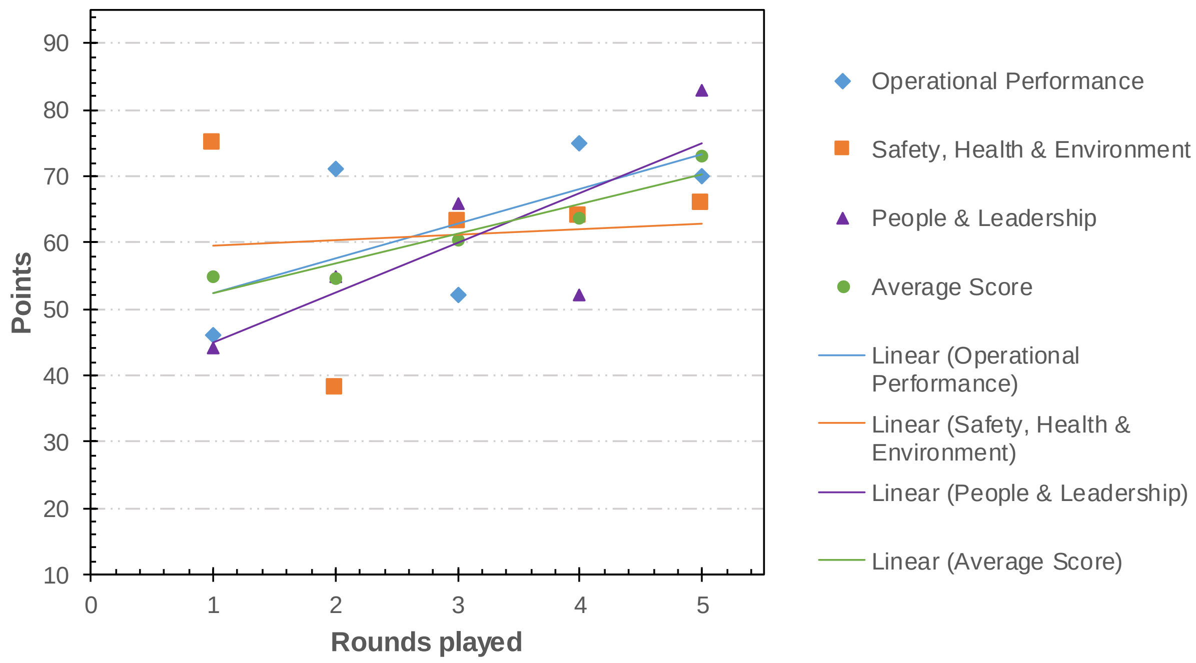

Figure 4-24: Example of dashboard score distribution after five rounds played

4.7 Implementation of measurement tool

To test the game in a real-world scenario with real front-line managers/supervisors attending an actual A2 Risk Management course, the implementation took place during a A2 Risk Management course at two of the Anglo American training facilities. It was planned to test it on a group of supervisors whose primary workplaces are at different locations around these sites. The mining sites are associated with the respective mining sites where the delegates to the programme are supervisors. After the A2 course, the Excel VBA file were given to the participants on either a flash drive or via email, where they will be allowed to play the game for as many rounds as they like to try to improve their scores.

The game is designed in such a manner that it should not take participants more than 10 minutes to play at least five rounds. After they've played, the results are captured in the background of the programmed file and the files will be saved and retrieved for analysis. The game will, however, be played in a collaborative environment where players will be asked their scores in different dashboard categories, as well as to discuss their different strategies and approaches. The players with the highest average scores and highest scores in each respective dashboard category will also be singled out and asked about their strategy on how they improved their scores in the repetitive rounds. The possibility of taking a lucky guess in a game does exist, but as discussed by psychologist, Mihály Csíkszentmihályi, in a game a player reaches a state of 'flow' which enhances the cognitive ability to improve their score through thought (Draeger, 2014).

The analysis of the players' results entails a detailed look into what categories most players favoured at first, how these changed in the next rounds, as well as if and by what percentage margin players improved their score. This data were used to compare to real world KPIs of the specific participants at their respective workplaces. The KPI data of the days leading up to the programme as well as the days after the programme were tested. This data were then also compared to the in-training theory tests the participants did in the A2 course to see if there is any correlation between knowledge gain and effectiveness of the risk management training on how they implement these concepts in the workplace.

4.8 Testing and validation

In order to see if the concept of playing the game and trying to improve your scores by using feedback and focusing specifically on certain aspects of the game, five random subjects were tested who are acquainted with the aspects and concept of the A2 Operational Risk Management course. They all played five rounds of the game to try to improve their scores. The results of this test will serve as a test run to see if and by how much players can improve their scores.

4.8.1 Demographic of subjects

According to Salkind (2010), demographics in research methods form the characteristics of a test population. Examples of demographics include age, gender, race, income, religion and education. Each of these characteristics has an influence on the response to the data collection method and the quality of data collected, which is an important part of the reliability of the data that is collected. In the case of this study, the most important demographic characteristic that influences the data is the occupation. As the game (*Time Risk Manager*) is aimed at supervisory level employees in a mining organisation, the known role of supervisor is an important variable as the game entails certain aspects that supervisory level employees are responsible for on a daily basis. Specific work procedures that are unique to the Anglo American A2 RMT programme are also included in the game, which will influence the results of the game if the player is not acquainted with the terms and correct procedures.

The five selected subjects were merely chosen and tested to get a perspective of the possibility of the game features to promote better learning and knowledge uptake through feedback and repetition, and to improve scores by playing a number of rounds. The subjects were presented with the A2 material to get acquainted with important principles, concepts and risk management associated work procedures. The demographics of the five participants are tabulated in Table 4-2.

Table 4-2: Initial game test subjects: demographics

Subject	Age	Location	Education	Occupation
1	24	Stellenbosch	M.Eng (Civil)	Full-time student
2	24	Cape Town	M.Eng (Engineering Management)	Full-time student
3	25	Stellenbosch	B.Eng (Mechanical)	Project Engineer
4	35	Witbank	Sustainable Development Diploma	ORM Trainer
5	33	Witbank	ORM Training	ORM Trainer

4.8.2 Participant dashboard scores

After reading the instructions the respective subjects' results are as follows:

1. <u>Participant 1:</u>

From Figure 4-25 it can be seen that the participant showed a great natural tendency to favour *Operational Performance (OP)* and *People & Leadership (PL)*, having scores of 79 and 89 respectively. This, however, came with a neglect of *Safety, Health & Environment (SHE)* at a score of 26. The feedback after the second round would have motivated the participant to focus more on, SHE, which the participant did, improving SHE to 53, but the other two categories were then neglected. With the goal being to make the most balanced decisions by following the feedback advice, the participant started to get the hang of their decision-making and increased the scores as well as maintaining a good average score. The player ended round five with the highest set of scores, with an average of 76.3, which is an 18% increase from their original starting average score.

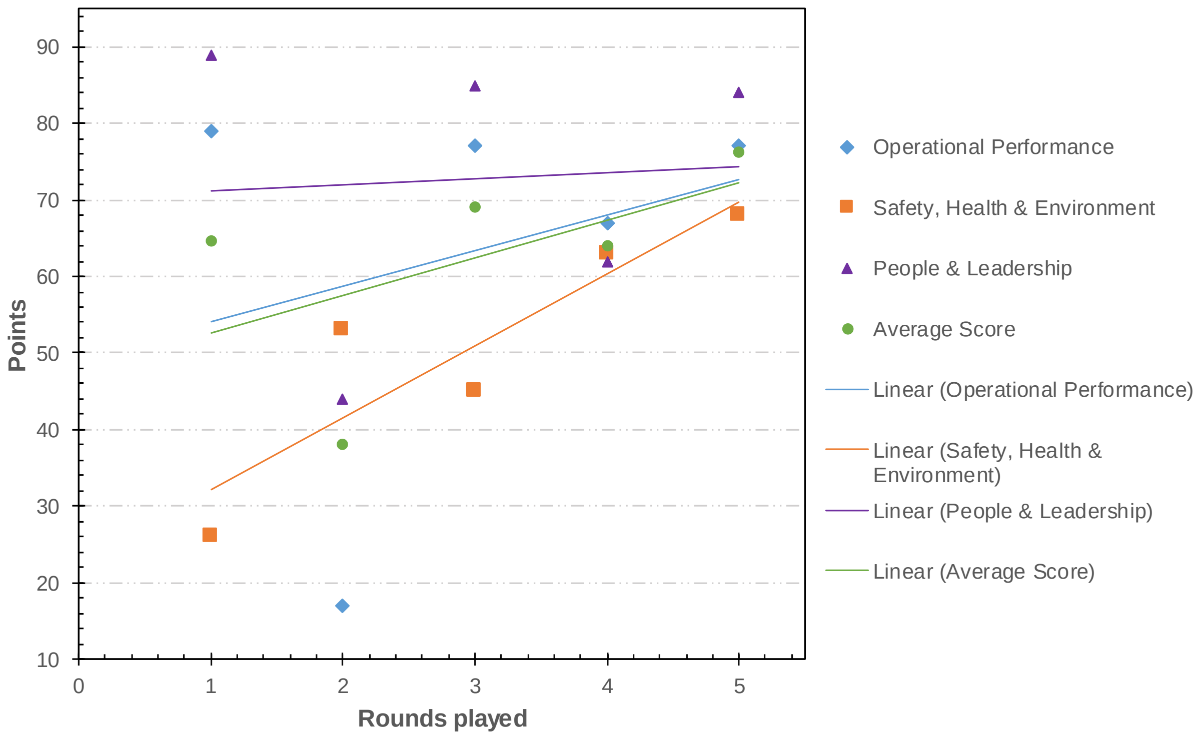

Figure 4-25: Participant 1 dashboard scores distribution

2. <u>Participant 2:</u>

What is interesting to notice in Figure 4-26 is that participant 2 had the same initial tendency to favour OP and PL, and when given feedback and advised to focus on SHE as well, had a great spike in SHE in the second round, increasing by 110% for the SHE category. Although the average score of 71.7% in the second round is high, it was mainly due to the very high SHE scores. In the third to final rounds, participant 2 started to follow the feedback advice and focused more on paying equal attention to all three categories, keeping the average scores very close to each other. It can be seen in round 3 that the dashboard scores are closest to one another compared to the other rounds, indicating the best round in terms of balanced decision-making. Although the participant ended with an average score which is 2.4% lower than the initial average score, their performance still showed an increase in consistency in task planning towards the last three rounds.

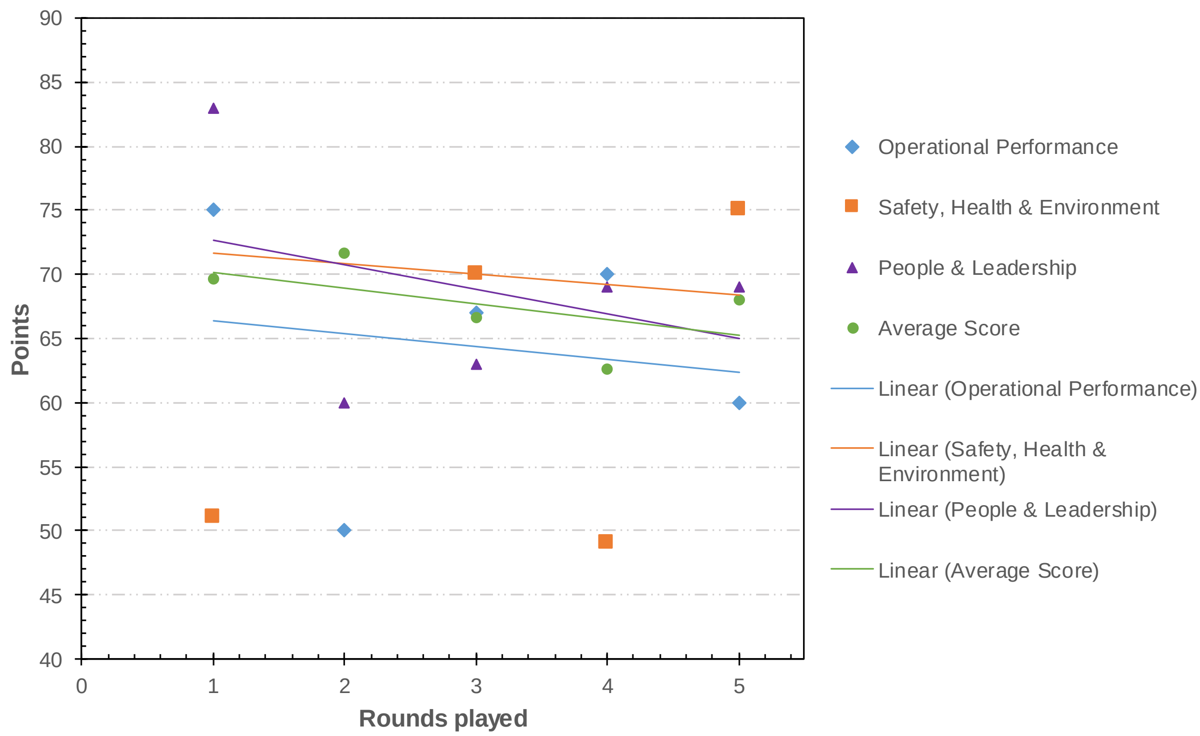

Figure 4-26: Participant 2 dashboard scores distribution

3. <u>Participant 3:</u>

As seen in Figure 4-27, participant 3 initially favoured OP by a great margin compared to SHE and PL. When advised to pay more attention to the other two categories the same trend as participants 1 and 2 followed, where an increase in the advised categories was seen with a drop in the most favoured category of the previous rounds. In addition, the participants started to focus on obtaining a greater average score by focusing on the different categories equally. With participant 3 particularly, it can be seen that by using the feedback advice, the average score increased on every round, ending with a score of 78, which is 52.9% higher than their initial average score.

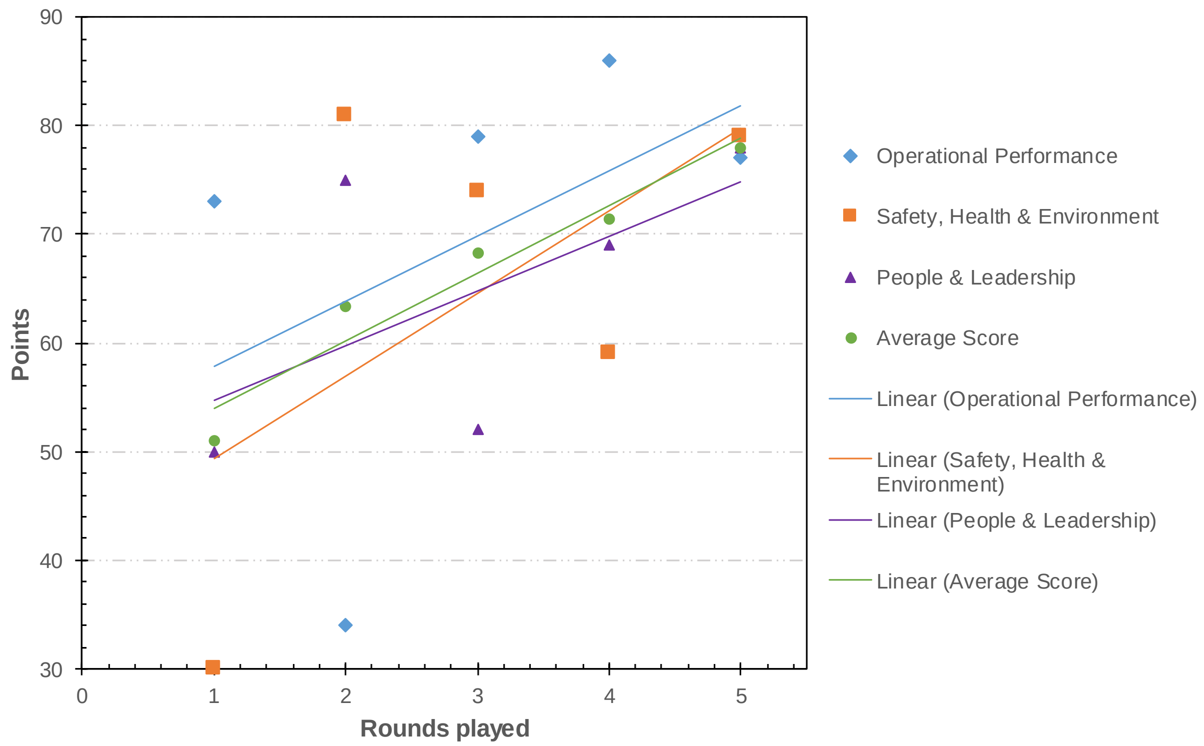

Figure 4-27: Participant 3 dashboard scores distribution

4. <u>Participant 4:</u>

As seen in Figure 4-28, participant 4 initially favoured SHE. When advised to focus more on OP, the participant started neglecting SHE too much. The fluctuation of SHE scores keeps on throughout the five rounds played, while the participant does however succeed in consistently improving OP and PL throughout the five rounds. Due to the constant improvement of OP and PL, the participant successfully increases his/her average score throughout the five rounds, increasing the score by 56.1% from 43.3 to 67.7.

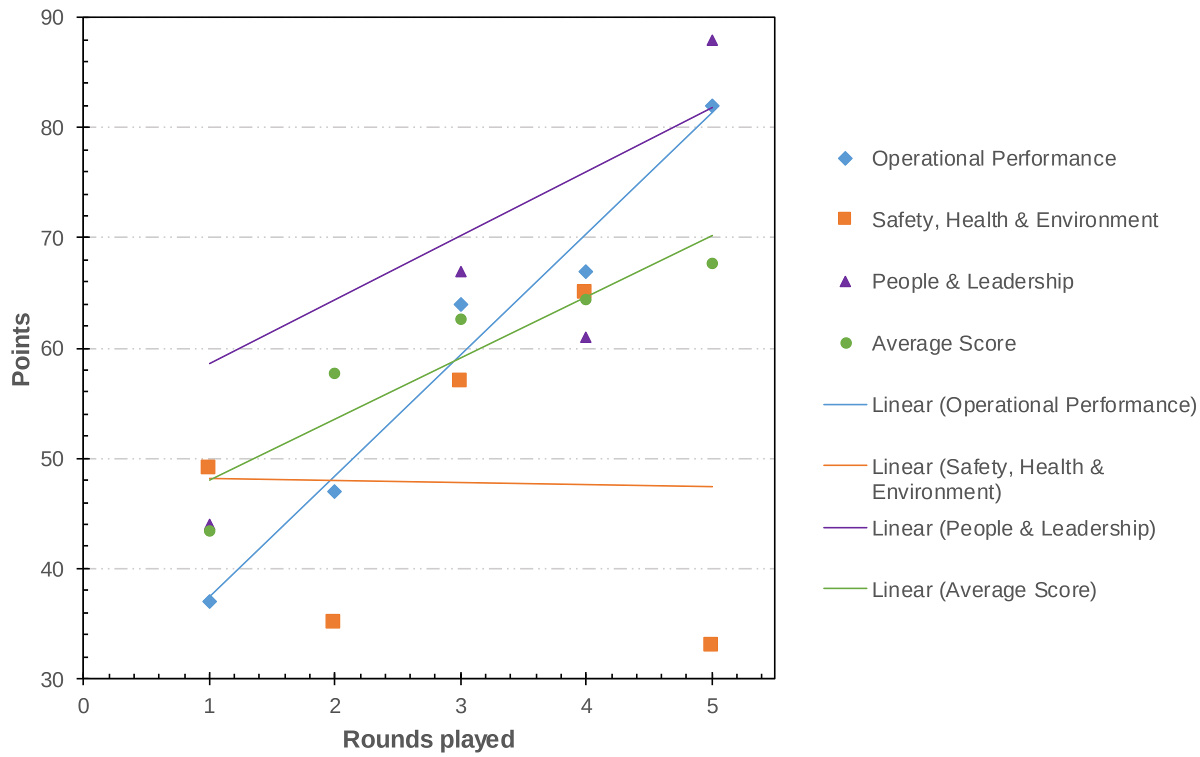

Figure 4-28: Participant 4 dashboard scores distribution

5. <u>Participant 5:</u>

In Figure 4-29 it can be seen that participant 5 focused mainly on PL throughout the five rounds played. The same tendency is seen as with Participant 4, where Participant 5's SHE scores fluctuates throughout the five rounds. Nevertheless, Participant 5 succeeds in increasing all the dashboard scores between the first and the fifth round played. Participant five succeeds in increasing his/her average score by 26.5% from 56.7 to 71.6.

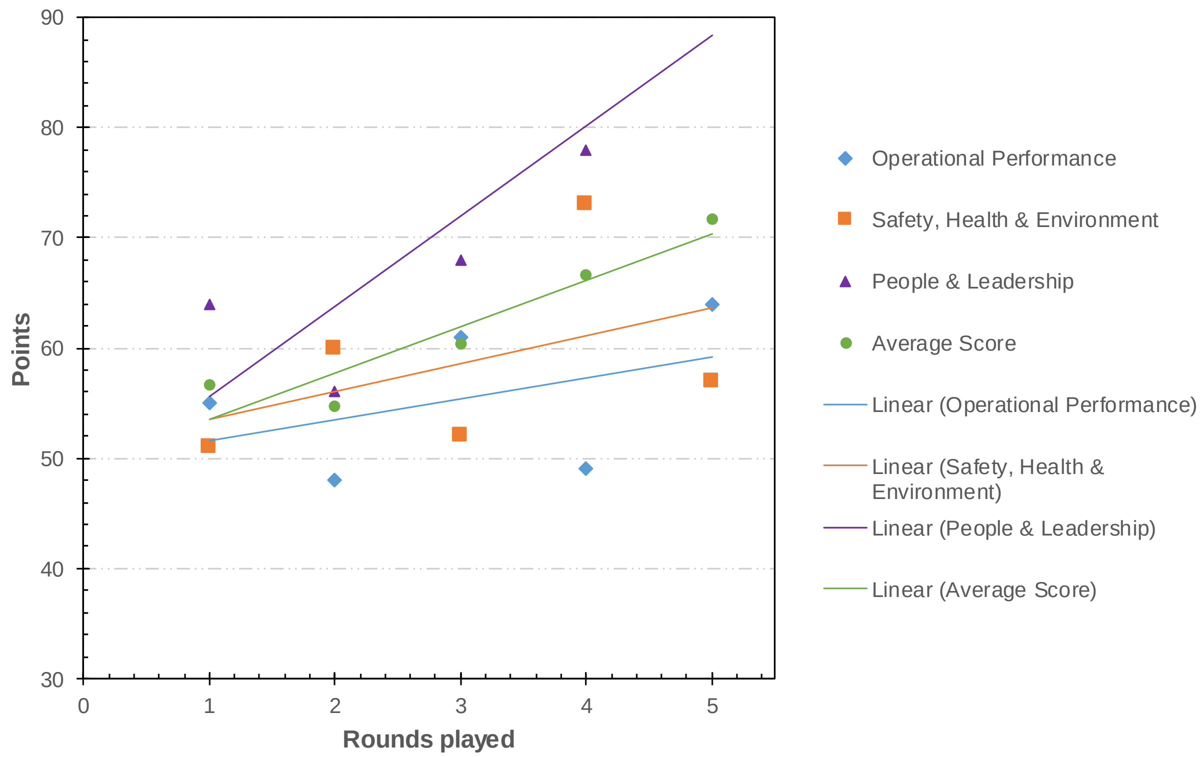

Figure 4-29: Participant 5 dashboard scores distribution

4.8.3 Statistical analysis

To see if there is a statistical improvement (on average) of the five subjects after playing five rounds each, a hypothesis test is done using an analysis of variance (ANOVA) with a fixed effect test calculating the corresponding F and p-values at a 95% confidence interval, as seen in Table 4-3.

Hypothesis:

The hypothesis tested from the test group of five subjects is whether there is a degree of learning achieved though playing a serious game in a training environment or if subjects are able to use the gameplay environment and feedback to improve their scores within five rounds played. A degree of learning would be signified by a statistical variance in *p*-values using a 95% confidence interval. The null hypothesis (H0) and alternative hypothesis (H1) are stated below:

H0: There is no statistically significant improvement in average scores after the five rounds played of the game.

H1: There is a statistically significant improvement in average scores achieved after five rounds played.

At a 95% confidence interval, a p-value ($p<0.05$) will reject H0 and accept the case of H1.

Table 4-3: Fixed effect test to calculate the p-value: average scores of test subjects

Effect	Fixed Effect Test for Average Scores. restricted maximum likelihood			
	Num. DF	Den. DF	F	p
Round	4	20	3.38	0.03

Following a repeated measures ANOVA test on the average scores achieved with restricted maximum likelihood using *Statistica*, a p-value of $p = 0.03$ was calculated. For the calculated value of $p < 0.05$, the null hypothesis is rejected and the H1 hypothesis is accepted. From a statistical analysis, it is thus evident that there is a statistically significant improvement in scores achieved after five rounds of playing the game, proving that by repeating the game through rounds and using feedback to improve, subjects have the ability to improve their SG scores.

4.9 Design and Development Conclusion

The objectives of the Design and Development section were to investigate different approaches to serious game designs, possible platforms on which to develop a game and the game mechanics and points system that would suit the overall project objective.

After research into needs of the specific training programme investigated (A2 ORM programme) a points system was created in the form of a digital board game, where supervisors are faced with a randomised set of everyday work scenarios having possible risks associated with them. The weekly tasks are time constraint and all impact a set of dashboard scores in the form of Operational Performance, Safety, Health & Environment and People & Leadership. In this tight time frame of decision-making the Supervisor must thus decide which of the tasks they are going to treat in the present week and which they will handle later, all having implications on the Supervisors' dashboard scores. The game is played in a collaborative in different rounds, with the idea for players to improve their dashboard scores in the following rounds using the feedback and advice given from the previous round.

Different game development platforms were investigated which also depended on the knowledge and skills of the author, as well as accessibility of participants. Through the completion of relevant on-line courses including a short course in Serious Gaming (Coursera, 2018) and a course on Excel VBA Programming (Udemy, 2019), the author decided to code the game on Excel VBA by implementing an investigated points system and user forms which will be easily accessible to participants.

The measurement tool was successfully created and through design iterations made more user-friendly, with a points and feedback system that promotes the improvement of Supervisor's decision-making and continuous improvement. Five subjects that were acquainted with the A2 ORM programme and objectives were tested playing five rounds each to see which dashboard categories are favoured more, as well as how the feedback can encourage them to improve. All five participants showed improvement in their decision-making, aiming to get greater average scores and continuously improving, with the greatest improvement being a 110% increase in average score after five rounds. A hypothesis test is done following an ANOVA to see if there is a statistically significant improvement in subjects' scores after five rounds played, which would prove the ability of using SG feedback and principles to learn and improve. The SG results from the participants proved that individuals learn throughout the gaming experience through the game characteristics implemented in the game design.

5 RESULTS AND DISCUSSION

Chapter 5 key objectives:

- Show results from the 'Time Risk Manager' game and discuss
- Show results from A2 RMT programme theory tests and discuss
- Show results from real-world KPIs (JRAs generated on site)
- Discuss correlations of the datasets
- Discuss the outcome of the dataset correlations

This results section shows and discusses the findings from the data gathered from groups of delegates to the A2 RMT programme. The aim is to structure the results in a manner that will provide an understanding of findings that were set out in the research objectives. Per group tested, the following methods are used to discuss points which answer the research questions:

- An analysis of variance (ANOVA) is applied to the dataset to establish whether a degree of learning is achieved through a gameplay environment (if all the requirements of an ANOVA are met). From the corresponding ANOVA the related F and p values are calculated to review the hypothesis (H0 or H1) and either accept or reject the null hypothesis.
- According to the p values calculated, it will be seen at what point the class (on average) showed a statistically significant improvement in scores compared to round 1. This will give a good insight on the number of repetitions needed to embed concepts.
- Spearman correlations will be used to test the hypothesis of there being a statistically significant correlation/relationship between the results obtained in the SG (*Time Risk Manager*) and the results obtained from a theoretical test on the A2 course content. This will be used to discuss the possible correlation between theoretical knowledge uptake and the actual understanding of the course content through application.
- Using the real-world KPI data from the sites that correspond with those of the delegates to the programme that were tested, a hypothesis test relating to an ANOVA will be done comparing the weeks before the training programme and the weeks after the programme to see if there is an increase in JRA completion after the programme attendance. This will be done to measure the impact and effectiveness of the A2 programme on work performance.
- 'Happy sheets' data will also be analysed to see if there is a correlation between how the delegates felt about (attitude towards) the training and the training environment with their respective game and theoretical test scores.

5.1 'Time Risk Manager' results

5.1.1 Group 1

The author attended an Anglo American A2 ORM programme on 12 and 13 August 2019 at the KBC Health & Safety Centre in Witbank (South Africa), where the game was played by a group of supervisors (group 1). The game was scheduled to be played near the end of the programme once important KPI concepts had been covered in the course, especially in-depth analysis and completion of a JRA which is one of the most important tasks of the FLM/supervisor on site.

Ten delegates each played five rounds of the game, trying to use their previous scores and the game feedback to improve their dashboard scores. Knowing from previous rounds which areas of the game to focus on, in combination with a gameplay environment and communication with other players and comparing their scores, the cognitive effects on learning and application as explained in the literature review could be tested (Draeger, 2014). Both the average scores achieved in the three subcategories as well as the median scores achieved are discussed in the following sections.

5.1.1.1 Average scores (Group 1)

The game results are shown in three dashboard categories, namely *Operational Performance*, *Safety, Health & Environment* and *People & Leadership*. Delegates to the programme were motivated by the game to try to obtain a good balance between these three categories and to try to improve their overall average score. The aim is for this to be done by improving in each specific category (especially if there is a category with a much lower score than the rest) and in the process to also increase the overall score.

Figure 5-1 shows the recorded average scores obtained in each round by the 10 participants. It is evident that every one of the players except one succeeded in improving their initial scores, with the largest improvement being player 2 with an increase of 83%, increasing the average score from 43 to 78.7.

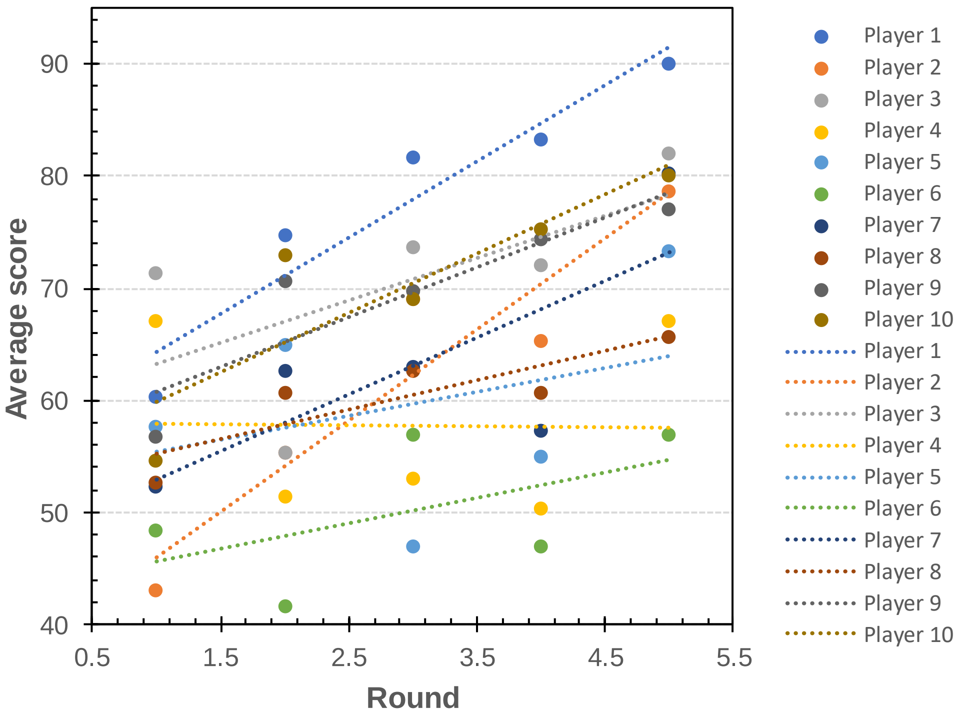

Figure 5-1: Scatterplot of average score vs. rounds played (Group 1)

Only player 4 did not succeed in increasing their average score, but still ended on the same initial score of 67 points. More importantly, it can be seen from Figure 5-1 that the majority of the players gradually increased their scores from one round to the next. This gradual increase is an indication of the cognitive ability of delegates to use feedback information and translate it into a more active learning and understanding of the material as explained by Draeger (2014). The trend seen in Figure 5-1 also verifies the findings from literature (Lameras et al., 2017), that a gameplay environment, with a competitive environment where scores are measured against other participants, might increase the learning ability and knowledge uptake.

To see at what point the class started to show a statistical improvement (on average), an analysis of variance (ANOVA) test was done. Following a Q-Q plot using *Statistica*, with the dependent variable being the average scores, it is evident that the data is normally distributed (Figure 5-2), which is an important assumption for the hypothesis test.

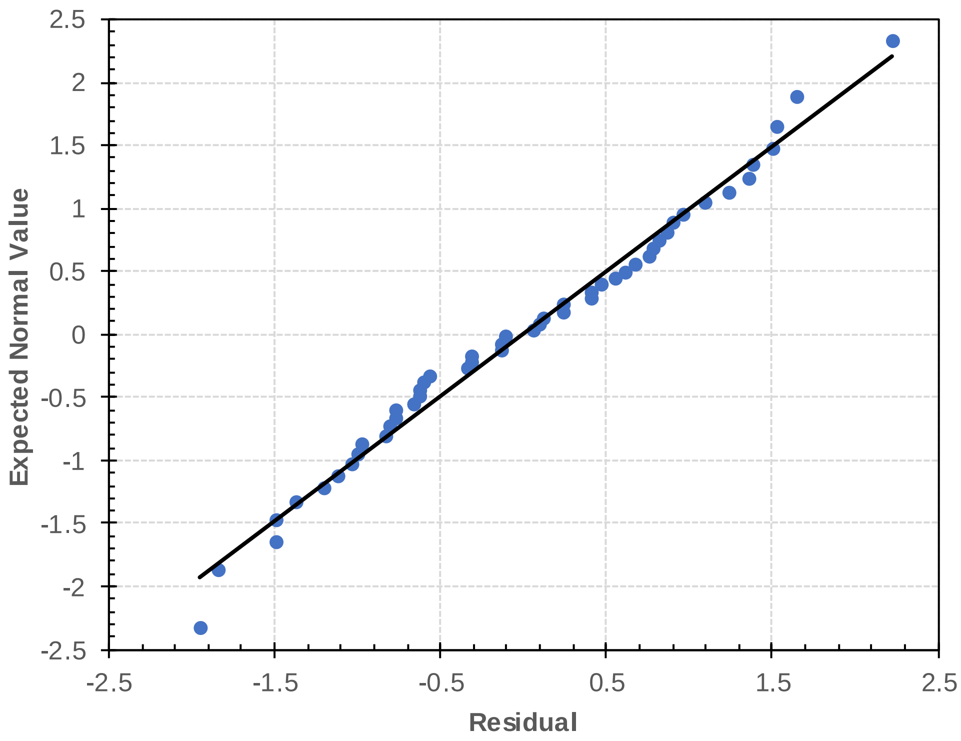

Figure 5-2: Q-Q plot with the average scores as dependent variable (Statistica) (Group 1)

Hypothesis:

The hypothesis tested from the collected data and which forms part of the objectives of this study, is whether there is a degree of earning achieved though playing a serious game in a training environment. A degree of learning would be signified by a statistical variance in *p*-values using a confidence interval of 95%. Comparing the *p*-values between rounds will also give insight into the number of rounds required for optimal learning ability. The null hypothesis (H0) and alternative hypothesis (H1) are stated below:

H0: There is no statistically significant improvement in average scores after the five rounds played of the game.

H1: There is a statistically significant improvement in average scores achieved after five rounds played.

For a confidence interval of 95%, a p-value ($p<0.05$) will reject H0 and accept the case of H1.

Table 5-1: Fixed effect test to calculate p-value: Average scores (Group 1)

Effect	Fixed Effect Test for Average Scores. Restricted maximum likelihood			
	Num. DF	**Den. DF**	**F**	**p**
Round	4	45	4.58	0.00345

Following a repeated measures ANOVA test on the average scores achieved with restricted maximum likelihood using *Statistica*, a p-value of $p = 0.00345$ was calculated. For the calculated value of $p < 0.05$, the null hypothesis is rejected and the H1 hypothesis is accepted. From a statistical analysis, it is thus evident that there is a statistically significant improvement in scores achieved after five rounds of playing the game, proving an increased level of learning through application of SG principles and characteristics as discussed in findings of Lameras et al., (2017). Figure 5-3 shows the findings of the LS means test, where the error bars indicate a 95% confidence interval. Means with different letters indicate a significant difference, and thus an indication of on what stage/level the players increased their scores as well as learning ability.

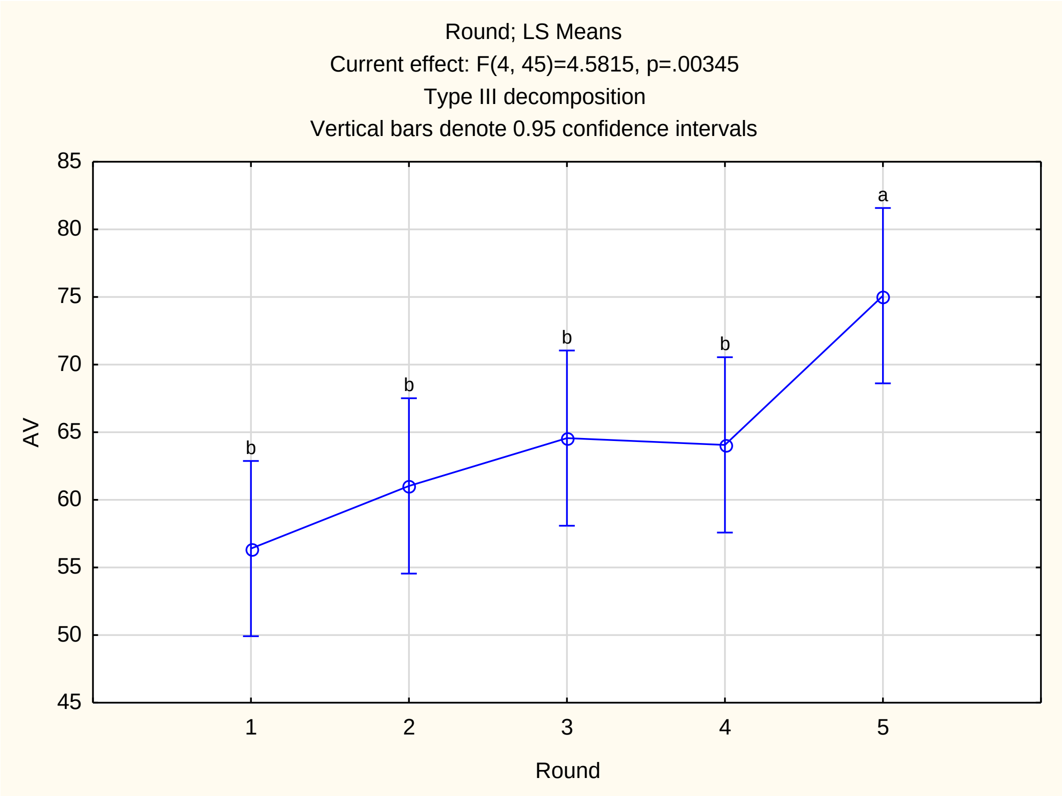

Figure 5-3: Least-squares means (LS-means) test results from the average scores in terms of rounds played (Statistica)

As a follow-up on the ANOVA, a Least Significant Difference (LSD) test is done for multiple comparisons as seen in Table 5-2. This test indicates at which stage and between what stages the players on average showed a statistical improvement in learning ability through playing the game. This is indicated by a p-value of $p < 0.05$ and can be seen by the bold rows in Table 5-2. The values in the table confirm the findings seen in LS-means plot as statistical differences are found between each round and round 5 respectively.

Table 5-2: Least-squares Means test between rounds: Average scores (Group 1)

Comparisons Cell	LSD Test: Average scores. Simultaneous confidence intervals				
	1st Mean	2nd Mean	Mean Difference	Standard Error	p
{1}-{2}	1	2	-4.63	4.55	0.31
{1}-{3}	1	3	-8.14	4.55	0.08
{1}-{4}	1	4	-7.67	4.55	0.10
{1}-{5}	**1**	**5**	**-18.7**	**4.55**	**0.00**
{2}-{3}	2	3	-3.53	4.55	0.44
{2}-{4}	2	4	-3.03	4.55	0.51
{2}-{5}	**2**	**5**	**-14.07**	**4.55**	**0.00**
{3}-{4}	3	4	0.5	4.55	0.91
{3}-{5}	**3**	**5**	**-10.53**	**4.55**	**0.03**
{4}-{5}	**4**	**5**	**-11.03**	**4.55**	**0.02**

5.1.1.2 Median scores (Group 1)

From the results of the average scores of the three dashboard categories as discussed in Section 5.1.1.1, it was seen that although the average score is a measuring point of the game in terms of ranking and high scores, a high average score does not always indicate an equal distribution of the three dashboard categories which influence the data analysis. From an analytical point of view, the same test and analysis was thus done as in Section 5.1.1.1 but using the median of the three dashboard category scores, after finding the dataset to be normally distributed as seen in Figure 5-5.

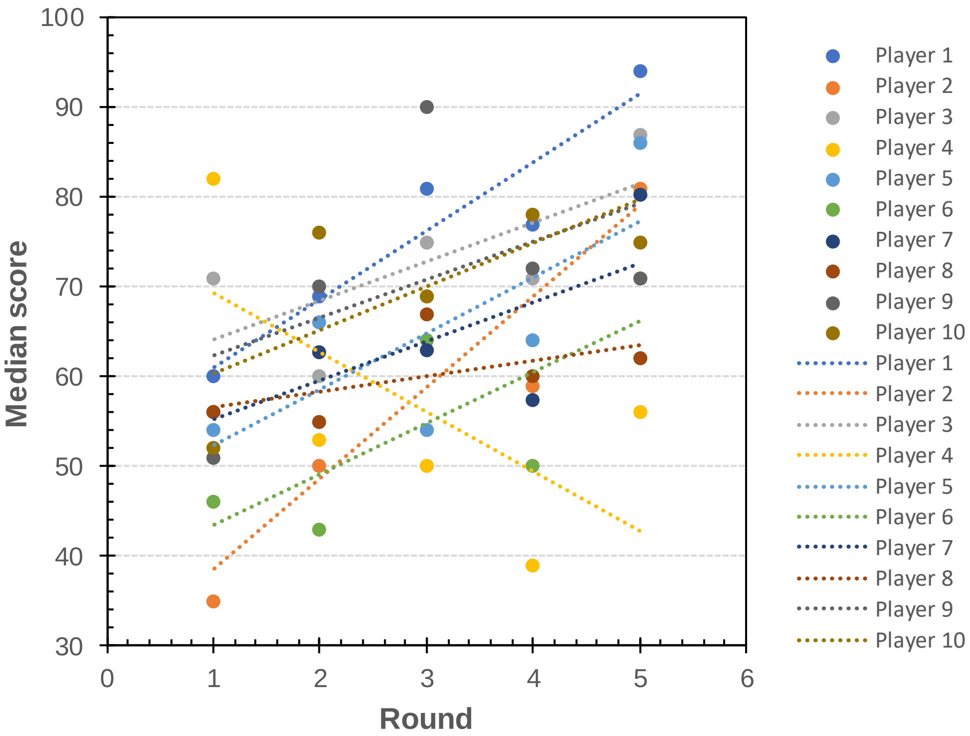

Figure 5-4: Scatterplot of median vs. rounds played (Group 1)

Figure 5-4 shows the recorded average scores obtained for each round by the 10 participants. It is evident that all of the players except one succeeded in improving their initial scores, with the largest improvement being player 2 with a median score increase of 131%, increasing the median score from 35 to 81. Player 2 also had the highest average score increase as seen in Section 5.1.1.1.

As seen in the average scores analysis in Section 5.1.1.1, player 4 is again the only one who did not succeed in increasing their score over the five rounds. Reasons for this can be due to a lack of understanding of the course content or from a lack of motivation of the specific delegate. Draeger (2014) describes this lack of motivation as a result of a player/delegate who is uninterested or might take longer to increase cognitive ability to increase understanding of the concepts through the SG characteristics. This lack of motivation or even lack of understanding of the course content can be investigated by analysing that specific delegate's 'happy sheets' as well as their results from the theoretical tests which will be discussed in the following sections.

To see at what point the class started to show a statistical improvement (on median scores), an analysis of variance (ANOVA) test was done. Following a Q-Q plot using *Statistica*, with the dependent variable being the median scores, it is evident that the data is normally distributed (Figure 5-5), which is an important assumption for the hypothesis test.

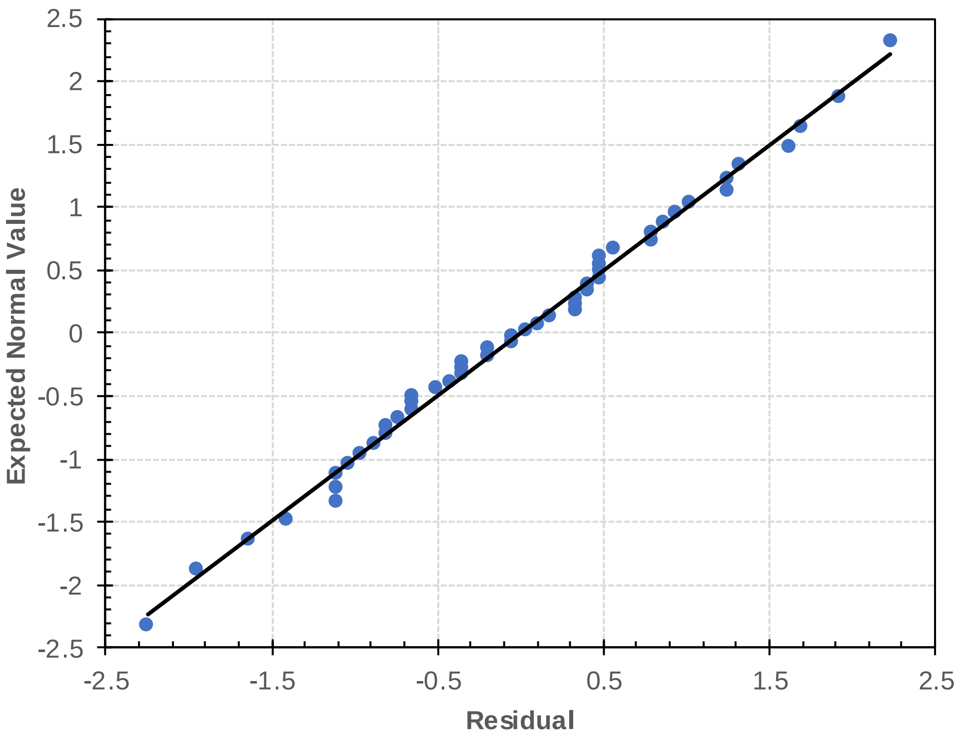

Figure 5-5: Q-Q plot with the median of the scores as dependent variable (Statistica) (Group 1)

Hypothesis:

H0: There is no statistically significant improvement in median scores after five rounds of the game played.

H1: There is statistically significant improvement in median scores achieved after 5 rounds played.

For a confidence interval of 95%, a p-value ($p<0.05$) will reject H0 and accept the case of H1.

Table 5-3: Fixed effect test to calculate p-value: Median (Group 1)

Effect	Fixed Effect Test for Average Scores. Restricted maximum likelihood			
	Num. DF	Den. DF	F	p
Round	4	45	3.91	0.01

Following a repeated measures ANOVA test on the average scores achieved with restricted maximum likelihood using *Statistica*, a p-value of $p = 0.01$ was calculated. For the calculated value of $p < 0.05$, the null hypothesis is rejected and the H1 hypothesis is accepted. From a statistical analysis, it is thus evident that there is a statistically significant improvement of scores achieved after five rounds of playing the game, proving an increased level of learning through application of the SG design characteristics as investigated by Lameras et al., (2017). Figure 5-6 shows the findings of the LS means test, where the error bars indicate a 95% confidence interval. Means with different letters indicate a significant difference, and thus an indication of at what stage the players increased their scores as well as learning ability.

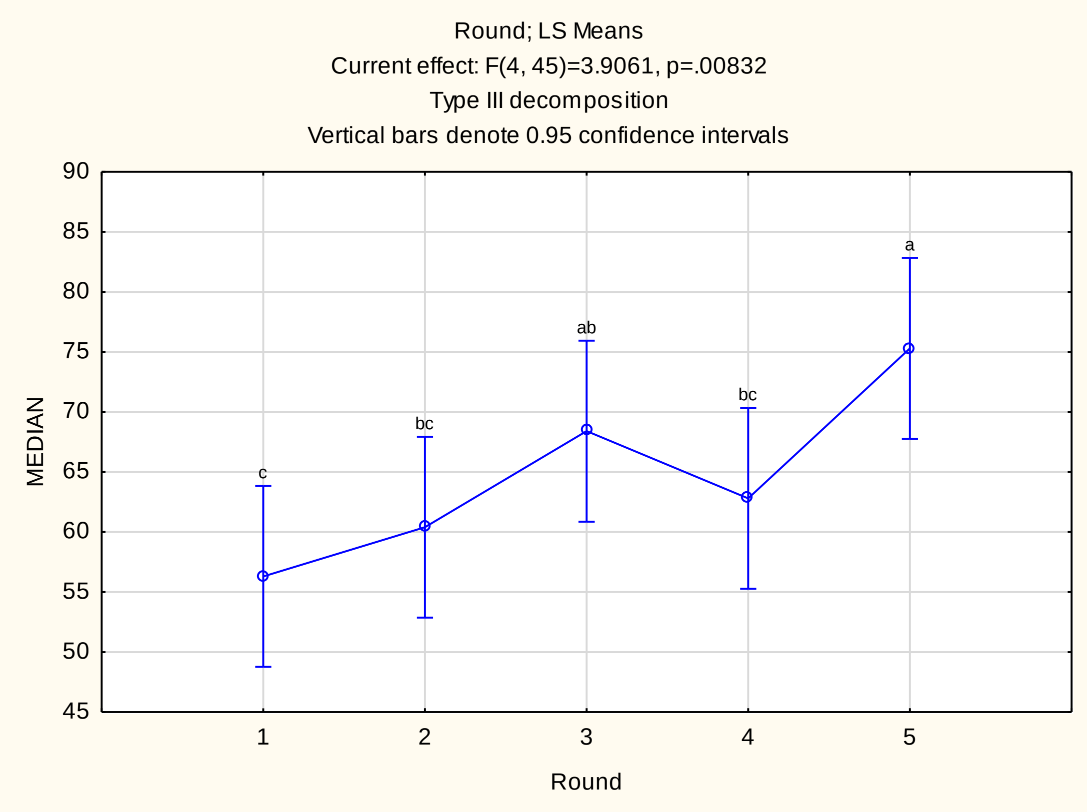

Figure 5-6: Least-squares means (LS-means) test results from the median in terms of rounds played (Statistica)

As a follow-up on the ANOVA, a Least Significant Difference (LSD) test is done for multiple comparisons as seen in Table 5-4. This test indicates at which stage and between what stages the players on average showed a statistical improvement in learning ability through playing the game. This is indicated by a p-value of $p < 0.05$ and can be seen by the bold rows in Table 5-4. The values in the table confirm the findings seen in LS-means plot as statistical differences are found between round 1 and five which is very important. Statistically significant differences (improvements) are also found between round 1 and 3, round 2 and 5, and round 4 and 5 respectively.

Table 5-4: Least-squares means test between rounds: Median of scores (Group 1)

Comparisons Cell	LSD Test: Average scores. Simultaneous confidence intervals				
	1st Mean	2nd Mean	Mean Difference	Standard Error	p
{1}-{2}	1	2	-4.10	5.29	0.44
{1}-{3}	**1**	**3**	**-12.10**	**5.29**	**0.03**
{1}-{4}	1	4	-6.50	5.29	0.23
{1}-{5}	**1**	**5**	**-19.00**	**5.29**	**0.00**
{2}-{3}	2	3	-8.00	5.29	0.14
{2}-{4}	2	4	-2.40	5.29	0.65
{2}-{5}	**2**	**5**	**-14.90**	**5.29**	**0.01**
{3}-{4}	3	4	5.60	5.29	0.30
{3}-{5}	3	5	-6.90	5.29	0.20
{4}-{5}	**4**	**5**	**-12.50**	**5.29**	**0.02**

In summary for the *Time Risk Manager* SG results for group 1; a hypothesis test was done using statistical analysis of variance (ANOVA) to find respective p-values representing a confidence level of 95%. The null hypothesis (H0) is that there is no statistically significant improvement in the SG scores. The improvement in the SG scores is indicative of the ability to learn concepts better through the characteristics of a Serious Game as implemented in the game design as found in literature (Lameras et al., 2017). The applied characteristics in the game design are that the game has rules, it has a goal, is competitive in nature and gives the user feedback.

The results of the game reject the null hypothesis (H0) and accept the H1, proving a statistically significant improvement in dashboard scores, which is indicative of a cognitive ability to increase knowledge of concepts through application of SG characteristics within the training programme. The delegates achieved better scores and showed statistically significant improvement in scores after five rounds played.

5.1.2 Group 2

The second group was a group of fifteen supervisors who attended the A2 RMT programme at Mogalakwena Platinum mine, where the SG was played. Fifteen delegates each played five rounds of the game, trying to use their previous scores and the game feedback to improve their dashboard scores.

5.1.2.1 Average scores (Group 2)

Figure 5-7 shows the recorded average scores obtained in each round by the fifteen participants. It is evident that all of the players, except player 6, succeeded in improving their initial average scores, with the largest improvement being player 11 with an increase of 142%, increasing the average score from 36.3 to 88. Even though player 6 did not manage to end with a higher score than his/her starting score of 52, he/she did get fluctuating scores in between rounds, which might be due to a lack of understanding of the course content and his/her role, or a lack of focus.

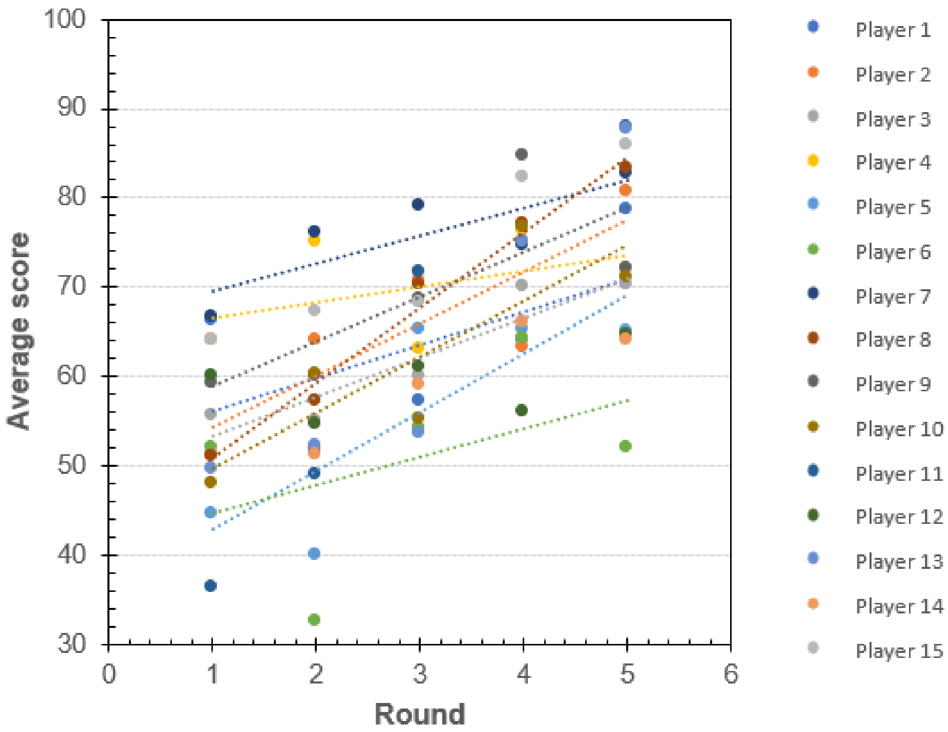

Figure 5-7: Scatterplot of average score vs. round played (Group 2)

To see if the class started to show a statistical improvement (on average) as the rounds of the SG continues, an analysis of variance (ANOVA) test was done. Following a Q-Q plot using *Statistica*, with the dependent variable being the average scores, it is evident that the data is normally distributed (*Figure 5-8*), which is an important assumption for the hypothesis test.

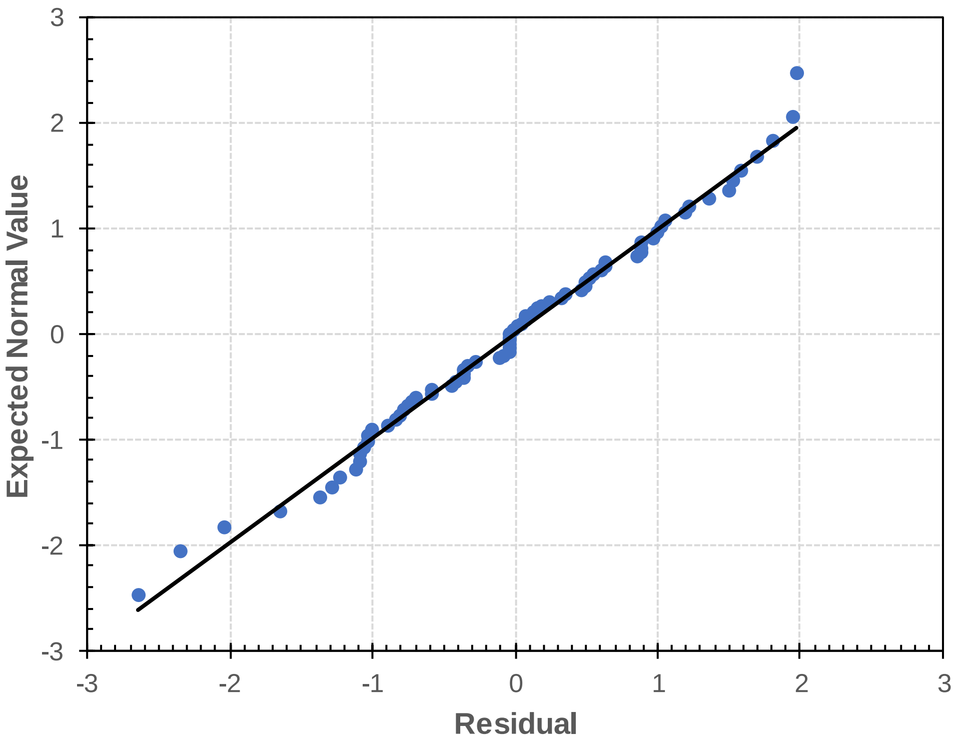

Figure 5-8: Q-Q plot with the average scores as dependent variable (Statistica) (Group 2)

Hypothesis:

The hypothesis tested is to determine whether there is a degree of learning achieved though playing a serious game in a training environment and whether delegates can increase their initial scores through the course of five game rounds. A degree of learning would be signified by a statistical variance in *p*-values using a 95% confidence interval. Comparing the *p*-values between rounds will also give insight into the number of rounds required for optimal learning ability. The null hypothesis (H0) and alternative hypothesis (H1) are stated below:

H0: There is no statistically significant improvement in average scores after the five rounds played of the game.

H1: There is a statistically significant improvement in average scores achieved after five rounds played.

For a 95% confidence interval, a p-value ($p<0.05$) will reject H0 and accept the case of H1.

Table 5-5: Fixed effect test to calculate p-value: Average scores (Group 2)

Effect	Fixed Effect Test for Average Scores. Restricted maximum likelihood			
	Num. DF	Den. DF	F	p
Round	4	70	12.40	$1.12x10^{-7}$

Following a repeated measures ANOVA test on the average scores achieved with restricted maximum likelihood using *Statistica*, a p-value of p =1.12×10^{-7} was calculated. For the calculated value of $p < 0.05$, the null hypothesis is rejected and the H1 hypothesis is accepted. From a statistical analysis, it is thus evident that there is a statistically significant improvement in average scores achieved after five rounds of playing the game, proving an increased level of learning through application of SG principles and characteristics as discussed in findings of Lameras et al., (2017).

5.1.2.2 Median scores (Group 2)

Figure 5-9 shows the recorded median of the dashboard category scores achieved in each round by the fifteen participants. It is evident that all of the players, except player 6 (the same as seen in the average scores), succeeded in improving their initial median scores, with the largest improvement being player 11 (the same as with the average scores) with an increase of 220%, increasing the average score from 29 to 93, which is a very large improvement. It can be seen from Figure 5-9 that player 6's median scores fluctuate quite significantly, which might be due to a lack of focus between the five rounds, a lack of interest or a misconception of his/her role and the course content.

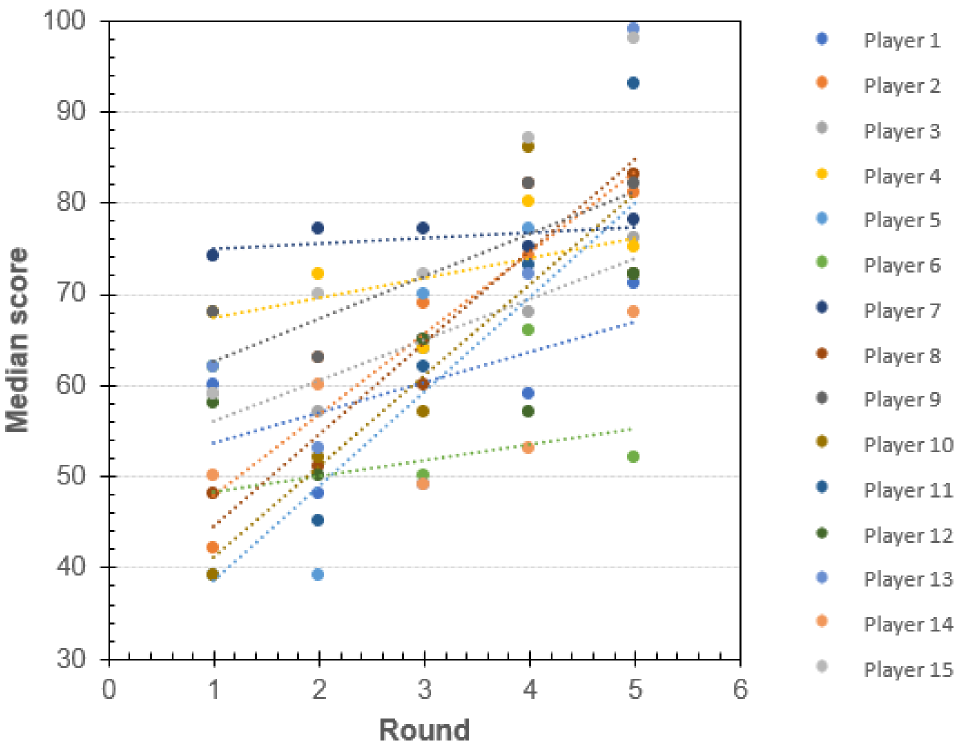

Figure 5-9: Scatterplot of median vs. round played (Group 2)

To see if the class started to show a statistical improvement (on average) as the rounds of the SG continues, an analysis of variance (ANOVA) test was done. Following a Q-Q plot using *Statistica*, with the dependent variable being the median scores, it is evident that the data is normally distributed (Figure 5-10), which is an important assumption for the hypothesis test.

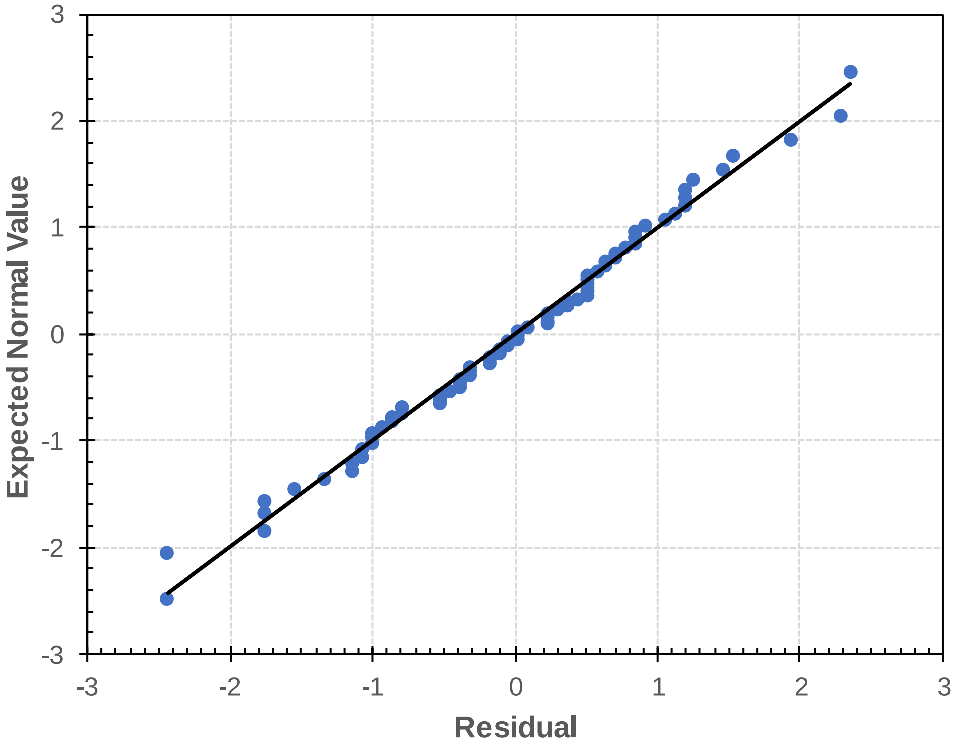

Figure 5-10: Q-Q plot with the median scores as dependent variable (Statistica) (Group 2)

Hypothesis:

Like in the previous sections, the hypothesis tested is to determine whether there is a degree of learning achieved though playing a serious game in a training environment and whether delegates can increase their initial scores through the course of five game rounds. A degree of learning would be signified by a statistical variance in *p*-values using a confidence interval of 95%. Comparing the *p*-values between rounds will also give insight into the number of rounds required for optimal learning ability. The null hypothesis (H0) and alternative hypothesis (H1) are stated below:

H0: There is no statistically significant improvement in median scores after the five rounds played of the game.

H1: There is a statistically significant improvement in median scores achieved after five rounds played.

For a 95% confidence interval, a p-value ($p<0.05$) will reject H0 and accept the case of H1.

Table 5-6: Fixed effect test to calculate p-value: Median scores (Group 2)

Effect	Fixed Effect Test for Average Scores. Restricted maximum likelihood			
	Num. DF	Den. DF	F	p
Round	4	70	12.40	$1.12\text{x}10^{-7}$

Following a repeated measures ANOVA test on the average scores achieved with restricted maximum likelihood using *Statistica*, a p-value of p =1.12×10^{-7} was calculated. For the calculated value of $p < 0.05$, the null hypothesis is rejected and the H1 hypothesis is accepted. From a statistical analysis, it is thus evident that there is a statistically significant improvement in average scores achieved after five rounds of playing the game, proving an increased level of learning through application of SG principles and characteristics as discussed in findings of Lameras et al., (2017).

5.1.3 Group 1 & 2 combined analysis

With the two groups tested as discussed in Sections 5.1.1 and 5.1.2 it is evident that in both cases a statistically significant increase in both average and median dashboard scores achieved between round 1 and 5 can be seen following an ANOVA. For purposes of statistical analysis, the SG results from the two groups are combined to use a hypothesis test in whether a statistical improvement is still evident, as well as how the two groups' results differ from each other.

5.1.3.1 Combined groups average scores

Like in the previous sections, an ANOVA is done to see if the class started to show a statistical improvement (on average) as the rounds of the SG continues. Following a Q-Q plot using *Statistica*, with the dependent variable being the average scores, it is evident that the data is normally distributed (Figure 5-11), which is an important assumption for the hypothesis test.

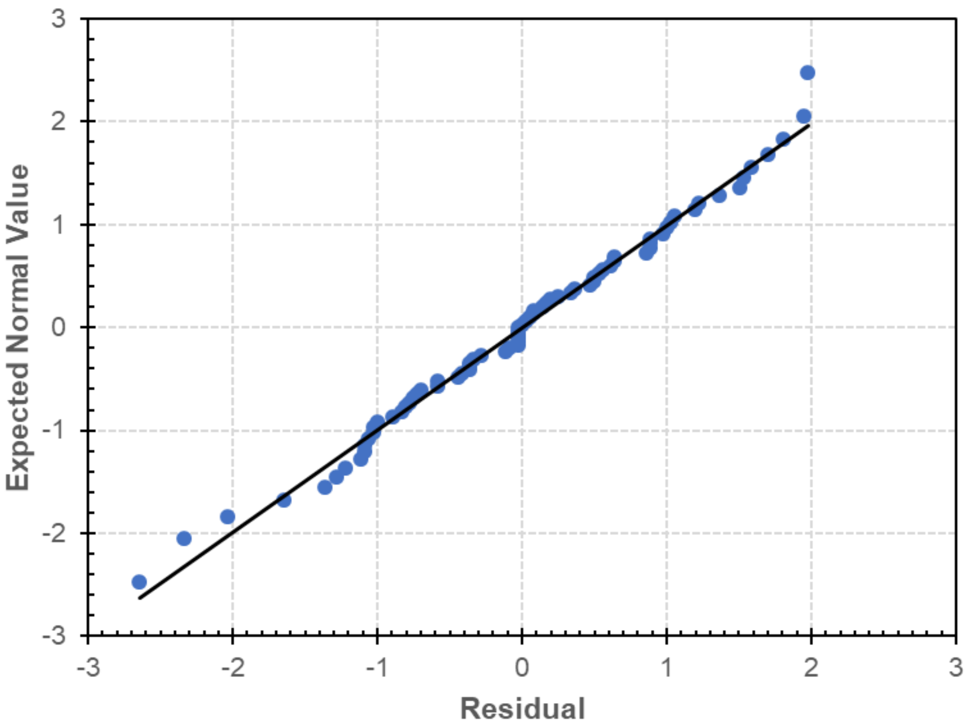

Figure 5-11: Q-Q plot with the average scores as dependent variable (Statistica) (Combined)

Like in the previous sections, the hypothesis tested is to determine whether there is a degree of learning achieved though playing a serious game in a training environment and whether delegates can increase their initial scores through the course of five game rounds. A degree of learning would be signified by a statistical variance in p-values using a confidence interval of 95%. Comparing the p-values between rounds will also give insight into the number of rounds required for optimal learning ability. The null hypothesis (H0) and alternative hypothesis (H1) are stated below:

H0: There is no statistically significant improvement in average scores after the five rounds played of the game.

H1: There is a statistically significant improvement in average scores achieved after five rounds played.

For a 95% confidence interval, a p-value ($p<0.05$) will reject H0 and accept the case of H1.

Table 5-7: Fixed effect test to calculate p-values: average scores (Combined)

Effect	Fixed effect test for average scores. Restricted maximum likelihood			
	Num. DF	Den. DF	F	p
Round	4	120	45.47	$3.11\text{x}10^{-10}$

Following a repeated measures ANOVA test on the average scores achieved from the total number of delegates who participated, with restricted maximum likelihood using Statistica, a p-value of p =3.11x10−10 was calculated. For the calculated value of $p < 0.05$, the null hypothesis is rejected and the H1 hypothesis is accepted. From a statistical analysis, it is thus evident that there is a statistically significant improvement in median scores achieved after five rounds of playing the game, which validates the statistical finding from the analysis of the individual group results.

5.1.3.2 Group comparison for average scores

As a follow-up on the ANOVA, a Least Significant Difference (LSD) test is done for multiple comparisons. This test indicates at which stage and between what stages the players on average showed a statistical improvement in learning ability through playing the game. This is indicated by a p-value of $p < 0.05$ and thus a statistical significance at the 95% confidence interval. These calculated values are indicated by a LS-means plot as statistical differences are found between each round and round 5 respectively (for both groups). This LS-means test considers the specific group and measures it against the rounds played for the average rounds played. A plot can be seen in Figure 5-12 , where the error bars indicate a 95% confidence interval. Means with different letters indicate a significant difference, and thus an indication of at what stage the players increased their scores as well as learning ability.

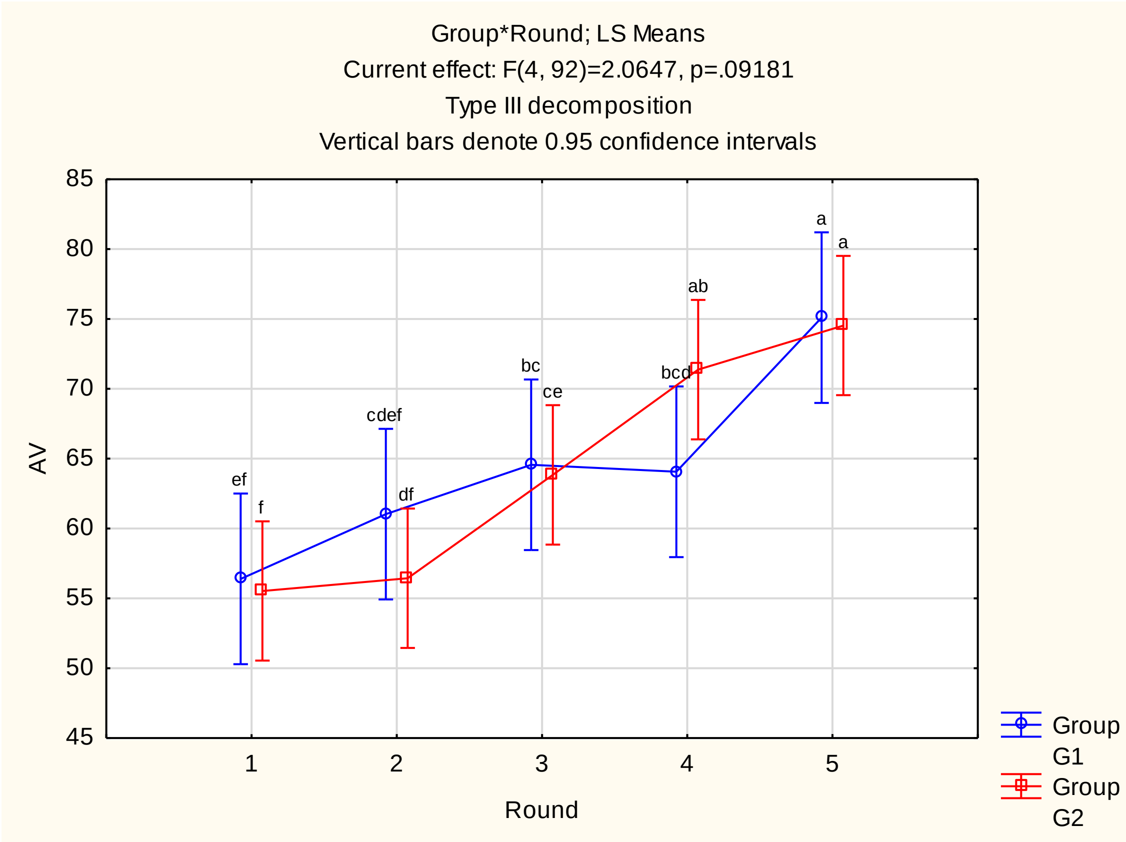

Figure 5-12: LS-means test results from the average in terms of rounds played (Statistica) (Group 1 vs group 2)

From Figure 5-12 it can be seen that for both groups, there is a statistical improvement in average scores achieved, as denoted by the different letter combinations on each of the error bars, except for round 4 of Group 1 where players did not succeed in increasing their scores from the previous round. The scores achieved in round 4 by Group 1 is however better than the second and third rounds, and in round 5 they show a very high improvement. The lower scores of round 4 for Group 1 can be due to players getting distracted, or even getting too caught up in the gameplay that the competitiveness element forces them to take chances. The players succeed in realising their mistakes to bring their average scores higher in the fifth round.

From the plot it can be seen that even though Group 1 achieves higher scores in the last round, they did start at a higher average score compared to Group 2, meaning that the increase within the five rounds played are almost equal for both groups. Group 2 succeeded in gradually increasing their scores by increasing every round played, whereas Group 1 struggled with round 4. By this difference it can be said that Group 2 was more consistent in applying the principles they've learnt and showed better performance in using the SG feedback to increase their scores.

5.2 Theoretical test results

This section aims to test if there is any statistical significance in the correlation between the results obtained from the theoretical tests written by the delegates after attending the A2 programme and their respective results obtained by playing the *Time Risk Manager* SG. Because the test is written after the A2 programme as well as after playing the SG, it is tested as if there is a correlation between the concepts learnt in the programme, and their application in the SG. The Pearson correlation is used in this case to measure the strength of the relationship between two quantitative, continuous variables. After the coefficient and p-value are calculated to test the set hypothesis, a conclusion will be made.

In an attempt to evaluate the effectiveness and impact of the A2 RMT course, the Kirkpatrick model of training evaluation is followed (Kirkpatrick D., 1996) as discussed in Section 2.2.1. This hypothesis aims to test level 2 of the Kirkpatrick model, which is 'Learning', as well as how this degree of learning relates to the behavioural application of the concepts learnt in the A2 RMT programme to the SG results. The SG results represent the decisions that a supervisor will make in daily mining operations and apply work procedures related to safety and management.

The theoretical test scores are compared to the increase in players' median scores achieved in the SG between the first and the fifth round played. Figure 5-13 indicates the correlation between the increase in median scores between rounds 1 to 5 with the theory test results for respective players in both groups 1 and group 2. The significance of this correlation will be tested statistically with a hypothesis test using a Pearson correlation. It has to be noted however, that even though player 4 from Group 1 and player 6 from Group 2 did not succeed in improving their scores, they both did still achieve the subminimum of 70% to pass the theoretical test. All the delegates succeeded in passing this test the first time, which is the current method the collaborating company use to measure a delegate's understanding of the course content. A hypothesis test follows to measure the correlation of the two groups' SG result to their respective theoretical test results. Anglo American does not currently implement a pre-test within their A2 RMT programme, so for the purposes of this study it was assumed that delegates to the programme have no theoretical background of the topics discussed and assessed in the post-test. Knowledge uptake is thus measured in terms of the post A2 test written by delegates, as the score achieved for this test indicates the theoretical knowledge the delegates attained by attendance of the A2 programme.

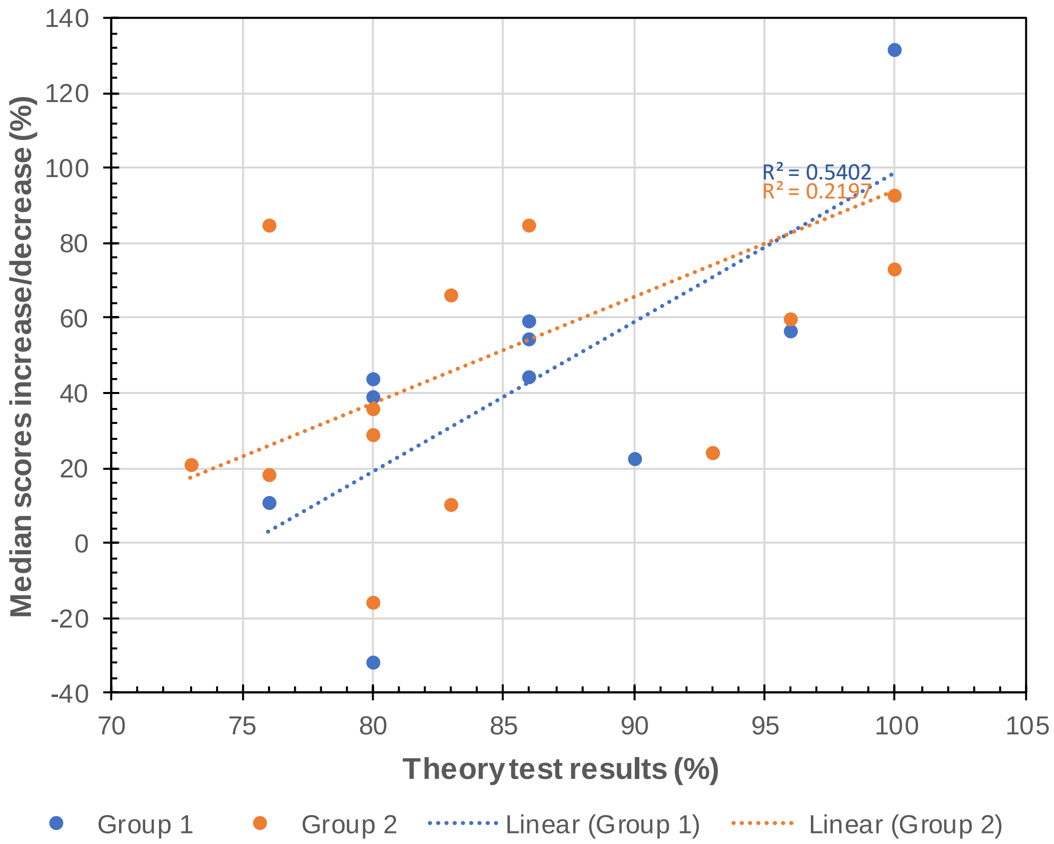

Figure 5-13: Scatterplot showing the correlations between median scores increase vs. theory test results (Group 1 and 2)

Hypothesis:

H0: There is no statistically significant correlation between the respective delegates'/players' theoretical test results and the results from playing the SG.

H1: There is a statistically significant correlation between the respective delegates'/players' theoretical test results and the results from playing the SG.

For a confidence interval of 95%, a p-value ($p < 0.05$) will reject H0 and accept the case of H1.

Using multiple regression on the *Statistica* software, with the dependent variable being the theory test results (%) and the independent variable being the increase in median scores a Pearson correlation was done, and thereafter a Spearman correlation. For both these correlations, the correlation coefficient r is calculated along with the p-values. In the case where the p-values are significantly smaller than 0.05, H0 will be rejected and H1 accepted. The Pearson and Spearman correlations were done using the *Statistica* software, and the calculated coefficients and p-values are shown in Table 5-8.

Table 5-8: Statistical correlation results of theory tests and SG results

Correlation	**Statistical correlations tests using *Statistica***	
	R	**p**
Pearson	0.52	0.0073
Spearman	0.54	0.01

The p-value for the Pearson correlation resulted in p = 0.0073, which is smaller than 0.05. For this reason, the null hypothesis (H0) is rejected and H1 is accepted. To validate this finding, a Spearman correlation was done which resulted in a p-value of p = 0.01. This is also smaller than 0.05, backing up the rejection of the null hypothesis (H0). H1 is accepted for the results obtained and analysed. There is thus a statistically significant correlation between the respective delegates'/players' theoretical test results and the results from playing the SG. Although the p-values indicate that the correlation is significant, the R-values suggest only a small percentage of the variation is accounted for. Other factors thus also exist which influence the correlation, for example the motivation of the delegates to improve their SG scores. The theoretical test results are higher for players obtaining a higher score in the Time Risk Manager SG, and lower for players obtaining a lower score in the Time Risk Manager SG.

What is interesting about the outcome of this correlation test is that it is indicative of a correlation between actual theoretical knowledge uptake and the ability to use the theoretical knowledge and apply it in real-world risk-associated scenarios. For the future, this is a positive indication for the use of serious games in training programmes not only to increase the learning ability of specific concepts, but to also use as evaluation tool within the levels of the Kirkpatrick Model (Kirkpatrick D., 1996) to measure the effectiveness and impact of knowledge uptake. The application of the concepts within the games and score increase through repetition which is indicative of a behavioural change in the player.

5.3 JRA completion on site

Level 4 of the Kirkpatrick model of evaluation, as discussed in Section 2.2.1 aims to evaluate the result of the training. In this case, the result of the training is a behavioural change in delegates. The delegates' outcomes or results are measured in terms of the operational objective of the A2 course, which is to understand the completion of Job Risk Assessments on site with a team for risk-related tasks to be undertaken by that specific team. The outcomes of the A2 RMT programme presented by Anglo American that are most closely linked to the training are the completion of JRAs.

To measure the effectiveness of the A2 programme in terms of KPIs, JRA completion data from the operational sites where the delegates to the tested programme work, were investigated. After the training on the importance of implementation as well as the correct completion and implementation of JRAs, it is expected to see an increase of completion and submitting of JRAs linked to the delegates that have attended the A2 programme. The effectiveness and impact will thus be measured, along with the theory test and SG game results, by the immediate uptake of information and increase of completion of JRAs, which is the most important part of the A2 programme.

5.3.1 Group 1

To test if there is an increase in the uptake of the A2 RMT programme principle of JRA importance due to attendance of the programme, it is tested if there is an increase in the number of JRAs generated on sites related to the delegates who attended the tested A2 programme. From the group tested, data was gathered from the delegates who work in operations that are related to risk-associated decision-making on a daily basis. JRA generation from 10 working days before attendance of the A2 course and 10 working days after attendance of the course were collected to see if there is an immediate impact after attendance of the course.

To see if there is a statistical significance in the increase in the number of JRAs generated before attendance of the programme and after the programme, a null hypothesis (H0) is set that there is no significant increase, for a confidence interval of 95%. This is done by performing a one-way ANOVA to compare the means of the datasets compared.

Hypothesis:

H0: There is no statistically significant increase in the number of JRAs generated after attendance of the A2 RMT programme to the number generated before.

H1: There is a statistically significant increase in the number of JRAs generated after attendance of the A2 RMT programme to the number generated before.

For a confidence interval of 95%, a p-value ($p < 0.05$) will reject H0 and accept the case of H1.

The p-value was calculated for the parametric test (one-way ANOVA), as well as the p-value for its non-parametric test (the Mann-Whitney test). The calculated p-values can be seen in Table 5-9.

Table 5-9: p-values calculated from parametric and non-parametric tests (Group 1)

Test	**Statistical tests using *Statistica***
	p
One-way ANOVA	0.02
Mann-Whitney	0.04

The p-value for the one-way ANOVA resulted in p = 0.02, which is smaller than 0.05. For this reason, the null hypothesis (H0) is rejected and H1 is accepted. The non-parametric equivalent test, the Mann-Whitney test resulted in p = 0.04, which is also smaller than 0.05 and confirms the rejection of the null hypothesis. H1 is thus accepted, that there is a statistically significant increase in the number of JRAs generated after attendance of the A2 RMT programme to the number generated before. The impact of the A2 RMT can thus be seen to be a behavioural change in supervisors in terms of awareness of risk management procedures such as the completion of JRAs before a team commences with a risk-related task/activity on site.

The A2 RMT programme has several outcomes, of which the only operational change that can be measured is the implementation of risk-associated work procedures such as the creation of awareness of hazards in the workplace and the controls available to mitigate or treat them. This is done by the completion of JRAs by a supervisor and their team, which addresses the risks and hazards associated with the task about to be done and the controls available for it. It also creates awareness and focus among the team members and ensures that everybody on a team understands their role and responsibility regarding safe operations.

5.3.2 Group 2

From the second group tested consisting of 15 delegates, the same hypothesis test is done as in section 5.3.1. This is done by performing a one-way ANOVA to compare the means of the datasets compared.

Hypothesis:

H0: There is no statistically significant increase in the number of JRAs generated after attendance of the A2 RMT programme to the number generated before.

H1: There is a statistically significant increase in the number of JRAs generated after attendance of the A2 RMT programme to the number generated before.

For a confidence interval of 95%, a p-value ($p < 0.05$) will reject H0 and accept the case of H1.

The p-value was calculated for the parametric test (one-way ANOVA), as well as the p-value for its non-parametric test (the Mann-Whitney test). The calculated p-values can be seen in Table 5-10.

Table 5-10: p-values calculated from parametric and non-parametric tests (Group 2)

Test	Statistical tests using *Statistica*
	p
One-way ANOVA	0.02
Mann-Whitney	0.015

The p-value for the one-way ANOVA resulted in p = 0.02, which is smaller than 0.05. For this reason, the null hypothesis (H0) is rejected and H1 is accepted. The non-parametric equivalent test, the Mann-Whitney test resulted in p = 0.015, which is also smaller than 0.05 and confirms the rejection of the null hypothesis. H1 is thus accepted, that there is a statistically significant increase in the number of JRAs generated after attendance of the A2 RMT programme to the number generated before. The impact of the A2 RMT can thus be seen to be a behavioural change in supervisors in terms of awareness of risk management procedures such as the completion of JRAs before a team commences with a risk-related task/activity on site, which is the same observation as seen in Group 1.

5.3.3 JRA completion vs. SG score increase

As part of the measurement of the effectiveness of the A2 RMT programme on delegates to the programme, as well as measurement of a behavioural change in the workplace due to the attendance of delegates to the programme, a correlation was investigated between the respective players' SG score increase between rounds 1 and 5 and their increase in completion of JRAs on site before and after their attendance to the programme. A statistically significant correlation between these two variables will give insight on a positive and negative behavioural change in delegates in terms of real world KPIs and how the SG characteristics may influence it. A Pearson correlation is used in this case to measure the strength of the relationship between two variables. After the coefficient and p-value are calculated to test the set hypothesis, a conclusion will be made. The hypothesis of the test is as follows:

Hypothesis:

H0: There is no statistically significant correlation between the respective delegates'/players' SG results and their respective JRA completion increase.

H1: There is a statistically significant correlation between the respective delegates'/players' SG results and their respective JRA completion increase.

For a confidence interval of 95%, a p-value ($p < 0.05$) will reject H0 and accept the case of H1.

Table 5-11: Statistical correlation results of SG results and JRA completion

Correlation	**Statistical correlations tests using *Statistica***	
	R	**p**
Pearson	0.82	0.0011
Spearman	0.80	0.0019

The p-value for the Pearson correlation resulted in p = 0.0011, which is smaller than 0.05. For this reason, the null hypothesis (H0) is rejected and H1 is accepted. To validate this finding, a Spearman correlation was done which resulted in a p-value of p = 0.0019. This is also smaller than 0.05, backing up the rejection of the null hypothesis (H0). H1 is accepted for the results obtained and analysed. There is thus a statistically significant correlation between the respective delegates'/players' SG results and their respective JRA completion increase. This statistical significance indicates a positive influence of the application of SG characteristics in the A2 RMT programme with a positive behavioural change of delegates to the A2 programme. This is a large statistical significance, which means that the use of the measurement tool might be used as a technique to estimate whether delegates will show a behavioural change in the workplace.

5.4 'Happy sheets' results

Happy sheets are used in the A2 RMT training programme to gain feedback from delegates to measure Level 1 (Reaction) of the Kirkpatrick model of evaluation (Kirkpatrick & Kirkpatrick, 2006). The happy sheets give insight into the degree to which participants found the training relevant to their jobs and engaging and can help the company to improve on lacking areas of training.

In the case of this study, the responses from the happy sheets can give possible clarification into specific scores achieved in the measurement of theory tests and the results from the SG played. The happy sheets to this specific programme are presented in two categories with category one being how the delegates perceived the course content and category two being how well delegates think the course objectives are met. These happy sheets and their outcomes per group are shown in sections 5.4.1 and 5.4.2. Due to ethical procedures from Anglo American, the happy sheets feedback is kept anonymous.

Even though the happy sheets can't specifically identify a connection between outliers in SG results and theory test results to a specific delegates' happy sheet feedback, specific areas within the course content can be identified for improvement and maybe identify a lack of understanding of specific course elements. How the delegates find the educator's overall presentation method can also influence the delegates' idea of the course and how well they understand the content.

5.4.1 Group 1

All the delegates from group 1 succeeded in improving their average scores between rounds one and five of the SG. When it comes to the median scores achieved as seen in Figure 5-4, player 4 was a clear outlier, being the only player not able to improve his/her median score. Reasons for this might be a lack of understanding of the course content, which might be due to the delegate not finding the course work interesting. From Table 5-12 it can be seen that for most feedback categories, delegates chose a 4 and 5 rating meaning that the course content and educator was perceived really well and up to standard. There was however one delegate who indicated that the quality of the material presented is not up to standard, and one delegate who found the educator's presentation methods and discussion skills to be bad. Even though these ratings can't be linked to specific delegates, the possibility for the one delegate who had a bad perception of the course content as seen in Table 5-12 to also perform bad in the SG results does exists as it influences his/her motivation or understanding. All the delegates did meet the subminimum to pass the theory test.

From Table 5-13 it can be seen that delegates believe that the course objectives were met, with ratings of 4 and 5, showing no indication of outliers. This is a good result as it means that the delegates believe that they learnt what they had to as set out by the course objectives.

Table 5-12: Happy sheet for participants' perceived idea of the course content (Group 1)

Question	**Description**	**1 (Poor)**	**2**	**3**	**4**	**5 (Excellent)**
1	How practical was this course in its application to your work	0	0	0	30% (3)	70% (7)
2	The time allocated to the course seemed to be?	0	0	0	40% (4)	60% (6)
3	The amount of material covered in the course seemed to be?	0	0	0	30% (3)	70% (7)
4	The quality of material covered in the course seemed to be?	0	0	10% (1)	20% (2)	70% (7)
5	In general, of what value was the content of the course to you?	0	0	0	30% (3)	70% (7)
6	Did the educator's overall presentation methods and discussion skills make the course interesting?	0	10% (1)	0	20% (2)	70% (7)

Table 5-13: Happy sheet for the delivery of objectives of the RMT programme (Group 1)

Number	Deliverable	Not met (1)	Slightly met (2)	Partly met (3)	Mostly met (4)	Fully met (5)
1	Understand the Anglo ORM process and where it fits into Anglo Safety Strategy	0	0	0	20% (2)	80% (8)
2	Understand the mindset change needed for proactive decision-making	0	0	0	20% (2)	80% (8)
3	Understand the supervisor's role in ORM	0	0	0	20% (2)	80% (8)
4	Introduced to the Anglo American ORM Journey Model	0	0	0	20% (2)	80% (8)
5	Apply JRA methodology to a relevant work example	0	0	0	10% (1)	90% (9)
6	Drive continuous/personal risk assessment process in your team	0	0	0	10% (1)	90% (9)

5.4.2 Group 2

In terms of theory tests and SG results, group 2 performed really well with all but one (player 6) of the delegates succeeding in improving their SG scores between rounds one and five of the game. All the delegates also succeeded in achieving the subminimum for the theory tests written. From Table 5-14 it can however be seen that two delegates found that the course content didn't have much value to them (rating of 3) and that they didn't perceive that educator's presentation methods to be very good (rating of 3). This feedback can be used by the organisation to improve on the educators' presentations methods and ensuring that they can deliver the objectives correctly.

Once again it can be seen Table 5-15 that most of the delegates believes that all the course objectives were fully met (most giving ratings of 5) and others rating that it was mostly met (rating of 4). This is a good indication as it indicates that the delegates knew the course objectives and believe that they have learnt through delivery of the course objectives.

Table 5-14: Happy sheet for participants' perceived idea of the course content (Group 2)

Question	Description	1 (Poor)	2	3	4	5 (Excellent)
1	How practical was this course in its application to your work	0	0	0	26.7% (4)	73.3% (11)
2	The time allocated to the course seemed to be?	0	0	0	40% (6)	60% (9)
3	The amount of material covered in the course seemed to be?	0	0	0	6.7% (1)	93.3% (14)
4	The quality of material covered in the course seemed to be?	0	0	0	6.7% (1)	93.3% (14)
5	In general, of what value was the content of the course to you?	0	0	13.4% (2)	33.3% (5)	53.3% (8)
6	Did the educator's overall presentation methods and discussion skills make the course interesting?	0	0	13.3% (2)	13.4% (2)	73.3% (11)

Table 5-15: Happy sheet for the delivery of objectives of the RMT programme (Group 1)

Number	Deliverable	Not met (1)	Slightly met (2)	Partly met (3)	Mostly met (4)	Fully met (5)
1	Understand the Anglo ORM process and where it fits into Anglo Safety Strategy	0	0	0	53.3% (8)	46.7% (7)
2	Understand the mindset change needed for proactive decision-making	0	0	0	26.7% (4)	73.3% (11)
3	Understand the supervisor's role in ORM	0	0	0	13.3% (2)	86.7% (13)
4	Introduced to the Anglo American ORM Journey Model	0	0	0	13.3% (2)	86.7% (13)
5	Apply JRA methodology to a relevant work example	0	0	0	20% (3)	80% (12)
6	Drive continuous/personal risk assessment process in your team	0	0	0	26.7% (4)	73.3% (11)

6 CONCLUSIONS AND RECOMMENDATIONS

Chapter 6 key objectives:

- Provide a summary of the project by discussing each of the objectives
- Show how the research objectives were met
- Elaborate on the key findings from each objective
- Discuss the research contribution
- Discuss the limitations of the study
- Discuss observations made at the RMT programmes
- Discuss recommendations for future work in the RMT environment

6.1 Research summary

6.1.1 Chapter 1: Background and problem statement

This research study investigated the effectiveness and impact of risk management training (RMT) at supervisory level within Anglo American by designing and developing a serious game with the aim that it be played within the specific RMT programme and act as an effectiveness measurement tool. To meet the objectives of the research study, the thesis is structured into six chapters. Important concepts, problem statement, research objectives and research strategy are discussed in Chapter 1. Chapter 1 also gives a background on the study by outlining the current state of unwanted events in the mining industry and what RMT programmes are being implemented at supervisory level in mining organisations

6.1.2 Chapter 2: Literature review

Chapter 2 included a systematic process of literature review using a search string methodology. The review was done in line with the following focus areas:

- The roles of supervisory level management in mining organisations and their responsibilities regarding operational risk management.
- Training evaluation models used, and the specific evaluation methods used at different levels of evaluation.
- The use of games in the training environment and how serious characteristics game can increase learning ability and knowledge retention, as well as what specific game characteristics are to be implemented into serious games design.
- What other mining companies are doing for ORM training strategy, and the current state of safety performance of these companies.

- How leadership at supervisory level plays a role in safety management and implementation of ORM.
- Different platforms available for serious game design for better application in training programmes and the mining environment.

6.1.3 Chapter 3: Research methodology

Chapter 3 discusses the research methodology followed throughout the course of the study in order to meet the requirements for each section of the study and ultimately meet the objectives. This chapter thus discussed how the objectives will be met, the different research approaches followed, the source and method of data collection, as well as the method used for data analysis.

6.1.4 Chapter 4: Design and development of an effectiveness measurement tool

Chapter 4 forms the largest part of this study as it uses the knowledge gained from the literature review regarding the roles of supervisors on mining sites, implementation of ORM in training programmes, training evaluation models and methods, current state of safety performance in the mining sector and real-world risk-associated mining activities and tasks supervisors deal with on a daily basis. SG design characteristics are investigated, along with characteristics associated with better learning to apply the findings from literature in a SG design to be played in supervisory level RMT programmes.

Together with this, the author investigated applicable serious games platforms and learnt the coding for the platform used to design and develop a successful SG. This chapter then discusses the validation of the SG and how the SG is applied in an actual RMT programme for a well-known mining organisation.

6.1.5 Chapter 5: Results and discussion

In Chapter 5, the results are discussed in terms of statistical analysis. Results obtained from a points system of the SG that was played at an actual RMT programme are analysed in term of players' ability to improve their scores throughout the course of different rounds of the game. Theory tests on the RMT programme content are analysed statistically to find correlations between the test scores and the points achieved in the SG. From the tested group, real world KPIs are investigated from the completion of JRAs at the sites where these delegates/supervisors work to see if the KPIs increased as a result of the attendance of the RMT programme. The measurement of these three elements forms part of the training programme evaluation in an attempt to map the effectiveness and impact of risk management training at supervisory level within a mining organization, and how SGs can supplement training programmes in improving this effectiveness and impact through better learning methods.

6.2 Research objectives

6.2.1 Objective 1

The main research objective of this study is to contribute to the improvement and development of operational risk management in the mining industry by measuring the effectiveness and impact of RMT at supervisory level within a mining organisation through the development of an appropriate measurement tool. This is done by the research objectives discussed in Section 1.6. To meet the first objective, specific research questions needed to be investigated:

a) What are the roles of a supervisor on a mining site?

From a literature review on management and leaderships styles of some of the largest mining companies in the world, it was found that a supervisory role in mining operations entails the implementation and oversight of safety procedures when their team executes a task, through planning, directing, checking and acting on observations. The supervisor thus takes on a leadership role on site, having the responsibility to interact with and understand their team members, be familiar with hazards on site and how to address them, enforce discipline, and be able to conduct job risk assessments.

b) What are the methods used for risk management training and what techniques are used to evaluate them?

The methods used for RMT is gathered from literature, as well as first-hand experience of the author through attendance of an RMT programme for supervisory level in a mining organisation. The basic requirement for RMT is the attendance of a 2-3-day RMT course for a group of supervisors. These courses cover the company principles and standings on risk and safety management, identification of hazards and the controls available, and how to communicate with their team in terms of safety management. These courses focus on the learning of implementation of safety work procedures with the goals to raise awareness of hazards and risks, as well as to correctly plan and schedule daily tasks to prevent possible unwanted events.

Delegates to such RMT programmes are assessed through group activities and their participation, pre- and/or post-training theoretical tests and assessment on the quality of Job Risk Assessments completed. An evaluation of the behavioural change in delegates as a result of attendance of the course is, however, not evaluated. This is thus the key to this study, as the aim is to use the four levels of the Kirkpatrick model of evaluation, to bring the four levels together with a measurement tool measure a behavioural change in delegates to the RMT programme as a result of their attendance to the programme (and so measuring the programme's effectiveness and impact).

c) How SGs in training programmes can be used to endure effective learning as well as evaluate a behavioural change

Recently, the uptake of serious games has seen a great increase not only at school level but also in adult learning. From the literature review it is evident that serious games have characteristics that improve the knowledge uptake and learning through stimulating cognitive abilities, which results in a better quality of learning without learners knowing it. These characteristics are investigated and the key characteristics to enhance better learning and stimulate a cognitive state of learning 'flow' among learners are:

- An SG must have rules.
- An SG must have goals and choices.
- An SG must have a competitive element.
- An SG must give the user constructive feedback on improvement for repetition.

With the main problem at supervisory level being that tasks are still unplanned on a daily basis, the management of risks on site is neglected which leads to unwanted events. After research into the above-mentioned research questions, an SG called *Time Risk Manager* is developed, aimed at supervisors who manage risk-related decisions with a time constraint. Following the needs for the A2 RMT programme of Anglo American and its principles, together with the research into the field of ORM and the supervisory role therein, a points system is created in the form of a digital board game, where supervisors are faced with a randomised set of everyday work scenarios having possible risks associated with them. The weekly tasks are time-constrained and all impact a set of dashboard scores in the form of Operational Performance, Safety, Health & Environment and People & Leadership. In this tight time frame of decision-making the supervisor must thus decide which of the tasks they are going to treat in the present week and which to treat later, all of these having implications on the FLM's dashboard scores.

After investigation into different platforms, it was found that a digital platform would be best for accessibility as well as capturing of data. The author coded the SG and its points system on Excel VBA with a user-friendly interface. The game is validated and approved by the involved mining organisation, to be used as a way to measure the effectiveness of the A2 programme through understanding of concepts and job expectations.

6.2.2 Objective 2

The second objective follows up on the design from the first objective and is to correlate the measurement tool with real-world performance indicators of a sample group of supervisors within the group, especially in terms of routine and non-routine task planning.

The designed SG is implemented in an actual RMT programme presented by Anglo American and played by the delegates to the programme. The measurement of effectiveness and impact of the programme is done by correlating the measurement tool with real-world KPIs in terms of the levels of training programme evaluation according to the Kirkpatrick model discussed in the literature review, with the aim of evaluating level three which is a behavioural change. Level two (learning) is measured through theoretical test results covering the course content, while level four (results) are measured as an increase or decrease in job performance after attending the programme. The results from the SG, and whether delegates succeeded in improving their scores through levels of the game, is correlated with level two and four in order to estimate a behavioural change in delegates and the impact SGs have on it.

It was found that the results aligned well with the predictions from literature, that SGs increase a learner's ability to learn and apply specific principles. From the two sample groups tested, an ANOVA is done and found that there is a statistically significant improvement in player median scores after five rounds played. The increase in delegates' scores from rounds one to five are correlated with the players' respective theory test results. A Pearson correlation between these datasets resulted in p-values smaller than 0.05, indicating a statistically significant correlation between the ability of respective players to increase their scores through understanding of the course content and their knowledge of the actual course content through a theory test.

Finally, the last tests are to see if there is a significant immediate increase in work performance after attendance of the A2 RMT course, as seen in the players'/delegates' increase in SG scores and its correlation with their theoretical knowledge. The KPI that is measured is the completion of JRAs on site, as this is the main outcome of the A2 programme. The increase in this documentation is done through effective scheduling and planning of work procedures related to safety risk management of supervisors. A one-way ANOVA is done comparing the amount of JRAs submitted ten workdays before and ten workdays after attendance of the A2 programme. This resulted in a p-value of 0.02 for both groups 1 and 2, indicating a statistically significant increase in JRAs submitted after attendance of the A2, at a confidence level of 95%. From the delegates/players who work on operations that entail high-risk events who complete JRAs on a daily basis, a hypothesis test was done to see if there is a statistically significant correlation between the increase in respective players' SG scores increase and their increase in JRA completion before and after attendance to the A2 RMT programme. A person correlation was done and with a p-value of 0.001 at a confidence interval of 95%, H0 was rejected, indicating a statistically significant correlation between delegates' ability to increase their SG scores and the behavioural change in terms of JRA completion.

The increase in knowledge gain from delegates to the programme, their ability to improve SG scores associated with the course content and their improvement in KPIs related to the A2 programme proves a positive behavioural change due to attendance of the A2 course and application of the course content in the workplace. It also indicates that the impact of SGs in RMT can help increase the effectiveness of the uptake and retention of knowledge and concepts, resulting in better application on the workplace. The implementation of SGs in RMT programmes can thus improve concept understanding and knowledge retention in this field, increasing the awareness of correct planning and scheduling of risk related tasks, ultimately improving the safety performance in the mining organisation.

6.3 Study limitations

Like any other research study, there are limitations to this study that should be acknowledged.

1. The design of the game, *Time Risk Manager*, is based on risk management training protocol and procedures followed by Anglo American. This means that specific terms used, and even full operational procedures followed within this company might be unique to the company within their risk management framework. The company does however belong to the ICMM and adheres to their standards, just as the other member companies do. This study can thus be used and be applicable to mining companies, by making small company owned adjustments in terms of terms, procedures and priorities.
2. Many of the mining operations still have important technologies to be implemented on site, like Enablon, which is a software that stores company data in order to maximize performance. In the case of this study, the data to be captured would be the generated JRA's. The absence of this on sites means the use of physical documents, which isn't as easily accessible and also hard to link to specific delegates who have completed the A2 training.
3. Mining companies in general, but especially Anglo American, are very large with many supervisors spread across various locations. This makes the implementation of new processes and the tracking of supervisor training completion hard.
4. In general, the mining organisation sends supervisors to the A2 RMT programme who not all might consist of supervisors dealing with high risk activities on a daily basis. This limits the measurement of KPIs as while all are still supervisors, they have different deliverables on site. It is thus recommended to train groups of supervisors who have the same work deliverables (KPIs).
5. Currently, Anglo American only implements a pre-test within their A3 and A4 RMT programmes for executives and higher management, and not in the A2 programme. The alteration of an already existing training system was not possible, which limits the measurement of the extent of the knowledge the delegates have before starting the programme. It was thus necessary to assume they don't know any of the course content before attending the programme.
6. Interpretation of the design of *Time Risk Manager,* as well as interpretation of the alignment of sets of results is dependent on the authors understanding of the subject. The SG design was based on developing an application that incorporates the characteristics of a SG that are linked to learning improvement.
7. Due to the fact that the SG needs to be tested at a training facility for a specific group at an actual A2 RMT course, it was difficult to get a lot of data, and 25 delegates were tested.

6.4 Research contribution

As this research focuses on the levels of evaluation of training, specifically on risk management training on supervisory level within the mining sector, it has a lot to offer in terms of safety management. The objectives of the study are set out to investigate the use of SGs and SG characteristics within a training programme to not only increase the effectiveness of training through better learning, but also to use SGs as a measurement tool to estimate a behavioral change in supervisory level management as a results of attendance to the RMT programme.

The objectives of this study were met through the successful design and development of a measurement tool in the form of a SG that was applied within an actual training RMT programme. The results indicate an increase in learning ability through the play of an SG in the programme, as well as a statistically significant correlation between SG scores and real world KPIs of delegates to the programme. The contribution to research is thus that the uptake of SGs in RMT programmes have a positive effect on supervisory level and is a subject worthy of further investigation on all levels of training in the mining sector.

6.5 Recommendations for future work

The findings from the game design discussed in Chapter 4, the results in Chapter 5, the observations at the A2 Risk Management Course, as well as the limitations discussed in Section 6.3, provide fruitful paths for future investigation and research that will improve the effectiveness and impact of risk management training.

From the positive results obtained, it is recommended that **SGs be implemented in risk management training** within the mining organization in order to potentially increase the effectiveness of training in terms of retention of concepts learnt and improve the impact it has by implementing the principles better and more consistent on mining sites. The current tool can be adapted and changed by the involved company into a more **user-friendly platform**, for example a phone application or tablet that can be sent around on site.

An area for future research in the **training environment** goes hand-in-hand with serious gaming, which is the use of **virtual reality** on mining sites. Operators performing tasks that have high risks will perform an operation virtually, allowing them to practice and perfect the work, minimizing errors and improving safety performance on mines. The virtual reality can then be used as a tool in the mining environment to supplement and support the training, in order to establish the understanding of specific concepts and procedures through repetition and handling of different, changing scenarios on site.

With regards to the measurement of the effectiveness and impact of the training, through the use of a tool in the form of a SG, it is recommended that the **data collection process** be improved. Improvements include the capturing of SG results data over a **longer period of time**, by letting workers play monthly or quarterly to test knowledge retention as well as keep them motivated to improve. It is recommended to implement a SG ranking system on respective operations, with possible rewards systems, giving workers incentive to keep focused and improving their risk management knowledge as well as promote continuous improvement on risk- and safety related operational procedures. It is also recommended that Anglo American (and other mining companies) gather as much as possible data from their RMT programmes in order to effectively measure the effectiveness and impact of these programmes.

The purpose of this chapter is to conclude the findings of the research study and design and discuss recommendations for future work to be done on this research as well as application of the SG and data collection process. The author believes that there is great potential for the use of serious games in risk management training, which will greatly influence the effectiveness of a risk management training programme. He also believes that mining organizations dealing with high risk activities every day can draw technical direction and inspiration from the designed and proposed effectiveness measurement tool.

7 REFERENCES

Abt, C. C. (1987). *Serious Games.* University Press of America.

All, A., Castellar, E. P., & Van Looy, J. (2015). Assessing the effectiveness of digital game-based learning: Best practices. *Computers & Education*, 90-103.

Amory, A. (2007). Game object model version II: A theoretical framework for educational game development. *Educational Technology Research & Development, 55*, 51-77.

Anderson, L., Krathwohl, D., & Bloom, B. (2001). *Anderson, L., Krathwohl, D., & Bloom, B. (n.d.). A taxonomy for learning, teaching, and assessing : a revision of Bloom's taxonomy of educational objectives.* New York: Longman.

Anglo American. (2015). Operational Risk Management Process: A2 Learner Workbook. United Kingdom: Anglo American (UK) Limited.

Anglo American. (2018). *Anglo American Sustainability Report 2018.* Retrieved December 16, 2018, from Anglo American: https://brasil.angloamerican.com/~/media/Files/A/Anglo-American-Brazil-V3/pdfs/aa-sustainability-report-2018.pdf

Anglo American ORM. (2017, November). Operational Risk Management Process: A2 Learner Workbook. *A2 Version 6.0*.

Anglo American ORM. (2018). *Sustainability Report 2018.* Retrieved December 19, 2018, from Anglo American: https://brasil.angloamerican.com/~/media/Files/A/Anglo-American-Brazil-V3/pdfs/aa-sustainability-report-2018.pdf

Anglo American Sustainability Report. (2017). Building Firm Foundations: Delivering a Sustainable Future.

Armstrong, M. B., & Landers, R. N. (2018). Gamification of employee training and development. *International Journal of Training and Development, 22*(2), 1-8.

Arnad, S., Lim, T., Carvalho, M., Bellotti, F., de Freitas, S., Louchart, S., . . . De Gloria, A. (2014). Mapping learning and game mechanics of serious games analysis. *British Journal of Educational Technology*. doi:10.1111/bjet.12113

Bachvarova, Y., Bocconi, S., Van der Pols, B., Popesu, M., & Roceanu, I. (2012). Measuring the effectiveness of learning with serious games in corporate training. *Procedia Computer Science, 15*, 221-232.

Bedwell, W. L., Pavlas, D., Heyne, K., Lazzara, E. H., & Salas, E. (2012). Towards a Taxonomy Linking Game Attributes to Learning. *Simulation & Gaming, 43*(6), 729-760. doi:10.1177/1046878112439444

Beetham, H. (2008). *Review: Design of learning programme phase 2.* Retrieved December 18, 2018, from Review of learning design as part of the JISC's Design for Learning programme: http://www.jisc.ac.uk/whatwedo/programmes/elearningpedagogy/designlearn.aspx

Bell, T., Urhahne, D., Schanze, S., & Ploetzner, R. (2010). Collaborative Inquiry Learning: Models, Tools and Challenges. *International Journal of Science Education, 32*(3), 349-377.

BHP. (2018). *BHP Sustainability Report 2018.* Retrieved December 16, 2018, from BHP Billiton: https://www.bhp.com/investor-centre/sustainability-report-2018

BHP Safety. (2018). *BHP Sustainability Report 2018.* Retrieved December 18, 2018, from https://d2s7ymlq1fp6va.cloudfront.net/#p=31

Boyle, E. A., Connolly, T. M., Hainey, T., & Boyle, J. M. (2012). Engagement in digital entertainment games: A systematic review. *Computers inHuman Behavior, 28*(3), 771-780. doi:http://dx.doi.org/10.1016/j.chb.2011.11.020

Boyle, E., Connolly, T., & Hainey, T. (2011). The role of psychologyin understanding the impact of computer games. *Entertainment Computing, 2*(2), 69-74. doi:http://dx.doi.org/10.1016/j.entcom.2010.12.002

Bradford, A. (2012). *Surveying Technical: Risk management activities of the mine surveyor.* Anglo American.

Bryman, Bell, Santos, D., Toit, D., Masenge, V. A., & Wagner. (2000). *Research Methodology: Business adn Management Contexts* (Revised Ed ed.). California: SAGE Publications Inc.

Bullock, M. (1979). *Work process control guide.* Idaho: Systems Safety Development Centre EG and G Inc.

Bybee, R., Trowbridge, L. W., & Powell, J. C. (2008). *Teaching Secondary School Science: Strategies for Developing Scientific Literacy.* New Jersey Merril.

Charan, R., Drotter, S., & Noel, J. (2011). *The Leadership Pipeline: How to Build the Leadership Powered Company* (2nd ed.). San Francisco: John Wiley & Sons Inc.

Charsky, D. (2010). From Edutainment to Serious Games: A Change in the Use of Serious Game Characteristics. *Games and Culture*. doi:10.1177/1555412009354727

Chong, Y. Y. (2001). Operational risk: an example from the mining industry. *Balance Sheet, 9*(2), 26-28.

CODELCO Sustainability. (2016). *CODELCO.* Retrieved December 17, 2018, from Corporation Nacional del Cobre: https://www.codelco.com/memoria2016/en/pdf/mem2016codelco-sustainability.pdf

Connoly, T. M., Boyle, E. A., MacArthur, E., Hainley, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers & Education, 59*(2), 661-686.

Cook, D. (2006). *What are game mechanics.* Retrieved December 18, 2018, from http://www.lostgarden.com/2006/10/whatare-game-mechanics.html

Coursera. (2018, June). Serious Gaming. Erasmus University, Rotterdam.

Crawford, B. (1999). Is It realistic to Expect a Preservice Teacher to Create an Inquiry-Based Classroom? *Journal of Science Teacher Education, 10*(3), 175-194.

Creswell, J. (2009). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches* (3rd ed.). California: SAGE Publications Inc.

DDI Development. (2017, July). *Top 7 software development methodologies with Pros and Cons.* Retrieved from http://ddi-dev.com/blog/programming/7-best-software-development-methodologies-pros-and-cons/

Diener, E., & Crandall, R. (1978). *Ethics in Social and Behavioral Research.* Chicago Press University: United States of America.

Domínguez, A., Saenz-de-Navarrete, J., de-Marcos, L., Fernández-Sanz, L., Pagés, C., & Martínez-Herráiz, J.-J. (2013). Gamifying learning experiences: Practical implications and outcomes. *Computers & Education, 60*(0), 380-392. doi:http://dx.doi.org/10.1016/j.compedu.2012.12.020

Downes, A. (2016, January). *4 Learning Evaluation Models You Can Use.* Retrieved April 20, 2018, from eLearning Industry: https://elearningindustry.com/4-learning-evaluation-models-can-use

Downes, A. (2016, January). *4 Learning Evaluation Moels You Can Use.* Retrieved April 20, 2018, from eLearning Industry: https://elearningindustry.com/4-learning-evaluation-models-can-use

Draeger, N. (2014, May 12). *5 Reasons You Need To Be Using Games For Corporate Training.* Retrieved April 22, 2018, from eLearning Industry: https://elearningindustry.com/5-reasons-you-need-to-be-using-games-for-corporate-training

Erhel, S., & Jamet, E. (2013). Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness. *Computers & Education*, 156-167.

Eurosis. (2018). *Simulation and Gaming Software Development Tools and Languages.* Retrieved May 4, 2018, from Eurosis: https://www.eurosis.org/cms/?q=node/61

Fabricatore, C. (2007, October 29-31). Gameplay and Gamemechanics: A Key to Quality in Video Games. *Expert meeting on Video Games and Education*. SanDiego de Chile. Retrieved December 18, 2018, from http://eprints.hud.ac.uk/20927/

Freeport-McMoran. (2018). *Working Toward Sustainable Development Report.* Retrieved December 17, 2018, from Freeport-McMoran: https://www.fcx.com/sites/fcx/files/documents/sustainability/wtsd_2018.pdf

FreePort-McMoran OH&S. (2018). *Sustsainability Report.* Retrieved December 17, 2018, from FreePort-McMoran: https://www.fcx.com/sustainability/health-safety/fatality-prevention

Gee, J. P. (2002). *What video games have to teach us about learning and literacy.* New York: Palgrave, Macmillan.

Gijlers, H., Saab, N., Joolingen, V., De Jong, T., & B.H.A.M, v. H.-W. (2009). Interaction Between Tool and Talk: How Instruction and Tools Support Consensus Building in Collaborative Inquiry-Learning Environments. *Journal of Computer Assisted Learning, 25*(3), 252-267.

Glencore. (2014). *Sustainibility Report 2014.* Retrieved January 14, 20119, from https://www.glencore.com/dam/jcr:b5638aa5-4cdb-4c91-9424-3b8c802dfef2/2014-Sustainability-Report.pdf

Glencore. (2018). *Glencore Sustainability Report.* Retrieved December 16, 2018, from https://www.glencore.com/dam:jcr/633f190c-76d6-42b3-beca-debb25134556/2018-Glencore-Sustainability-Report_.pdf

Glencore Sustainability. (2018). *Glencore.* Retrieved December 17, 2018, from https://www.glencore.com/en/sustainability/safety

González-González, C., Toledo-Delgado, P., Collazos-Ordoñez, C., & González-Sánchez, J. L. (2014). Design and analysis of collaborative interactions in social educational vodeogames. *Computers in Human Behavior, 57*(4), 602-611. doi:http://dx.doi.org/10.1016/j.chb.2013.06.039

Grossman, R., & Salas, E. (2011). The tranfer of training: what really matters. *International Journal of Training and Development, 15*(2), 103-119.

Guerra-Lopez, I. (2008). *Performance Evaluation: Proven approaches for improving program and organzational performance.* San Francisco: Jossey-Bass.

Gunter, G., Kenny, R., & Vick, E. (2006). A Case for a Formal Design Paradigm for Serious Games. *The Journal of the International Media and Arts Association, 3*(1), 1-19. doi:citeulike-article-id:9301918

Hainey, T., Connolly, T., Stansfield, M., & Boyle, E. (2011). The differences in motivations of online game players and offline game players: A combined analysis of three studies in higher education level. *Computers and Education, 17*(8), 2197-2211. doi:http://dx.doi.org/10.1016/j.compedu.2011.06.001

Hainley, V., & Henderson, J. (2006). Instructional design principles for serious games. *MultiLingual*, 49-52.

Hess, T., & Gunter, G. (2013). Serious game-based adn nongame-based online courses: Learning experiences and outcomes. *British Journal of Educational Technology, 44*(3), 372-385.

Heuberger, R. (2005). Risk analysis in the mining industry. *The Journal of The South African Institute of Mining and Metallurgy*, 75-79.

Hutchinson, S., & Purcell, J. (2008). *Front line managers and the delivery of effective people management: A studu of front line managers in the NHS.* Bristol: Bristol Business School: University of West of England.

ICMM. (2018). Retrieved January 16, 2019, from International Council of Minining & Metals: https://www.icmm.com/en-gb/health-and-safety/safety/safety-data-and-indicators

Jacobs, K. (2018, August 27). Top 10 World's Biggest Mining Companies 2018. Retrieved January 14, 2019, from http://mining-recruitment-jobs.com/top-10-worlds-biggest-mining-companies-2018/

Jones, A., Gaved, M., Kukulska-Hulme, A., Scanlon, E., Pearson, C., Lameras, P. D., & Jones, J. (2014). Creating coherent incidental learning journeys on Smartphones through feedback and progress indicators: the SCAMP framework. *International Journal of Mobile Human Computer Interaction*.

Juul, J. (2005). *Half-real: Video games between real-rules and fictional worlds.* MIT Press Books.

Kirkpatrick, D. (1996). Revisiting Kirkpatrick's four-level-model. *Training & Development, 50*(1), 54-57.

Kirkpatrick, D. L., & Kirkpatrick, J. D. (2006). *Evaluating Training Programs: The For Levels* (3rd ed.). San Francisco, CA: Berrett-Koehler Publishers.

Laamarti, F., Aid, M., & El Saddik, A. (2014). An Overview of Serious Games. *International Journal of Computer Games Technology*, 1-15.

Lameras, P. (2015). *Essential Featuresof Serious Games Design in Higher Education.* Coventry University: Society for Research into Higher Education.

Lameras, P., Dunwell, I., Stewart, C., Clarke, S., & Petridis, P. (2017). Essential features of serious games design in higher educatio: Linking learning attributes to game mechanics. *British Journal of Educational Technology, 48*(4), 972-994.

Lameras, P., Petridis, P., Torrens, P., Dunwell, I., Hendrix, M., & Arnab, S. (2014). Training Science Teachers to Design Lesson Plans through an Inquiry-Based Serious Game. *The 14th IEEE International Conference on Advanced Learning Technologies.* Athens Greece.

Laurillard, D. (2002). *Rethinking university teaching: A conversational framework for the effectiveuse of learning technologies.* London: RoutledgeFalmer.

McLaggen, E., Bezuidenhout, A., & Botha, C. (2013). Leadership style and organisational commitment in the mining industry in Mpumalanga. *SA Journal of Human Resource Management, 11*(1), 1-16.

Munoz-Merino, P., Molina, M., Munoz-Organero, M., & Kloos, C. (2014). Motivation and Emotions in Competition Systems for Education. *Transactions on Education, 57*, 182-187.

Orpen, C. (1999). The influence of training environment on trainee motivation and perceived training quality. *International Journal of Training and Development, 3*(1), 34-43.

Petticrew, M., & Roberts, H. (2006). How to find the studies: The literature search. In *Systematic Reviews in the Social Sciences: A Practical Guide* (pp. 79-124). Oxford: Blackwell Piblishing.

Pham, E. (2017, August 2). *How to Measure the Effectiveness of Employee Training Programs.* Retrieved April 20, 2018, from Wibe Academy: https://www.wibeacademy.com/en/blog/measure-effectiveness-employee-training-programs

Poddar, A. (2014, December 22). *Research Methodology: Research Design.* Retrieved from Slideshare: https://www.slideshare.net/Poddar25/reserch-methodolgy-research-design

Popay, J., Roberts, H., Sowden, A., Petticrew, M., Arai, L., Rodgers, M., & Britten, M. (2006). *Guidence on the conduct of narrative synthesis in systematic reviews.* London: Institute of Health Research.

RioTinto. (2018). *Sustainability report.* Retrieved January 15, 2018, from Rio Tinto: https://www.riotinto.com/documents/RT_2018_Sustainable_development_report.pdf

RioTinto Health & Safety. (2018). *rio Tinto.* Retrieved December 18, 2018, from https://www.riotinto.com/ourcommitment/health-and-safety-24274.aspx

Roberts, A. (1990). Evaluating Training Programmes. *International Trade Forum: Business Premium Collection, 26*(4), 18-23.

Salkind, N. (2010). *Encyclopedia of research design.* Thousan dOaks, CA: SAGE Publications.

Smith, S. P. (2017, December). Adult Learners: Effective Training Methods. *Professional Safety, 62*(12), pp. 22-25.

Swanson, E. A., Nicholson, A. C., Boese, T. A., Cram, E., Stineman, A. M., & Tew, K. (2011). Comparison of Selected Teaching Strategies Incorporating Simulation and Student Outcomes. *Clinical Simulation in Nursing, 7*(3), 81-90. doi:http://dx.doi.org/10.1016/j.ecns.2009.12.011

Switzer, K. C., Nagy, M. S., & Mullins, M. E. (2005). The Influence of Training Reoutation, Managerial Support, and Self-Efficacy on Pre-Training Motivation and Perceived Training Transfer. *Applied H.R.M, 10*(1), 21-34.

U.S. Department of Defense . (2003, May). *The DoD Use of Risk Management Scorecard.* Retrieved from United States Department of Defense: http://unpan1.un.org/intradoc/groups/public/documents/aspa/unpan013239.pdf

Udemy. (2019, April 2019). *The Ultimate Excel Programmer Course: Excel VBA.* Retrieved from Udemy: https://www.udemy.com/certificate/UC-X1ZPVMUH/

Van der Honert, A. (2014). *Estimating The Continuous Risk Of Accidents Occurring In The South African Mining Industry.* Stellenbosch: University of Stellenbosch.

Van der Spek, E. D., Wouters, P., & Van Oostendorp, H. (2011). Code Red: Triage Or COgnition-based DEsign Rules Enhancing Decisionmaking TRaining In A Game Environment. *British Journal of Educational Technology, 42*(3), 441-455. doi:10.1111/j.1467-8535.2009.01021.x

Vermeulen, H., & Gain, J. (2017). *Experimental Methodology for Evaluating Learning in Serious Games.* Cape Town: Departement of Computer Science: University of Cape Town.

Zhang, J., & Lu, J. (2014). Using Mobile Serious Games for Learning Programming. *The Fourth Conference on Advanced Communications and Computation* (pp. 24-30). West Yorkshire: University of Huddersfield.

APPENDIX A: SCENARIO DECISION GAME CARDS

The cards that will be discussed in this Appendix will show an example of the card that the players will see when they have to make their decisions, as well as the associated points system that will run in the background and calculate the dashboard scores. The associated score/penalty to each scenario will also be subject to a percentage probability that the event might or might not occur.

A total of 32 cards are created, falling into four categories (pillars of the Nertney wheel as discussed in Chapter 4) of 8 cards. Each of the four categories is classified according to a percentage probability that that events might actually occur.

In each round of the game players will be dealt 20 cards, consisting of close to equal amounts from each category. If the event is chosen to be treated *now* and it actually occurs, the player is awarded with points allocated to that activity in the respective dashboard fields. If a player decides to treat an event *later* and it does occur (having a negative impact), allocated points for that activity is deducted from the respective dashboard scores. The categories for the dashboard scores to gain points in, are categorised in terms of the overall objective of a FLM on site, namely *Operational Performance*, *Safety, Health & Environment,* and *People & Leadership*.

Following is the scenario cards as the players will encounter them in the game. The points added and deducted in the respective dashboard scores for the specific scenario card are also indicated, but not seen by the player. This dashboard scoring system will be used and programmed in the background to calculate the final score of the player. The scenario cards are listed below in order of their respective Nertney wheel category.

Table A-1: Game scenario cards 1-8 (People & Competency)

Fatigue		**Hours to complete: 4**			**Card 1**
Risk Identification		People have been working long hours for some time on top of excessive travel time between home and work. These factors are impacting the productivity and safety performance, and absenteeism is also increasing.			
Risk Assessment					
Potential Risk Treatment		Review the shift roster. Introduce mid- shift breaks. Hire additional people or increase contractor presence.			
If Treated Now & Event Occurs					
Operational Performance	0	**Safety, Health & Environment**	+8	**People & Leadership**	+8
If Treated Later & Event Occurs					
Operational Performance	0	**Safety, Health & Environment**	-8	**People & Leadership**	-8

Skills Shortage		Hours to complete: 5			Card 2
Risk Identification		A shortage of experienced operators of plant and heavy earth equipment impacts on your ability to meet your production targets.			
Risk Assessment					
Potential Risk Treatment		You start an aggressive program of sending candidates to be training. External training personnel are brought in to fast-track the process.			
If Treated Now & Event Occurs					
Operational Performance	+8	**Safety, Health & Environment**	0	**People & Leadership**	+8
If Treated Later & Event Occurs					
Operational Performance	-8	**Safety, Health & Environment**	0	**People & Leadership**	-8

Disregarding Safety Procedure		Hours to complete: 8			Card 3
Risk Identification		You see increasing amount of employee's disregard safety procedure while not being supervised. This corresponds to high potential incidents			
Risk Assessment					
Potential Risk Treatment		Invest in safety compliance and awareness programme and train people in the consequences of high tolerance to risk. Initiate and implement culture change workshops.			
If Treated Now & Event Occurs					
Operational Performance	0	**Safety, Health & Environment**	+8	**People & Leadership**	+4
If Treated Later & Event Occurs					
Operational Performance	0	**Safety, Health & Environment**	-8	**People & Leadership**	-4

Driver Competency		Hours to complete: 3			Card 4
Risk Identification		Driving training sessions are cancelled due to production needs.			
Risk Assessment					
Potential Risk Treatment		Hire additional resources or reinstall driver training.			
If Treated Now & Event Occurs					
Operational Performance	+8	**Safety, Health & Environment**	0	**People & Leadership**	+4
If Treated Later & Event Occurs					
Operational Performance	-8	**Safety, Health & Environment**	0	**People & Leadership**	-4

Unplanned Task Changes		**Hours to complete: 6**			**Card 5**
Risk Identification		Unplanned change occurs while busy with a task.			
Risk Assessment					
Potential Risk Treatment		Assist and make sure each team member applies the SLAM tool effectively			
If Treated Now & Event Occurs					
Operational Performance	0	**Safety, Health & Environment**	+4	**People & Leadership**	+8
If Treated Later & Event Occurs					
Operational Performance	0	**Safety, Health & Environment**	-4	**People & Leadership**	-8

Task Specific Competency		**Hours to complete: 7**			**Card 6**
Risk Identification		There is a team member assisting on a technical task to which he hasn't completed proper training in, but the workforce is needed.			
Risk Assessment					
Potential Risk Treatment		Replace the member with someone who has the proper training. Make sure all team members have the right skills/ knowledge to complete the task.			
If Treated Now & Event Occurs					
Operational Performance	+9	**Safety, Health & Environment**	+4	**People & Leadership**	+4
If Treated Later & Event Occurs					
Operational Performance	-9	**Safety, Health & Environment**	-4	**People & Leadership**	-4

Training Required		**Hours to complete: 3**			**Card 7**
Risk Identification		An A1 risk management training course is due for your team to attend.			
Risk Assessment					
Potential Risk Treatment		Book the team to attend the training as soon as possible.			
If Treated Now & Event Occurs					
Operational Performance	0	**Safety, Health & Environment**	+8	**People & Leadership**	+7
If Treated Later & Event Occurs					
Operational Performance	0	**Safety, Health & Environment**	-8	**People & Leadership**	-7

Unfamiliar Site Equipment		Hours to complete: 4			Card 8
Risk Identification		A new piece of machinery is introduced, and training is required for teams to operate it.			
		Risk Assessment			
Potential Risk Treatment		Let the teams get training to ensure competency of equipment usage, to ensure safe work procedures.			
		If Treated Now & Event Occurs			
Operational Performance	+8	**Safety, Health & Environment**	+8	**People & Leadership**	0
		If Treated Later & Event Occurs			
Operational Performance	-8	**Safety, Health & Environment**	-8	**People & Leadership**	0

Table A-2: Game scenario cards 9-16 (Equipment Integrity)

Equipment Failure		Hours to complete: 7			Card 9
Risk Identification		Urgent, increased maintenance requirements for critical mining equipment is identified, impacting the availability and production			
		Risk Assessment			
Potential Risk Treatment		Prioritize preventative maintenance and the hiring of equipment to cover maintenance downtime. Implement new maintenance and production scheduling meetings and training of key people to ensure correct maintenance is carried out.			
		If Treated Now & Event Occurs			
Operational Performance	+8	**Safety, Health & Environment**	+8	**People & Leadership**	0
		If Treated Later & Event Occurs			
Operational Performance	-8	**Safety, Health & Environment**	-8	**People & Leadership**	0

Equipment Shortage		Hours to complete: 6			Card 10
Risk Identification		Equipment Shortage due to supplier not delivering a key piece of equipment needed for a project.			
		Risk Assessment			
Potential Risk Treatment		Spend time reallocating teams to different tasks while waiting for the equipment			
		If Treated Now & Event Occurs			
Operational Performance	4	**Safety, Health & Environment**	0	**People & Leadership**	+8
		If Treated Later & Event Occurs			
Operational Performance	-4	**Safety, Health & Environment**	0	**People & Leadership**	-8

Production Downtime		**Hours to complete: 4**			**Card 11**
Risk Identification		There's a major delay on the conveyer system where your team is working, affecting production.			
Risk Assessment					
Potential Risk Treatment		Get the mechanics to fix the conveyor while workers proceed with a different task.			
If Treated Now & Event Occurs					
Operational Performance	+8	**Safety, Health & Environment**	0	**People & Leadership**	+7
If Treated Later & Event Occurs					
Operational Performance	-8	**Safety, Health & Environment**	0	**People & Leadership**	-7

Equipment Failure		**Hours to complete: 7**			**Card 12**
Risk Identification		There has been reports of equipment breakdowns while one of the teams are busy with the task.			
Risk Assessment					
Potential Risk Treatment		Stop the work until the equipment is fixed, implicating production. Otherwise continue with defective equipment which can hold serious safety implications			
If Treated Now & Event Occurs					
Operational Performance	+4	**Safety, Health & Environment**	+8	**People & Leadership**	0
If Treated Later & Event Occurs					
Operational Performance	-4	**Safety, Health & Environment**	-8	**People & Leadership**	0

Production		**Hours to complete: 4**			**Card 13**
Risk Identification		A new production improvement technology is introduced and may possibly increase equipment reliability improvements.			
Risk Assessment					
Potential Risk Treatment		Get a team to perform a field trial of the new technology.			
If Treated Now & Event Occurs					
Operational Performance	+4	**Safety, Health & Environment**	+7	**People & Leadership**	0
If Treated Later & Event Occurs					
Operational Performance	-4	**Safety, Health & Environment**	-7	**People & Leadership**	0

Geotechnical Hazards		**Hours to complete: 4**			**Card 14**
Risk Identification		Pit wall slope failures increase dramatically. No injuries have been reported, but the possibility exists.			
Risk Assessment					
Potential Risk Treatment		Get geotechnical experts on site to perform geophysical mapping to identify issues.			
If Treated Now & Event Occurs					
Operational Performance	+8	**Safety, Health & Environment**	0	**People & Leadership**	+8
If Treated Later & Event Occurs					
Operational Performance	-8	**Safety, Health & Environment**	0	**People & Leadership**	+8

New Equipment		**Hours to complete: 5**			**Card 15**
Risk Identification		During the PTO, it is seen that although the new equipment makes the job more effective, it holds different hazards for the task. The JRA possibly needs to be updated.			
Risk Assessment					
Potential Risk Treatment		Take time to review and update the JRA with the team.			
If Treated Now & Event Occurs					
Operational Performance	+4	**Safety, Health & Environment**	+7	**People & Leadership**	0
If Treated Later & Event Occurs					
Operational Performance	-4	**Safety, Health & Environment**	-7	**People & Leadership**	0

Equipment Failure		**Hours to complete: 3**			**Card 16**
Risk Identification		A production line conveyor has a scheduled maintenance, but the team says it's still fine.			
Risk Assessment					
Potential Risk Treatment		Can you afford to keep this equipment operating beyond scheduled service? Follow procedure and schedule the service, which will influence production, but increase safety in equipment integrity.			
If Treated Now & Event Occurs					
Operational Performance	0	**Safety, Health & Environment**	+8	**People & Leadership**	+8
If Treated Later & Event Occurs					
Operational Performance	0	**Safety, Health & Environment**	-8	**People & Leadership**	-8

Table A-3: Game scenario cards 17-24 (Work Methods/Operating Procedure)

Incorrect Work Methods		**Hours to complete: 6**			**Card 17**
Risk Identification		A team arrived late and rush to their tasks for the day without performing a JRA.			
Risk Assessment					
Potential Risk Treatment		Supervise while the team completes the JRA.			
If Treated Now & Event Occurs					
Operational Performance	0	**Safety, Health & Environment**	+8	**People & Leadership**	+8
If Treated Later & Event Occurs					
Operational Performance	0	**Safety, Health & Environment**	-8	**People & Leadership**	-8

Incorrect Operating Procedure		**Hours to complete: 8**			**Card 18**
Risk Identification		You see one of your teams conducting a high-risk task with too little people necessary for the job.			
Risk Assessment					
Potential Risk Treatment		Act on the sight and get the correct number of team members for the job.			
If Treated Now & Event Occurs					
Operational Performance	+4	**Safety, Health & Environment**	+10	**People & Leadership**	+8
If Treated Later & Event Occurs					
Operational Performance	-4	**Safety, Health & Environment**	-10	**People & Leadership**	-8

Too little team members for job		**Hours to complete: 6**			**Card 19**
Risk Identification		A high-risk job needs to be completed and all the team members weren't present in the briefing.			
Risk Assessment					
Potential Risk Treatment		Stop proceedings and make sure every team member knows the procedure to be followed to complete the task.			
If Treated Now & Event Occurs					
Operational Performance	0	**Safety, Health & Environment**	+8	**People & Leadership**	+7
If Treated Later & Event Occurs					
Operational Performance	0	**Safety, Health & Environment**	-8	**People & Leadership**	-7

Incorrect Work Methods		Hours to complete: 5			Card 20
Risk Identification		A team starts a new task and have left out key elements on the WED checklist.			
		Risk Assessment			
Potential Risk Treatment		Stop proceedings and check that all checklist of the WED is complete.			
		If Treated Now & Event Occurs			
Operational Performance	+9	**Safety, Health & Environment**	+1	**People & Leadership**	+4
		If Treated Later & Event Occurs			
Operational Performance	-9	**Safety, Health & Environment**	-1	**People & Leadership**	-4

High Noise Levels		Hours to complete: 4			Card 21
Risk Identification		The noise levels on site has been very high which introduces the risk of hearing damage to your team.			
		Risk Assessment			
Potential Risk Treatment		Make sure the team wears the correct PPE and explain the consequences of not wearing it correctly.			
		If Treated Now & Event Occurs			
Operational Performance	+8	**Safety, Health & Environment**	+8	**People & Leadership**	0
		If Treated Later & Event Occurs			
Operational Performance	-8	**Safety, Health & Environment**	-8	**People & Leadership**	0

Power Outage on Site		Hours to complete: 3			Card 22
Risk Identification		A sudden power outage occurs on one of the main sections of the plant, and the generator doesn't start.			
		Risk Assessment			
Potential Risk Treatment		Attend to the situation immediately and get the electricians to fix the problem.			
		If Treated Now & Event Occurs			
Operational Performance	+10	**Safety, Health & Environment**	0	**People & Leadership**	+4
		If Treated Later & Event Occurs			
Operational Performance	-10	**Safety, Health & Environment**	0	**People & Leadership**	-4

Incorrect Operating Procedures		Hours to complete: 4			Card 23
Risk Identification		A team is starting with Task Risk Management before starting a new job. They however start developing a Standard Operating Procedure (SOP) before going through the JRA.			
Risk Assessment					
Potential Risk Treatment		See through that they complete the JRA adequately before commencing with the SOP.			
If Treated Now & Event Occurs					
Operational Performance	+8	**Safety, Health & Environment**	+4	**People & Leadership**	+8
If Treated Later & Event Occurs					
Operational Performance	-8	**Safety, Health & Environment**	-4	**People & Leadership**	-8

Changes in Safety Controls		Hours to complete: 4			Card 24
Risk Identification		Changes are made to specific tools for a job, which means the, which means controls cannot be implemented as specified. The JRA must likely be reviewed.			
Risk Assessment					
Potential Risk Treatment		Review the JRA to see if it is still suitable.			
If Treated Now & Event Occurs					
Operational Performance	+4	**Safety, Health & Environment**	+4	**People & Leadership**	+4
If Treated Later & Event Occurs					
Operational Performance	-4	**Safety, Health & Environment**	-4	**People & Leadership**	-4

Table A-4: Game scenario cards 25-32 (Supervision/Control)

Task Planning and Scheduling		Hours to complete: 3			Card 25
Risk Identification		You as supervisor is needed at a meeting, but you haven't checked that everybody on site is cleared for the day.			
Risk Assessment					
Potential Risk Treatment		Make sure everyone on site is approved before leaving.			
If Treated Now & Event Occurs					
Operational Performance	+8	**Safety, Health & Environment**	0	**People & Leadership**	+8
If Treated Later & Event Occurs					
Operational Performance	-8	**Safety, Health & Environment**	0	**People & Leadership**	-8

Water Contamination		Hours to complete: 3			Card 26
Risk Identification		Growing community concern about water quality in the local water catchment area. Allegations are raised that it is your operation contaminating the water supply.			
Risk Assessment					
Potential Risk Treatment		Introduce a full measurement programme of local water sources to ensure understanding of water quality both upstream and downstream of the site. Invest in water treatment technology on site and provide the community with the technology to deal with the contaminated water.			
If Treated Now & Event Occurs					
Operational Performance	0	Safety, Health & Environment	+8	People & Leadership	+4
If Treated Later & Event Occurs					
Operational Performance	0	Safety, Health & Environment	-8	People & Leadership	-4

Occupational Health		Hours to complete: 4			Card 27
Risk Identification		Several employees have been absent and due to lung disease/sickness.			
Risk Assessment					
Potential Risk Treatment		Increase awareness and supervision on the correct PPE of your teams, making sure that masks are worn on dusty areas.			
If Treated Now & Event Occurs					
Operational Performance	+4	Safety, Health & Environment	+8	People & Leadership	+5
If Treated Later & Event Occurs					
Operational Performance	-4	Safety, Health & Environment	-8	People & Leadership	-5

Transportation Safety		Hours to complete: 8			Card 28
Risk Identification		Transport related incident occurs on-site with a possible fatality.			
Risk Assessment					
Potential Risk Treatment		Shut down the site to investigate the cause of the incident, but at expense of operational performance.			
If Treated Now & Event Occurs					
Operational Performance	+8	Safety, Health & Environment	+10	People & Leadership	0
If Treated Later & Event Occurs					
Operational Performance	-8	Safety, Health & Environment	-10	People & Leadership	0

Operational Changes		Hours to complete: 7			Card 29
Risk Identification		There are new team members on site and have already gone through training.			
Risk Assessment					
Potential Risk Treatment		Make sure they know their roles and responsibilities before commencing with tasks.			
If Treated Now & Event Occurs					
Operational Performance	+8	Safety, Health & Environment	0	People & Leadership	+8
If Treated Later & Event Occurs					
Operational Performance	-8	Safety, Health & Environment	0	People & Leadership	-8

Occupational Health		Hours to complete: 6			Card 30
Risk Identification		A key team member has arrived at work under the influence (intoxicated).			
Risk Assessment					
Potential Risk Treatment		Attend to the situation and follow the right procedures, or let it slide.			
If Treated Now & Event Occurs					
Operational Performance	0	Safety, Health & Environment	+5	People & Leadership	+6
If Treated Later & Event Occurs					
Operational Performance	0	Safety, Health & Environment	-5	People & Leadership	-6

Occupational Health		Hours to complete: 6			Card 31
Risk Identification		A key team member is struggling with personal issues, affecting his ability to do his work.			
Risk Assessment					
Potential Risk Treatment		Get acquainted with the situation and attend to the member with the correct procedures.			
If Treated Now & Event Occurs					
Operational Performance	+8	Safety, Health & Environment	+8	People & Leadership	+8
If Treated Later & Event Occurs					
Operational Performance	-8	Safety, Health & Environment	-8	People & Leadership	-8

Operational Procedure		Hours to complete: 3			Card 32
Risk Identification		A JRA has been completed, but some of the team members still seem uncertain.			
Risk Assessment					
Potential Risk Treatment		Spend time supervising and make sure that the objectives of the task are understood effectively.			
If Treated Now & Event Occurs					
Operational Performance	+8	Safety, Health & Environment	0	People & Leadership	+4
If Treated Later & Event Occurs					
Operational Performance	-8	Safety, Health & Environment	0	People & Leadership	-4

APPENDIX B: PRE- AND POST A2 TESTS

These multiple-choice tests forms part of the Learning Life Cycle (LLC) and establishes a knowledge gain assessment of participants, as it contains ideas and concepts learnt in the A2 course.

Questionnaire 1:

Question 1: (3 Marks)

Choose **three** examples of common mining energies.

A	Gravitational (Objects)
B	Kaleidoscopic
C	Machine (Fixed)
D	Noise

Question 2: (2 Marks)

Choose **two** hazards associated with electrical energies

A	High Voltage Current
B	Falling Rock
C	Broken Insulation

Question 3: (2 Marks)

Choose **two** consequences associated with the hazard of noise.

A	Viral Illness
B	Hearing Impairment
C	Deafness
D	Blindness

Question 4: (2 Marks)

Choose **two** reasons why the Front-Line Manager/Supervisor plays a critical role in the Operational Risk Management Process.

A	Does not interact with the employees
B	Has the skills and ability to develop high quality Work Execution Documents (WED)
C	Has responsibility for implementation and execution of Task Risk Management
D	Cannot conduct on-the-spot assessments

Question 5: (1 Mark)

Choose **True or False**. Energies are the only source of hazards.

A	True
B	False

Question 6: (1 Mark)

Choose **True or False**. The Front-Line Manager/Supervisor is able to do an effective Job Risk Assessment (JRA) without assistance from other employees.

A	True
B	False

Question 7: (1 Marks)

Choose **True or False**. An UNINTENTIONAL human failing is referred to as a VIOLATION.

A	True
B	False

QUESTION 8: (5 MARKS)

Choose the number matching the explanation/example for each of the words/terms in the table. The same number can't be used twice.

Word/term	No. of matching explanation	No.	Explanation
Controls		1	SLAM
Risk		2	Mechanisms used to eliminate or reduce the level of risk associated with exposure to the hazard
Continuous Risk Management		3	Speeding
Hazard		4	A potential situation or condition where the hazard is released
Unwanted Event		5	The chance of something happening that will leave a negative impact on the task objective

QUESTION 9: (3 MARKS)

Choose **three** correct levels of the 4 Layer Operational Risk Management Model

A	Resilient
B	Issue-based
C	Baseline
D	Task

QUESTION 10: (3 MARKS)

Choose **three** correct elements of the Nertney Wheel.

A	Fit for purpose equipment
B	Competent People

C	Controlled Work Environment
D	Treat the Risks

Question 11: (2 Marks)

Choose **two** methods to control hazards and risk exposure according to the Control Hierarchy Model:

A	Engineering
B	Alienation
C	Substitution

Question 12: (1 Mark)

Choose True or False. When conducting a JRA it is important to consider the objectives of the task that will be undertaken.

A	True
B	False

Question 13: (1 Mark)

Choose True or False. When conducting a JRA one would identify the controls after the unwanted events have been identified.

A	True
B	False

Question 14: (1 Mark)

Choose True or False. When conducting a JRA, there can be only ONE hazard for each job step.

A	True
B	False

Question 15: (2 Marks)

Choose **two** correct answers. The purpose of the Work Execution Document (WED) is to:

A	Support the Front Line during work execution
B	Provide feedback from work execution
C	Replace a SLAM

Total: ………………/30

Percentage: ………………%

Questionnaire 2:

Question 1: (3 Marks)

Choose **three** examples of common mining energies.

A	Biological
B	Electrical
C	Lighting
D	People

Question 2: (3 Marks)

Choose **three** hazards associated with human behaviour.

A	Virus
B	Slip
C	Trip
D	Repetitive motion strain

Question 3: (2 Marks)

Choose **two** consequences associated with the hazard of light vehicles.

A	Collision with pedestrian on public road
B	Driving on public road
C	Collision with machinery
D	None of the above

Question 4: (2 Marks)

Choose **two** reasons why the Front-Line Manager/Supervisor plays a critical role in the Operational Risk Management Process.

A	Does not have the authority to enforce discipline
B	Knows and understands the employees
C	Has the skills and ability to develop a high-quality Work Execution Document (WED)
D	Cannot conduct on-the-spot assessments

Question 5: (1 Mark)

Choose **True or False**. If, while developing or reviewing the JRA, the work team cannot establish an acceptable/satisfactory amount of control for the risks, then an 'issue' should be declared.

A	True
B	False

Question 6: (1 Mark)

Choose **True or False**. The Front-Line Manager/Supervisor is not required to conduct Planned Task Observations (PTO's)

A	True
B	False

Question 7: (2 Marks)

Choose two appropriate controls for the unwanted event of a diesel spill.

A	Injection
B	Stope support
C	Drip trays
D	Approved containers

Question 8: (5 Marks)

Choose the number matching the explanation/example for each of the words/terms in the table. The same number can't be used twice.

Word/term	No. of matching explanation	No.	Explanation
Controls		1	Substitution
Energies		2	Mechanisms used to eliminate or reduce the level of risk associated with exposure to the hazard
Control Hierarchy		3	SLAM
Continuous Risk Management		4	A potential situation or condition where the hazard is released
Unwanted Event		5	Gravity

Question 9: (3 Marks)

Choose **three** correct levels of the 4 Layer Operational Risk Management Model

A	Issue-based
B	Baseline
C	Resilient
D	Task

Question 10: (3 Marks)

Choose **three** correct steps in the Risk Management Model.

A	Identify the unwanted events
B	Behaviour, motivation and attitude
C	Analyse and evaluate the risks
D	Consider the controls/barriers

Question 11: (3 Marks)

Choose **three** methods to control hazards and risk exposure according to the Control Hierarchy Model:

A	Elimination
B	Administrative
C	Substitution
D	Evolution

Question 12: (1 Mark)

Choose True or False. When conducting a JRA one would first define the task objectives before identifying the job steps and job-specific hazards.

A	True
B	False

Question 13: (1 Mark)

Choose True or False. A JRA should be reviewed for suitability if there are changes to the specified work method.

A	True
B	False

Total: ………………/30

Percentage: ………………%

Questionnaire 3:

Question 1: (3 Marks)

Choose **three** examples of common mining energies.

A	Noise
B	Lighting
C	Chemical
D	Thermal

Question 2: (2 Marks)

Choose **two** hazards associated with mechanical energies

A	Speeding
B	Sharp edges
C	Rotating elements

Question 3: (2 Marks)

Choose **two** consequences associated with the hazard of gas under high pressure.

A	Bursting pipe
B	Structures which could fall
C	Viral illness
D	Hazardous gas inhalation

Question 4: (2 Marks)

Choose **two** reasons why the Front-Line Manager/Supervisor plays a critical role in the Operational Risk Management Process.

A	Can conduct an on-the-spot risk assessment
B	Does not have authority to enforce discipline
C	Has the skills and ability to develop a high-quality Work Execution Document (WED)
D	Does not interact with the employees

Question 5: (1 Mark)

Choose true or false. While doing a JRA, it is necessary to list all unwanted events and associated consequences for that job.

A	True
B	False

Question 6: (1 Mark)

Memory lapse is an example of INTENTIONAL human failing.

A	True
B	False

Question 7: (2 Marks)

Choose **two** consequences associated with the hazard of noise.

A	Hearing Impairment
B	Viral Illness
C	Deafness
D	Blindness

Question 8: (5 Marks)

Choose the number matching the explanation/example for each of the words/terms in the table.

Word/term	No. of matching explanation	No.	Explanation
Unwanted event		1	PPE
Continuous risk management		2	Chance of something happening that will have an effect on the control objectives
Controls		3	Substitution
Risk		4	A possible release of/or exposure to the hazard in an uncontrolled manner
Control hierarchy		5	SLAM

Question 9: (3 Marks)

Choose **three** correct levels of the 4 Layer Operational Risk Management Model

A	Continuous
B	Resilient
C	Issue based
D	Baseline

Question 10: (3 Marks)

According to the Control Hierarchy Model, choose **three** correct methods to control hazards and risk exposure.

A	Separation
B	Elimination
C	Alienation
D	Engineering

Question 11: (3 Marks)

Choose **three** correct steps in the Risk Management Model.

A	Analyse and evaluate risks
B	Assess attitudes and motivation
C	Understand the hazards
D	Identify unwanted events

Question 12: (1 Mark)

Choose True or False. When conducting a Job Risk Assessment (JRA), one would first identify the job steps and job-specific hazards before defining the task objectives.

A	True
B	False

Question 13: (1 Mark)

Choose True or False. When conducting a Job Risk Assessment (JRA), more than one control may be listed to address a single unwanted event.

A	True
B	False

Question 14: (1 Mark)

Choose True or False. A JRA should be reviewed for suitability if there are changes made to the specified work method.

A	True
B	False

Total: ………………/30

Percentage: ………………%

APPENDIX C: POINTS SYSTEM FRAMEWORK

Table C-1: Points system

				If treated now			If treated later		
				Points awarded			Points deducted		
Decision (Card Number)	Classification (Nertney Wheel)	Importance Factor Ranking	Hours to complete	Operational Performance	Safety, Health & Environment	People & Leadership	Operational Performance	Safety, Health & Environment	People & Leadership
1	People & Competency	5	4	0	8	8	0	-8	-8
2	People & Competency	4	5	8	0	8	-8	0	-8
3	People & Competency	1	8	0	8	4	0	-8	-4
4	People & Competency	8	3	8	0	4	-8	0	-4
5	People & Competency	3	6	0	4	8	0	-4	-8
6	People & Competency	2	7	9	4	4	-9	-4	-4
7	People & Competency	7	3	0	8	7	0	-8	-7
8	People & Competency	6	4	8	8	0	-8	-8	0
Totals			**40**	**33**	**40**	**43**	**-33**	**-40**	**-43**
9	Equipment Integrity	2	7	8	8	0	-8	-8	0
10	Equipment Integrity	3	6	4	0	8	-4	0	-8
11	Equipment Integrity	5	4	8	0	7	-8	0	-7
12	Equipment Integrity	1	7	4	8	0	-4	-8	0
13	Equipment Integrity	6	4	4	7	0	-4	-7	0
14	Equipment Integrity	8	4	8	0	8	-8	0	-8
15	Equipment Integrity	4	5	4	7	0	-4	-7	0
16	Equipment Integrity	7	3	0	8	8	0	-8	-8
Totals			**40**	**40**	**38**	**31**	**-40**	**-38**	**-31**
17	Work Methods/Operating Procedure	3	6	0	8	8	0	-8	-8
18	Work Methods/Operating Procedure	1	8	4	10	8	-4	-10	-8
19	Work Methods/Operating Procedure	2	6	0	8	7	0	-8	-7
20	Work Methods/Operating Procedure	4	5	9	1	4	-9	-1	-4
21	Work Methods/Operating Procedure	7	4	8	8	0	-8	-8	0
22	Work Methods/Operating Procedure	8	3	10	0	4	-10	0	-4
23	Work Methods/Operating Procedure	6	4	8	4	8	-8	-4	-8
24	Work Methods/Operating Procedure	5	4	4	4	4	-4	-4	-4
Totals			**40**	**43**	**43**	**43**	**-43**	**-43**	**-43**
25	Supervision/Control	7	3	8	0	8	-8	0	-8
26	Supervision/Control	6	3	0	8	4	0	-8	-4
27	Supervision/Control	5	4	4	8	5	-4	-8	-5
28	Supervision/Control	1	8	8	10	0	-8	-10	0
29	Supervision/Control	2	7	8	0	8	-8	0	-8
30	Supervision/Control	4	6	0	5	6	0	-5	-6
31	Supervision/Control	3	6	8	8	8	-8	-8	-8
32	Supervision/Control	8	3	8	0	4	-8	0	-4
Totals			**40**	**44**	**39**	**43**	**-44**	**-39**	**-43**
Total Points Available			**160**	**160**	**160**	**160**	**-160**	**-160**	**-160**

APPENDIX D: EXCEL VBA CODING

Dashboard Scores UserForm:

```
Dim maxScore As Integer
Dim maxWidth As Integer
Dim minWidth As Integer
Private Sub BtnBacktoMainMenu_Click()
   Unload Me
End Sub

Private Sub lblRecommendations_Click()
End Sub

Public Sub UserForm_Initialize()
   Dim valOP As Integer
   Dim valSHE As Integer
   Dim valPL As Integer
   Dim a As Integer
   Dim b As Integer
   Dim c As Integer
   Dim AVGscore As Double

   maxScore = 100  ' maximum score that would fill a bar completely
   maxWidth = 400  ' max width of bar (in Pixel) corresponding to a score of 100
   minWidth = 1  ' width to which the bar is forced when score turns out to be negative (to prevent
crashing when setting a negative width for label

   scoreOP = Module1.sumScore(1) + 60
   scoreSHE = Module1.sumScore(2) + 60
   scorePL = Module1.sumScore(3) + 60
   penltOP = Module1.sumPenlt(1)
   penltSHE = Module1.sumPenlt(2)
   penltPL = Module1.sumPenlt(3)

   valOP = WorksheetFunction.Max(scoreOP + penltOP, 0)
   valSHE = WorksheetFunction.Max(scoreSHE + penltSHE, 0)
   valPL = WorksheetFunction.Max(scorePL + penltPL, 0)
```

```
' show score as a progress bar:    'TAKE NOTE: penalties are stored NEGATIVE in Sheet, thus must be ADDED in these calculations
UserFormDashboardScores.LabelOP.Width = WorksheetFunction.Max(minWidth, (scoreOP + penltOP) * maxWidth / maxScore)
UserFormDashboardScores.LabelSHE.Width = WorksheetFunction.Max(minWidth, (scoreSHE + penltSHE) * maxWidth / maxScore)
UserFormDashboardScores.LabelPL.Width = WorksheetFunction.Max(minWidth, (scorePL + penltPL) * maxWidth / maxScore)
' show score as a number next to progress bar:
UserFormDashboardScores.LabelScoreOP.Caption = valOP
UserFormDashboardScores.LabelScoreSHE.Caption = valSHE
UserFormDashboardScores.LabelScorePL.Caption = valPL

AVGscore = (valOP + valSHE + valPL) / 3

UserFormDashboardScores.lblAVGscore.Caption = "Average Score: " & AVGscore

a = scoreOP + penltOP
b = scoreSHE + penltSHE
c = scorePL + penltPL
If (a > b) And (b > c) Then                    'abc
    UserFormDashboardScores.lblRecommendations.Caption = "Your daily decisions are focussed mainly on Operational Performance improvements, but you are lacking on decisions which promotes People & Leadership. Try to improve your decision making in terms of People & Leadership and to get a more even distribution of dashboard scores."
Else
    If (a > c) And (c > b) Then                'acb
        UserFormDashboardScores.lblRecommendations.Caption = "Your Operational Performance decision making  is good, but you are lacking in decisions which promotes Safety, Health & Environment. Try to make better decisions on the safety and health of other employees."
    Else
        If (b > a) And (a > c) Then            'bac
            UserFormDashboardScores.lblRecommendations.Caption = "Your daily decisions are focussed mainly on Safety, Health & Environment improvements, but you are lacking on decisions which promotes People & Leadership. Try to improve your decision making in terms of People & Leadership and to get a more even distribution of dashboard scores."
        Else
            If (b > c) And (c > a) Then        'bca
                UserFormDashboardScores.lblRecommendations.Caption = "Safety, Health & Environment is important for sustainability, but at the moment it comes at expense of Operational Performance. Try to make decisions which also focusses on keeping operations running smoothly."
```

```
        Else
          If (c > a) And (a > b) Then       'cab
            UserFormDashboardScores.lblRecommendations.Caption = "You are showing great decision  making that promotes People & Leadership on site, but at the expense of Safety, Heath & Environment. Try to make decisions that keeps Operational Performance high while still promoting a safe working environment."
          Else
            If (c > b) And (b > a) Then     'cba
              UserFormDashboardScores.lblRecommendations.Caption = "You are showing great decision  making that promotes People & Leadership on site, but at the expense of Operational Performance. Try to make decisions that keeps Operational Performance high while still promoting good People & Leadership decisions."
            Else   'test cases where scores are duplicates
              If (a = b) Then
                If (a > c) Then
                  UserFormDashboardScores.lblRecommendations.Caption = "Your daily decisions promotes good control over People & Leadership and Safety, Health & Environment, but at expense of Operational Performance. Try to focus on decisions which will promotes Operational Performance, but still keeps the other scores high."
                Else
                  If (a < c) Then
                    UserFormDashboardScores.lblRecommendations.Caption = "Your decisions are promoting great Operational Performance, but are lacking in Safety, Health & Environment and People & Leadership. Try to make decisions which will increase scores in the lacking areas."
                  Else
                    UserFormDashboardScores.lblRecommendations.Caption = "Your decisions shows good control over all aspects of the dashboard scores. Now try to make decisions which wil increase these scores, while maintaining a balance in these aspects."
                  End If
                End If
              End If
              If (a = c) Then
                If (a > b) Then
                  UserFormDashboardScores.lblRecommendations.Caption = " Your daily decisions promotes good control over People & Leadership and OperationalPerformance, but at expense of Safety, Health & Environment. Try to focus on decisions which will promotes the Safety and Health of employees, but still keeps the other scores high."
                Else
                  If (a < b) Then
                    UserFormDashboardScores.lblRecommendations.Caption = "Your decisions are promoting great Safety, Health & Environment conditions, but are lacking in Operational Performance and People & Leadership. Try to make decisions which will increase scores in the lacking areas."
```

```
                  Else
                    UserFormDashboardScores.lblRecommendations.Caption = "Your decisions shows good control over all aspects of the dashboard scores. Now try to make decisions which wil increase these scores, while maintaining a balance in these aspects."
                  End If
                End If
              End If
              If (b = c) Then
                If (a > b) Then
                  UserFormDashboardScores.lblRecommendations.Caption = "Your decisions are promoting great Operational Performance, but are lacking in Safety, Health & Environment and People & Leadership. Try to make decisions which will increase scores in the lacking areas."
                Else
                  If (a < b) Then
                    UserFormDashboardScores.lblRecommendations.Caption = "Your daily decisions promotes good control over People & Leadership and Safety, Health & Environment, but at expense of Operational Performance. Try to focus on decisions which will promotes Operational Performance, but still keeps the other scores high."
                  Else
                    UserFormDashboardScores.lblRecommendations.Caption = "Your decisions shows good control over all aspects of the dashboard scores. Now try to make decisions which wil increase these scores, while maintaining a balance in these aspects."
                  End If
                End If
              End If
            End If
          End If
        End If
      End If
    End If
  End If
End Sub
```

Game Play Userform:

The coding of this userform is linked to an Excel data file containing the points system as explained in Appendix A:

```
' variables defined outside any subroutine are global, and thus accessible from anywhere
Dim selectedcards() As Integer    '0 = treat later  1 = now  2 = overtime
' int selectedcards[20];
```

```
Dim cardCategory() As Integer   'There are 4 categories containing 8 cards each, of which 5 will be chosen out of each category for each new round played
Dim cardHours() As Double   'hours required to complete task
Dim cardWeights() As Double   'weighting 3 columns, 1 = Operational Performance, 2 = Safety, health & Environemnt, 3 = People & Leadership
Dim cardDescription1() As String   ' will be shown below card selection box when a particular card was shown
Dim cardDescription2() As String   ' will be shown below card selection box when a particular card was shown
Dim cardDescriptionHeading1() As String   ' will be shown below card selection box when a particular card was shown
Dim cardDescriptionHeading2() As String   ' will be shown below card selection box when a particular card was shown
Dim Scores() As Integer   'scores assigned to card in terms of  OP, SHE & PL
Dim Penalty() As Integer   'Penalties for doing task later assigned to card in terms of  OP, SHE & PL
Dim shuffledIndices() As Integer
Dim NumCards As Integer
Dim NumCardsOnScreen As Integer
Dim SelectedCard As Integer

Private Sub BtnDone_Click()
Unload Me
End Sub

Private Sub BtnStartOver_Click()
   Call UserForm_Initialize
End Sub

Public Sub UserForm_Initialize()
   Dim i As Integer
   Dim k As Integer
   NumCards = 32
   NumCardsOnScreen = 20
   ReDim selectedcards(1 To NumCardsOnScreen) As Integer
   ReDim shuffledIndices(1 To NumCardsOnScreen) As Integer
   ReDim cardHours(1 To NumCards) As Double
   ReDim cardCategory(1 To NumCards) As Integer
   ReDim cardWeights(1 To NumCards, 1 To 3) As Double
```

```
    ReDim cardDescription1(1 To NumCards) As String
    ReDim cardDescription2(1 To NumCards) As String
    ReDim cardDescriptionHeading1(1 To NumCards) As String
    ReDim cardDescriptionHeading2(1 To NumCards) As String
    ReDim Scores(1 To 3, 1 To NumCards) As Integer
    ReDim Penalty(1 To 3, 1 To NumCards) As Integer

    ' From Sheet1: read hours, weightings and descriptions into arrays
    For i = 1 To NumCards
        cardHours(i) = Sheets("Data").Range("J2").Offset(i, 0).Value
        For k = 1 To 3
            cardWeights(i, k) = Sheets("Data").Range("K2").Offset(i, k - 1).Value
        Next k
        cardCategory(i) = Sheets("Data").Range("G2").Offset(i, 0).Value
        cardDescription1(i) = Sheets("Data").Range("R2").Offset(i, 0).Value
        cardDescription2(i) = Sheets("Data").Range("T2").Offset(i, 0).Value
        cardDescriptionHeading1(i) = Sheets("Data").Range("Q2").Offset(i, 0).Value
        cardDescriptionHeading2(i) = Sheets("Data").Range("S2").Offset(i, 0).Value
        For k = 1 To 3   ' runs through  OP, SHE & PL
            Scores(k, i) = Sheets("Data").Range("K2").Offset(i, k - 1).Value ' scores are in columns K,L,M
            Penalty(k, i) = Sheets("Data").Range("N2").Offset(i, k - 1).Value ' penalties  in columns N,O,P
        Next k
    Next i
    Call generateShuffledCardArray
    evaluateAndupdateScreen
End Sub

Private Sub BtnAddLater_Click()
    If SelectedCard > 0 And SelectedCard <= NumCardsOnScreen Then
        selectedcards(SelectedCard) = 0
    End If
    SelectedCard = 0
    evaluateAndupdateScreen
End Sub

Private Sub BtnAddNow_Click()
```

```
  If SelectedCard > 0 And SelectedCard <= NumCardsOnScreen Then
    selectedcards(SelectedCard) = 1
  End If
  SelectedCard = 0
  evaluateAndupdateScreen
End Sub
Private Sub BtnAddOvertime_Click()
  If SelectedCard > 0 And SelectedCard <= NumCardsOnScreen Then
    selectedcards(SelectedCard) = 2
  End If
  SelectedCard = 0
  evaluateAndupdateScreen
End Sub
Private Sub generateShuffledCardArray()   'when new game is started, 5 cards out of each category must be chosen
Dim i As Integer
Dim k As Integer
Dim j As Integer
Dim CardsPerCat As Integer
Dim counters(1 To 4) As Integer
Dim duplicates As Boolean
CardsPerCat = 5
For i = 1 To NumCardsOnScreen
  Do
    shuffledIndices(i) = WorksheetFunction.RandBetween(1, 32)
    For k = 1 To 4
      counters(k) = 0
    Next k
    duplicates = False
    For k = 1 To i
      counters(cardCategory(shuffledIndices(k))) = counters(cardCategory(shuffledIndices(k))) + 1
    Next k
    For j = 1 To i - 1     'compare all exisiting entries to the newly generated entry
      If shuffledIndices(j) = shuffledIndices(i) Then 'if duplicate detected
        duplicates = True
      End If
    Next j
```

```
   Loop Until counters(1) <= CardsPerCat And counters(2) <= CardsPerCat And counters(3) <=
CardsPerCat And counters(4) <= CardsPerCat And Not duplicates
Next i
End Sub
Private Function CardMatch(SelectedCard As Integer)   ' returns the index of the card in the array of 32
cards. Input: 1..20, output: 1..32
   CardMatch = shuffledIndices(SelectedCard)
End Function
Private Sub evaluateAndupdateScreen()
Dim i As Integer
Dim lblNormalTime As String
Dim lblOverTime As String
Dim hoursNormaltime As Double
Dim hoursOvertime As Double
Dim HoursmaxNormal As Double
Dim HoursMaxOvertime As Double
HoursmaxNormal = Sheets("Data").Range("B10").Value
HoursmaxNormal = Sheets("Data").Range("B10").Value
HoursMaxOvertime = Sheets("Data").Range("B11").Value

If SelectedCard = 0 Then ' Buttons greyed out unless a card is selected
   BtnAddLater.Enabled = False
   BtnAddNow.Enabled = False
   BtnAddOvertime.Enabled = False
Else
   BtnAddLater.Enabled = True
   BtnAddNow.Enabled = True
   BtnAddOvertime.Enabled = True
   Select Case selectedcards(SelectedCard)
      Case 0
         BtnAddLater.Enabled = False
      Case 1
         BtnAddNow.Enabled = False
      Case 2
         BtnAddOvertime.Enabled = False
   End Select
End If
```

```
For i = 1 To NumCardsOnScreen
    Select Case selectedcards(i)
    Case 1
        lblNormalTime = lblNormalTime & "   " & i   'construct strings for labels on the right based on selected cards
    Case 2
        lblOverTime = lblOverTime & "   " & i
    End Select

    If selectedcards(i) = 0 Then    ' change colour of used cards, make available cards black
        Select Case i
            Case 1
            BtnCard1.ForeColor = ColorConstants.vbBlack
            Case 2
            BtnCard2.ForeColor = ColorConstants.vbBlack
            Case 3
            BtnCard3.ForeColor = ColorConstants.vbBlack
            Case 4
            BtnCard4.ForeColor = ColorConstants.vbBlack
            Case 5
            BtnCard5.ForeColor = ColorConstants.vbBlack
            Case 6
            BtnCard6.ForeColor = ColorConstants.vbBlack
            Case 7
            BtnCard7.ForeColor = ColorConstants.vbBlack
            Case 8
            BtnCard8.ForeColor = ColorConstants.vbBlack
            Case 9
            BtnCard9.ForeColor = ColorConstants.vbBlack
            Case 10
            BtnCard10.ForeColor = ColorConstants.vbBlack
            Case 11
            BtnCard11.ForeColor = ColorConstants.vbBlack
            Case 12
            BtnCard12.ForeColor = ColorConstants.vbBlack
            Case 13
```

```
        BtnCard13.ForeColor = ColorConstants.vbBlack
        Case 14
        BtnCard14.ForeColor = ColorConstants.vbBlack
        Case 15
        BtnCard15.ForeColor = ColorConstants.vbBlack
        Case 16
        BtnCard16.ForeColor = ColorConstants.vbBlack
        Case 17
        BtnCard17.ForeColor = ColorConstants.vbBlack
        Case 18
        BtnCard18.ForeColor = ColorConstants.vbBlack
        Case 19
        BtnCard19.ForeColor = ColorConstants.vbBlack
        Case 20
        BtnCard20.ForeColor = ColorConstants.vbBlack
    End Select
Else
    If selectedcards(i) > 0 Then
    Select Case i
        Case 1
        BtnCard1.ForeColor = ColorConstants.vbGreen
        Case 2
        BtnCard2.ForeColor = ColorConstants.vbGreen
        Case 3
        BtnCard3.ForeColor = ColorConstants.vbGreen
        Case 4
        BtnCard4.ForeColor = ColorConstants.vbGreen
        Case 5
        BtnCard5.ForeColor = ColorConstants.vbGreen
        Case 6
        BtnCard6.ForeColor = ColorConstants.vbGreen
        Case 7
        BtnCard7.ForeColor = ColorConstants.vbGreen
        Case 8
        BtnCard8.ForeColor = ColorConstants.vbGreen
        Case 9
```

```
            BtnCard9.ForeColor = ColorConstants.vbGreen
            Case 10
            BtnCard10.ForeColor = ColorConstants.vbGreen
            Case 11
            BtnCard11.ForeColor = ColorConstants.vbGreen
            Case 12
            BtnCard12.ForeColor = ColorConstants.vbGreen
            Case 13
            BtnCard13.ForeColor = ColorConstants.vbGreen
            Case 14
            BtnCard14.ForeColor = ColorConstants.vbGreen
            Case 15
            BtnCard15.ForeColor = ColorConstants.vbGreen
            Case 16
            BtnCard16.ForeColor = ColorConstants.vbGreen
            Case 17
            BtnCard17.ForeColor = ColorConstants.vbGreen
            Case 18
            BtnCard18.ForeColor = ColorConstants.vbGreen
            Case 19
            BtnCard19.ForeColor = ColorConstants.vbGreen
            Case 20
            BtnCard20.ForeColor = ColorConstants.vbGreen
        End Select
        End If
    End If
Next i

LabelSelectionsNormalTime.Caption = lblNormalTime
LabelSelectionsOvertime.Caption = lblOverTime

If SelectedCard = 0 Then
    LabelDescription1.Caption = ""
    LabelDescription2.Caption = ""
    LabelHeading1.Caption = ""
    LabelHeading2.Caption = ""
```

```
      LabelTimeRequired.Caption = "Select a card to see its description"
   Else
      LabelDescription1.Caption = cardDescription1(CardMatch(SelectedCard))     ' show description and required time for selected card
      LabelDescription2.Caption = cardDescription2(CardMatch(SelectedCard))     ' show description and required time for selected card
      LabelHeading1.Caption = cardDescriptionHeading1(CardMatch(SelectedCard))     ' show description and required time for selected card
      LabelHeading2.Caption = cardDescriptionHeading2(CardMatch(SelectedCard))     ' show description and required time for selected card
      LabelTimeRequired.Caption = "Task requires " & cardHours(CardMatch(SelectedCard)) & " hours"
   End If
   ' calculate total hours required and display total hours available for normal time 7 overtime
   For i = 1 To NumCardsOnScreen
      Select Case selectedcards(i)
         Case 1
            hoursNormaltime = hoursNormaltime + cardHours(CardMatch(i))
         Case 2
            hoursOvertime = hoursOvertime + cardHours(CardMatch(i))
      End Select
   Next i
   LabelTimeRemainingNormaltime = "Time remaining: " & HoursmaxNormal - hoursNormaltime & " hours"
   LabelTimeRemainingOvertime = "Time remaining: " & HoursMaxOvertime - hoursOvertime & " hours"

   If (HoursmaxNormal - hoursNormaltime < 0 Or HoursMaxOvertime - hoursOvertime < 0) Then
      BtnCompile.Enabled = False
      BtnCompile.Caption = "Check that time remaining is non-negative"
   Else
      BtnCompile.Enabled = True
      BtnCompile.Caption = "Compile"
   End If

End Sub
Private Sub BtnCard1_Click()
   SelectedCard = 1
   evaluateAndupdateScreen
```

```
End Sub
Private Sub BtnCard2_Click()
  SelectedCard = 2
  evaluateAndupdateScreen
End Sub
Private Sub BtnCard3_Click()
  SelectedCard = 3
  evaluateAndupdateScreen
End Sub
Private Sub BtnCard4_Click()
  SelectedCard = 4
  evaluateAndupdateScreen
End Sub
Private Sub BtnCard5_Click()
  SelectedCard = 5
  evaluateAndupdateScreen
End Sub
Private Sub BtnCard6_Click()
  SelectedCard = 6
  evaluateAndupdateScreen
End Sub
Private Sub BtnCard7_Click()
  SelectedCard = 7
  evaluateAndupdateScreen
End Sub
Private Sub BtnCard8_Click()
  SelectedCard = 8
  evaluateAndupdateScreen
End Sub
Private Sub BtnCard9_Click()
  SelectedCard = 9
  evaluateAndupdateScreen
End Sub
Private Sub BtnCard10_Click()
  SelectedCard = 10
  evaluateAndupdateScreen
```

```
End Sub
Private Sub BtnCard11_Click()
   SelectedCard = 11
   evaluateAndupdateScreen
End Sub
Private Sub BtnCard12_Click()
   SelectedCard = 12
   evaluateAndupdateScreen
End Sub
Private Sub BtnCard13_Click()
   SelectedCard = 13
   evaluateAndupdateScreen
End Sub
Private Sub BtnCard14_Click()
   SelectedCard = 14
   evaluateAndupdateScreen
End Sub
Private Sub BtnCard15_Click()
   SelectedCard = 15
   evaluateAndupdateScreen
End Sub
Private Sub BtnCard16_Click()
   SelectedCard = 16
   evaluateAndupdateScreen
End Sub
Private Sub BtnCard17_Click()
   SelectedCard = 17
   evaluateAndupdateScreen
End Sub
Private Sub BtnCard18_Click()
   SelectedCard = 18
   evaluateAndupdateScreen
End Sub
Private Sub BtnCard19_Click()
   SelectedCard = 19
   evaluateAndupdateScreen
```

```
End Sub
Private Sub BtnCard20_Click()
   SelectedCard = 20
   evaluateAndupdateScreen
End Sub

Private Sub BtnCompile_Click()
   Dim count0 As Integer   'Treat later
   Dim count1 As Integer   'Treat now
   Dim count2 As Integer   'Treat overtime
   Dim i As Integer
   Dim k As Integer   ' runs through the Performance Categories
   Dim CardLookup As Integer   ' which card from original 32 we're working with, i.e. CardLookup =
CardMatch(selectedcards(i))
   Dim CategoryOfCard As Integer   ' the category of the selected card needs to be known, so that the
corresponding OP, SHE or PL score gets counted
   count0 = 0
   count1 = 0
   count2 = 0
   sumScore(1) = 0
   sumScore(2) = 0
   sumScore(3) = 0
   sumPenlt(1) = 0
   sumPenlt(2) = 0
   sumPenlt(3) = 0

   For i = 1 To NumCardsOnScreen
      CardLookup = CardMatch(i)
      CategoryOfCard = cardCategory(CardLookup)
      Select Case selectedcards(i)
         Case 0
         count0 = count0 + 1   'Treat later
         For k = 1 To 3
            'sumPenlt(cardCategory(CardLookup)) = sumPenlt(cardCategory(CardLookup)) +
Penalty(CategoryOfCard, CardLookup)
            sumPenlt(k) = sumPenlt(k) + Penalty(k, CardLookup)
         Next k
```

```
        Case 1
        count1 = count1 + 1   'Treat now
        For k = 1 To 3
          sumScore(k) = sumScore(k) + Scores(k, CardLookup)
          'sumScore(cardCategory(CardLookup)) = sumScore(cardCategory(CardLookup)) +
Scores(CategoryOfCard, CardLookup)
        Next k
        Case 2
        count2 = count2 + 1   'Treat overtime
        For k = 1 To 3
          sumScore(k) = sumScore(k) + Scores(k, CardLookup)
        Next k
        'sumScore(cardCategory(CardLookup)) = sumScore(cardCategory(CardLookup)) +
Scores(CategoryOfCard, CardLookup)
      End Select
  Next i

  UserFormGame.LabelOutput.Caption = "Treat later: " & count0 & " Treat now: " & count1 & "
Overtime: " & count2
  UserFormDashboardScores.Show
  Call StoreScore
End Sub

Private Sub StoreScore()
Dim row As Integer
Dim k As Integer
Dim SumAverage As Integer
Dim score As Integer
row = 0
While (Not IsEmpty(Sheets("UserScores").Range("A2").Offset(row, 0)))
  row = row + 1    ' find the bottom-most entry
Wend
  row = row + 1
  Sheets("UserScores").Range("A1").Offset(row, 0).Value = row
  For k = 1 To 3
     score = WorksheetFunction.Max(0, sumScore(k) + 60 + sumPenlt(k))
     Sheets("UserScores").Range("A1").Offset(row, k).Value = score
```

```
    SumAverage = SumAverage + score
  Next k
  Sheets("UserScores").Range("A1").Offset(row, 4).Value = SumAverage / 3
End Sub
'opsie 1:
'  3 stelle van 20 knoppies
'  as een geclick word, word dit gedisable / greyed out
'  en vertoon by die normalTime
'
'opsie 2:
'  1 stel van 20 knoppies
'  verander Left  & Top attribute, .: verskuif kaart
'
'opsie 3:
'  label by normaltime & label by overtime
'  as knoppie gedruk word, verander knoppie se kleur, en word die knoppie se nommer by een van die labels gevoeg
```

Main Menu Userform:

```
Private Sub BtnCompile_Click()
   UserFormGame.Show
End Sub
Private Sub BtnInstructions_Click()
   UserFormInstructions.Show
End Sub
Private Sub BtnScores_Click()
   UserFormDashboardScores.Show
End Sub
Private Sub Image1_BeforeDragOver(ByVal Cancel As MSForms.ReturnBoolean, ByVal Data As MSForms.DataObject, ByVal X As Single, ByVal Y As Single, ByVal DragState As MSForms.fmDragState, ByVal Effect As MSForms.ReturnEffect, ByVal Shift As Integer)


End Sub
```

APPENDIX E: RAW DATA

1. Game-Play & theory tests results

Test/validation group:

The following tables are the raw data collected from the SG gameplay by subjects that were selected for means of validation of the ability of participants to use the feedback of the game to improve their scores over five rounds. Results of this can be seen in Section 4.8 of this document.

Table E-1: Raw data: SG results from test group subjects

PLAYER	Round	Dashboard scores			Average	Median
		OP	SHE	PL		
1	1	79	26	89	64.7	79
1	2	17	53	44	38.0	44
1	3	77	45	85	69.0	77
1	4	67	63	62	64.0	63
1	5	77	68	84	76.3	77
2	1	75	51	83	69.7	75
2	2	50	105	60	71.7	60
2	3	67	70	63	66.7	67
2	4	70	49	69	62.7	69
2	5	60	75	69	68.0	69
3	1	73	30	50	51.0	50
3	2	34	81	75	63.3	75
3	3	79	74	52	68.3	74
3	4	86	59	69	71.3	69
3	5	77	79	78	78.0	78
4	1	37	49	44	43.3	44
4	2	47	35	91	57.7	47
4	3	64	57	67	62.7	64
4	4	67	65	61	64.3	65
4	5	82	33	88	67.7	82
5	1	55	51	64	56.7	55
5	2	48	60	56	54.7	56
5	3	61	52	68	60.3	61
5	4	49	73	78	66.7	73
5	5	64	57	94	71.7	64

Group 1 raw data:

The following tables are the raw data collected from the gameplay at KBC Health & Safety (one of Anglo American's training facilities) during a A2 RMT training programme. The tables also contain the results that the players achieved in the theoretical examination after the A2 training programme.

Table E-2: Raw data: SG results from Group 1

PLAYER	Round	Dashboard scores			Average	Median
		OP	SHE	PL		
1	1	60	79	42	60.3	60
1	2	68	69	87	74.7	69
1	3	81	83	81	81.7	81
1	4	73	77	100	83.3	77
1	5	73	94	103	90.0	94
2	1	34	60	35	43.0	35
2	2	50	66	50	55.3	50
2	3	73	65	69	69.0	69
2	4	41	96	59	65.3	59
2	5	81	64	91	78.7	81
3	1	71	68	75	71.3	71
3	2	71	60	35	55.3	60
3	3	68	75	78	73.7	75
3	4	80	71	65	72.0	71
3	5	95	64	87	82.0	87
4	1	34	82	85	67.0	82
4	2	76	53	25	51.3	53
4	3	50	48	61	53.0	50
4	4	34	78	39	50.3	39
4	5	56	51	94	67.0	56
5	1	45	74	54	57.7	54
5	2	66	82	47	65.0	66
5	3	54	55	32	47.0	54
5	4	67	64	34	55.0	64
5	5	110	24	86	73.3	86
6	1	46	54	45	48.3	46
6	2	49	43	33	41.7	43
6	3	26	64	81	57.0	64
6	4	62	50	29	47.0	50
6	5	26	71	74	57.0	71
7	1	72	29	56	52.3	56
7	2	61	62	65	62.7	62
7	3	65	66	58	63.0	65
7	4	58	64	50	57.3	58
7	5	114	57	70	80.3	70

8	1	44	56	58	52.7	56
8	2	55	49	78	60.7	55
8	3	67	69	52	62.7	67
8	4	60	56	66	60.7	60
8	5	90	45	62	65.7	62
9	1	51	41	78	56.7	51
9	2	70	57	85	70.7	70
9	3	24	95	90	69.7	90
9	4	97	72	54	74.3	72
9	5	68	71	92	77.0	71
10	1	52	62	50	54.7	52
10	2	79	64	76	73.0	76
10	3	64	69	74	69.0	69
10	4	69	78	79	75.3	78
10	5	75	95	70	80.0	75

Group 1 theoretical test results:

The following table indicates the results that the delegates obtained for the post-A2 training theoretical test. These results will be used to correlate with the results that the respective players/delegates obtained in the SG.

Table E-3: Theory test results: Group 1

Player	Theory test result (%)
1	96
2	100
3	90
4	80
5	86
6	86
7	80
8	76
9	80
10	86

Group 1 JRA generation:

The table represents the findings from the JRAs generated on sites where supervisors who attended the A2 programme work on operational sites.

Table E-4: JRA completion data: Group 1

Working days	JRA's Completed before A2	JRA's Completed after A2
1	4	8
2	5	4
3	6	5
4	4	6
5	4	4
6	2	8
7	6	7
8	3	6
9	6	5
10	4	8

Group 2 raw data:

The following tables are the raw data collected from the gameplay at Mogalakwena platinum mine (at an Anglo American's training facility) during a A2 RMT training programme. The tables also contain the results that the players achieved in the theoretical examination after the A2 training programme.

Table E-5: Raw data: SG results from Group 2

PLAYER	Round	Dashboard scores			Average	Median
		OP	SHE	PL		
1	1	90	49	60	66.3	60
1	2	38	48	69	51.7	48
1	3	66	42	64	57.3	64
1	4	59	58	75	64.0	59
1	5	58	71	107	78.7	71
2	1	76	42	36	51.3	42
2	2	80	63	49	64.0	63
2	3	75	69	68	70.7	69
2	4	74	42	74	63.3	74
2	5	81	72	89	80.7	81
3	1	42	59	66	55.7	59
3	2	57	70	38	55.0	57
3	3	65	65	50	60.0	65
3	4	77	65	68	70.0	68
3	5	41	94	76	70.3	76
4	1	68	78	46	64.0	68

4	2	71	72	82	75.0	72
4	3	49	76	64	63.0	64
4	4	82	80	67	76.3	80
4	5	75	65	76	72.0	75
5	1	39	64	31	44.7	39
5	2	39	19	62	40.0	39
5	3	54	70	72	65.3	70
5	4	35	84	77	65.3	77
5	5	73	50	72	65.0	72
6	1	17	77	62	52.0	62
6	2	16	53	29	32.7	29
6	3	50	45	68	54.3	50
6	4	66	51	76	64.3	66
6	5	52	35	69	52.0	52
7	1	74	52	74	66.7	74
7	2	77	61	90	76.0	77
7	3	107	53	77	79.0	77
7	4	70	75	79	74.7	75
7	5	78	68	102	82.7	78
8	1	66	48	39	51.0	48
8	2	75	51	46	57.3	51
8	3	58	60	93	70.3	60
8	4	98	51	82	77.0	82
8	5	110	57	83	83.3	83
9	1	42	68	68	59.3	68
9	2	63	52	65	60.0	63
9	3	90	51	65	68.7	65
9	4	109	63	82	84.7	82
9	5	88	46	82	72.0	82
10	1	39	70	35	48.0	39
10	2	52	80	49	60.3	52
10	3	57	58	51	55.3	57
10	4	53	86	91	76.7	86
10	5	86	55	72	71.0	72
11	1	54	26	29	36.3	29
11	2	44	58	45	49.0	45
11	3	50	62	103	71.7	62
11	4	67	73	85	75.0	73
11	5	93	71	100	88.0	93
12	1	58	47	75	60.0	58
12	2	98	16	50	54.7	50
12	3	65	40	78	61.0	65
12	4	57	53	58	56.0	57
12	5	72	49	73	64.7	72
13	1	62	19	68	49.7	62

13	2	58	46	53	52.3	53
13	3	68	44	49	53.7	49
13	4	72	81	72	75.0	72
13	5	99	51	113	87.7	99
14	1	50	93	49	64.0	50
14	2	66	60	28	51.3	60
14	3	43	49	85	59.0	49
14	4	94	51	53	66.0	53
14	5	68	43	81	64.0	68
15	1	59	54	79	64.0	59
15	2	74	58	70	67.3	70
15	3	58	75	72	68.3	72
15	4	98	62	87	82.3	87
15	5	107	53	98	86.0	98

Group 2 theoretical test results:

The following table indicates the results that the delegates obtained for the post-A2 training theoretical test. These results will be used to correlate with the results that the respective players/delegates obtained in the SG.

Table E-6: Theory test results: Group 2

Player	Theory test result (%)
1	76
2	100
3	80
4	83
5	86
6	80
7	93
8	100
9	73
10	76
11	96
12	93
13	96
14	80
15	83

Group 2 JRA generation:

The table represents the findings from the JRAs generated on sites where supervisors who attended the A2 programme work on operational sites.

Table E-7: JRA completion data: Group 2

Working days	JRA's Completed before A2	JRA's Completed after A2
1	6	8
2	4	7
3	5	6
4	5	6
5	4	4
6	3	7
7	8	6
8	4	6
9	6	9
10	5	8

APPENDIX F: DATA ANALYSIS

Test group:

1. Normal probability plot for with average scores achieved as dependent variable. This is done to test for a normal distribution and meet the requirements for an ANOVA.

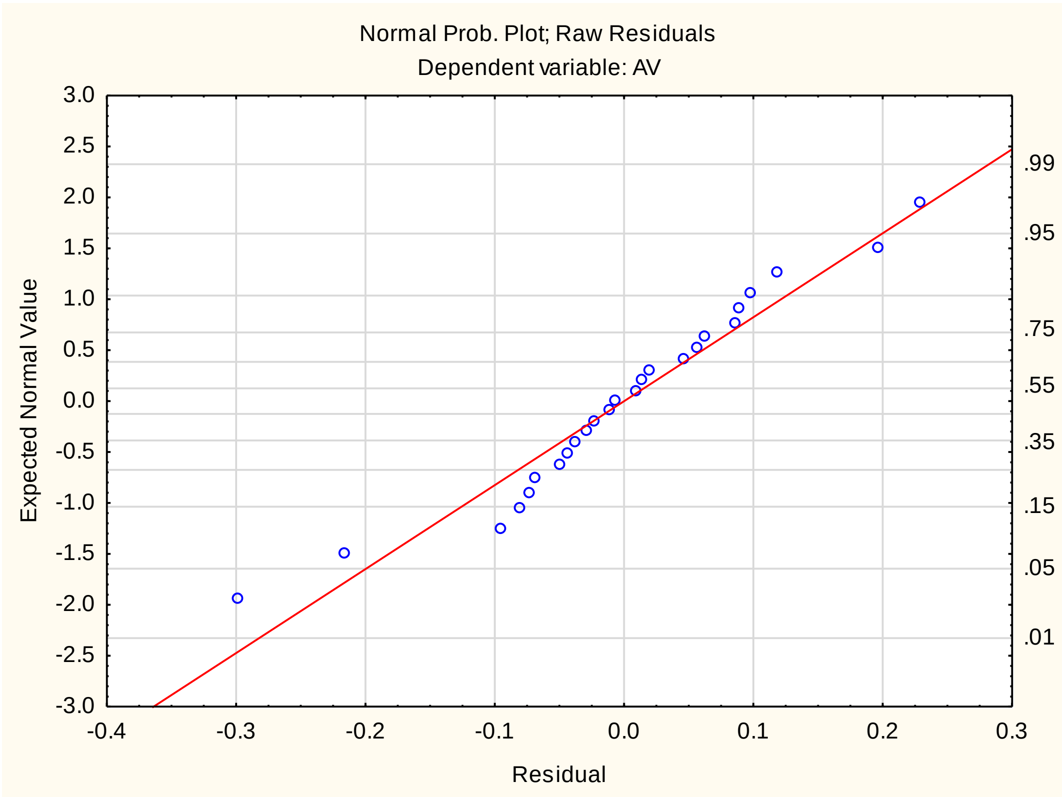

Figure F-1: Normal probability plot with average scores as dependent variable (Test group)

2. Fixed effect test for average scores obtained by five subjects over five rounds played each:

Table F-1: Fixed effect test to calculate p-values: average scores (Test group)

	Fixed Effect Test for AV (Test Group in DATA GAMES 4 20191108) Restricted Maximum Likelihood (REML) Type III decomposition grouping vars: PLAYER, Round Fixed: Round			
Effect	Num. DF	Den. DF	F	p
Round	4	20	3.38	0.03

3. Least significance difference (LSD) test for the average scores obtained by the subjects over five rounds played:

Table F-2: Least-squares means test between rounds: average scores (Test group)

Comparisons Cell {#1}-{#2}	LSD test; variable AV (Test Group in DATA GAMES 4 20191108) Simultaneous confidence intervals 1st Mean	2nd Mean	Mean Differ.	Standard Error	p
{1}-{2}	1	2	0.00	5.01	1.00
{1}-{3}	1	3	-8.33	5.01	0.11
{1}-{4}	1	4	-8.73	5.01	0.10
{1}-{5}	1	5	-15.27	5.01	0.01
{2}-{3}	2	3	-8.33	5.01	0.11
{2}-{4}	2	4	-8.73	5.01	0.10
{2}-{5}	2	5	-15.27	5.01	0.01
{3}-{4}	3	4	-0.40	5.01	0.94
{3}-{5}	3	5	-6.93	5.01	0.18
{4}-{5}	4	5	-6.53	5.01	0.21

4. Descriptive statistics obtained from the average score's analysis:

Table F-3: LS-means test descriptive statistics: average scores (Test group)

Cell No.	Round; LS Means (Test Group in DATA GAMES 4 20191108) Current effect: F(4, 20)=3.3773, p=.02887 Type III decomposition Round	AV Mean	AV Std.Err.	AV -95.00%	AV +95.00%	N
1	1	57.06667	3.544260	49.67347	64.45986	5
2	2	57.06667	3.544260	49.67347	64.45986	5
3	3	65.40000	3.544260	58.00680	72.79320	5
4	4	65.80000	3.544260	58.40680	73.19320	5
5	5	72.33333	3.544260	64.94014	79.72653	5

5. Least squares mean analysis of the average scores obtained:

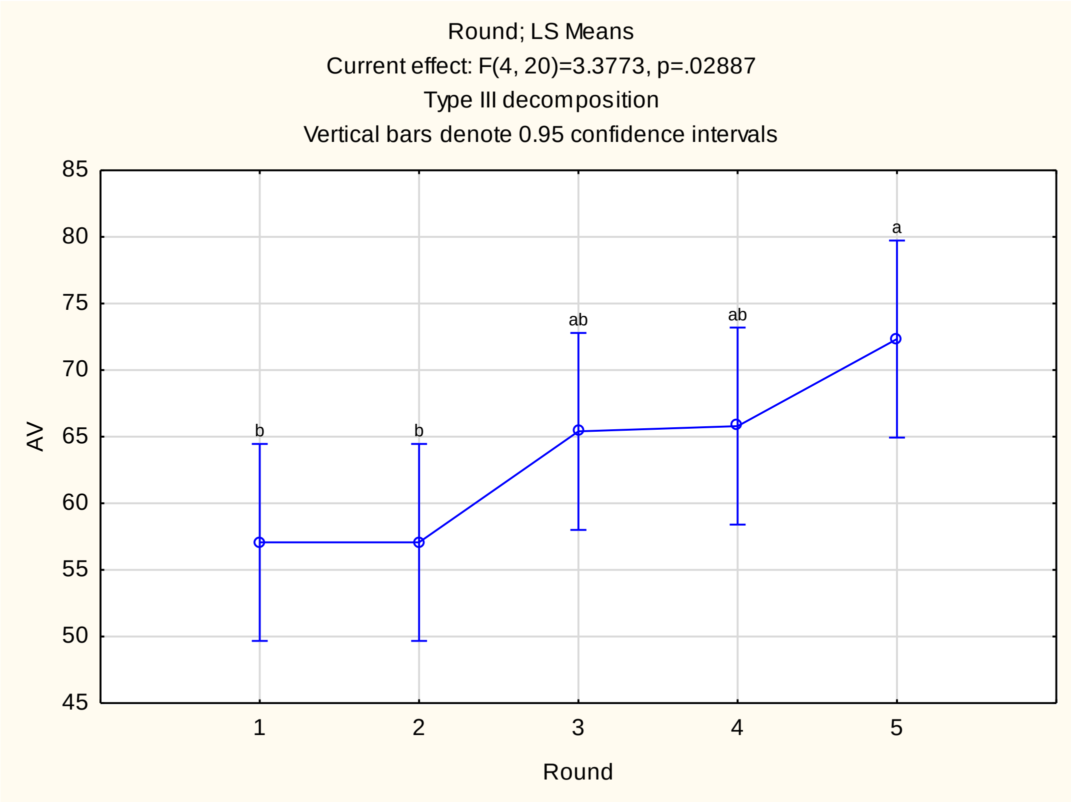

Figure F-2: LS-means test results from the average scores in terms of rounds played (Test group)

Group 1:

The analysis of the data collected from the results of the SG (Time Risk Manager) at the A2 programme, the theoretical test written after the A2 programme, and the completion of JRA's from Anglo American after implementation of the SG at an allocated A2 programme, was analysed using the *STATISTICA* software package in collaboration with the Stellenbosch University Statistics Department.

1. Fixed effect test for Average scores obtained by players over five rounds played each:

Table F-4: Fixed effect test to calculate p-values: average scores (Group 1)

	Fixed Effect Test for AV (DATA GAMES 20190830) Restricted Maximum Likelihood (REML) Type III decomposition grouping vars: PLAYER, Round Fixed: Round Random: PLAYER(Round)			
Effect	Num. DF	Den. DF	F	p
Round	4	45	4.58	0.00

2. Least significance difference (LSD) test for the average scores obtained by the players over five rounds played:

Table F-5: Least-squares means test between rounds: average scores (Group 1)

Comparisons Cell {#1}-{#2}	LSD test; variable AV (DATA GAMES 20190830) Simultaneous confidence intervals Effect: Round 1st Mean	2nd Mean	Mean Differ.	Standard Error	p
{1}-{2}	1	2	-4.63	4.55	0.31
{1}-{3}	1	3	-8.17	4.55	0.08
{1}-{4}	1	4	-7.67	4.55	0.10
{1}-{5}	1	5	-18.70	4.55	0.00
{2}-{3}	2	3	-3.53	4.55	0.44
{2}-{4}	2	4	-3.03	4.55	0.51
{2}-{5}	2	5	-14.07	4.55	0.00
{3}-{4}	3	4	0.50	4.55	0.91
{3}-{5}	3	5	-10.53	4.55	0.03
{4}-{5}	4	5	-11.03	4.55	0.02

3. Descriptive statistics obtained from the average score's analysis:

Table F-6: LS-means test descriptive statistics: average scores (Group 1)

Effect	Descriptive Statistics (DATA GAMES 20190830) Level of Factor	Level of Factor	N	AV Mean	AV Std.Dev.
Total			50	64.23	11.57
Round	1		10	56.40	8.37
Round	2		10	61.03	10.41
Round	3		10	64.57	10.25
Round	4		10	64.07	11.96
Round	5		10	75.10	9.56

4. Least squares mean analysis of the average scores obtained:

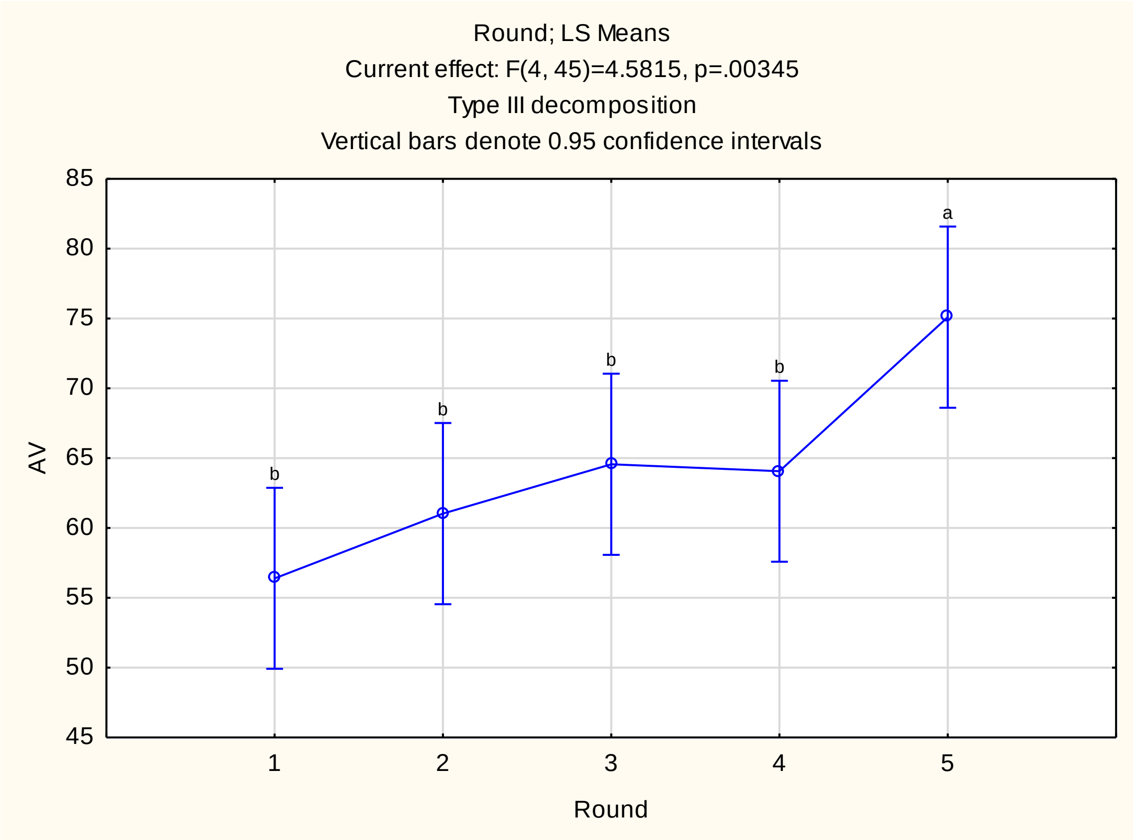

Figure F-3: LS-means test results from the average scores in terms of rounds played (Group 1)

5. Fixed effect test for Median scores obtained by players over five rounds played each:

Table F-7: Fixed effect test to calculate p-values: median scores (Group 1)

	Fixed Effect Test for MEDIAN (DATA GAMES 20190830) Restricted Maximum Likelihood (REML) Type III decomposition grouping vars: PLAYER, Round Fixed: Round Random: PLAYER(Round)			
Effect	Num. DF	Den. DF	F	p
Round	4	45	3.91	0.01

6. Least significance difference (LSD) test for the median scores obtained by the players over five rounds played:

Table F-8: Least-squares means test between rounds: median scores (Group 1)

Comparisons Cell {#1}-{#2}	LSD test; variable MEDIAN (DATA GAMES 20190830) Simultaneous confidence intervals Effect: Round 1st Mean	2nd Mean	Mean Differ.	Standard Error	p
{1}-{2}	1	2	-4.10	5.29	0.44
{1}-{3}	1	3	-12.10	5.29	0.03
{1}-{4}	1	4	-6.50	5.29	0.23
{1}-{5}	1	5	-19.00	5.29	0.00
{2}-{3}	2	3	-8.00	5.29	0.14
{2}-{4}	2	4	-2.40	5.29	0.65
{2}-{5}	2	5	-14.90	5.29	0.01
{3}-{4}	3	4	5.60	5.29	0.30
{3}-{5}	3	5	-6.90	5.29	0.20
{4}-{5}	4	5	-12.50	5.29	0.02

7. Descriptive statistics obtained from the average score's analysis:

Table F-9: LS-means test descriptive statistics: median scores (Group 1)

Effect	Descriptive Statistics (DATA GAMES 20190830) Level of Factor	Level of Factor	N	MEDIAN Mean	MEDIAN Std.Dev.
Total			50	64.64	13.16
Round	1		10	56.30	12.92
Round	2		10	60.40	10.21
Round	3		10	68.40	11.78
Round	4		10	62.80	12.30
Round	5		10	75.30	11.78

8. Least squares mean analysis of the median scores obtained:

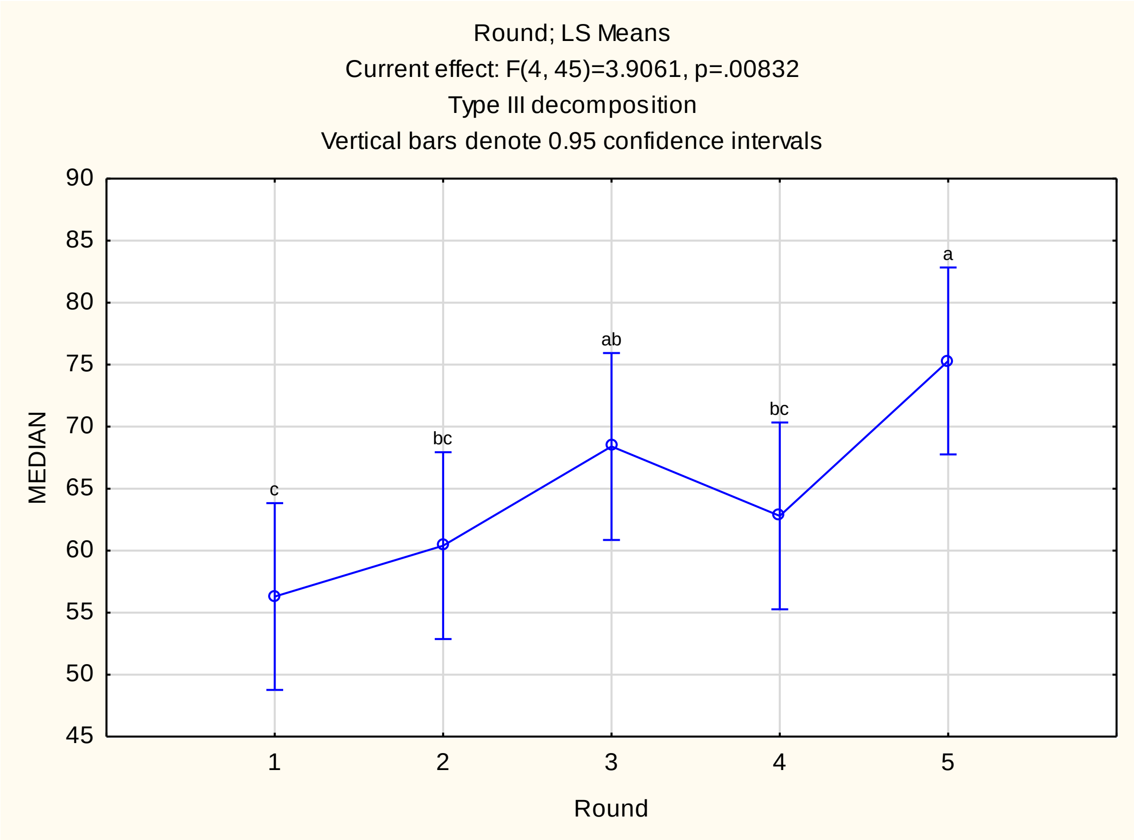

Figure F-4: LS-means test results from the median scores in terms of rounds played (Group 1)

9. 2D scatterplots with linear regression finding the relationship between the average score increase (between rounds 1 and 5) and the median scores increase (between rounds 1 and 5), with the theoretical test results of the respective players/delegates:

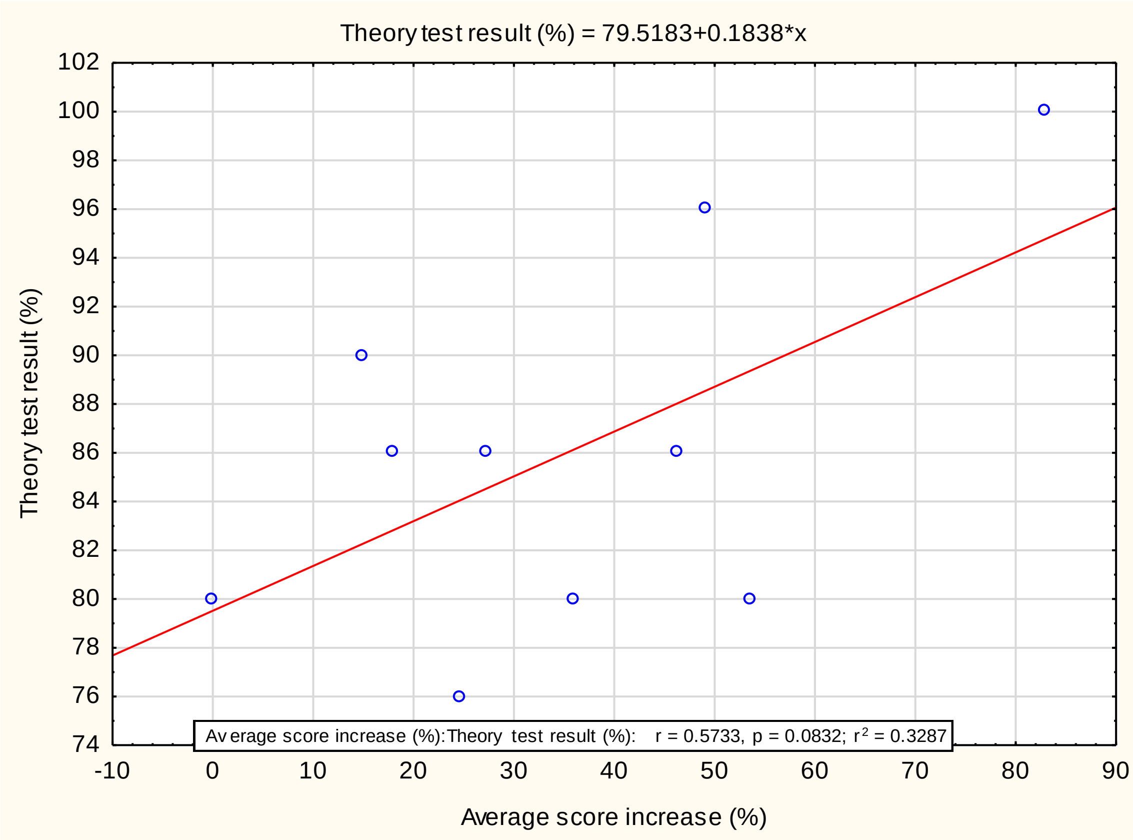

Figure F-5: Scatterplot with linear regression of average score increase vs. theory test results (Group 1)

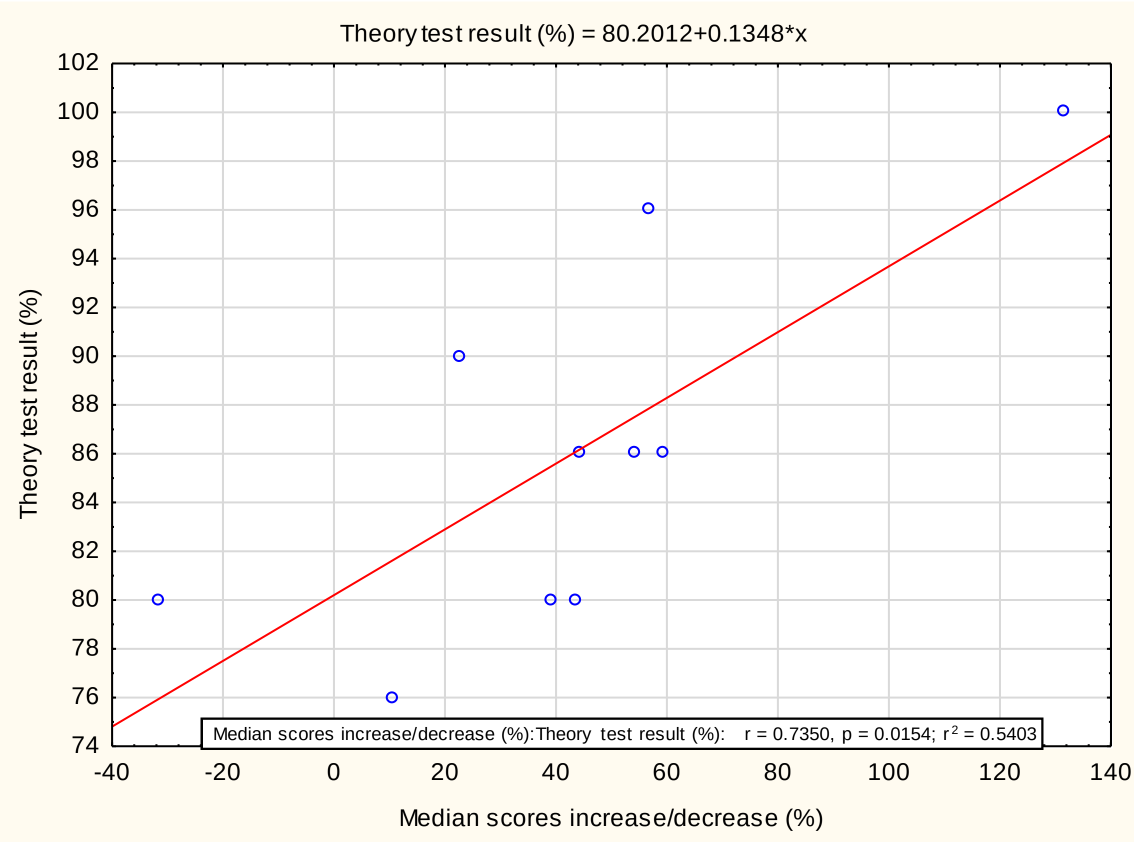

Figure F-6: Scatterplot with linear regression of median score increase vs. theory test results (Group 1)

10. 2D scatterplot of the percentage median score increase with respects to the respective theoretical test results of the players. This graph also indicates the confidence interval with the data points falling within the limit bounds with no outliers.

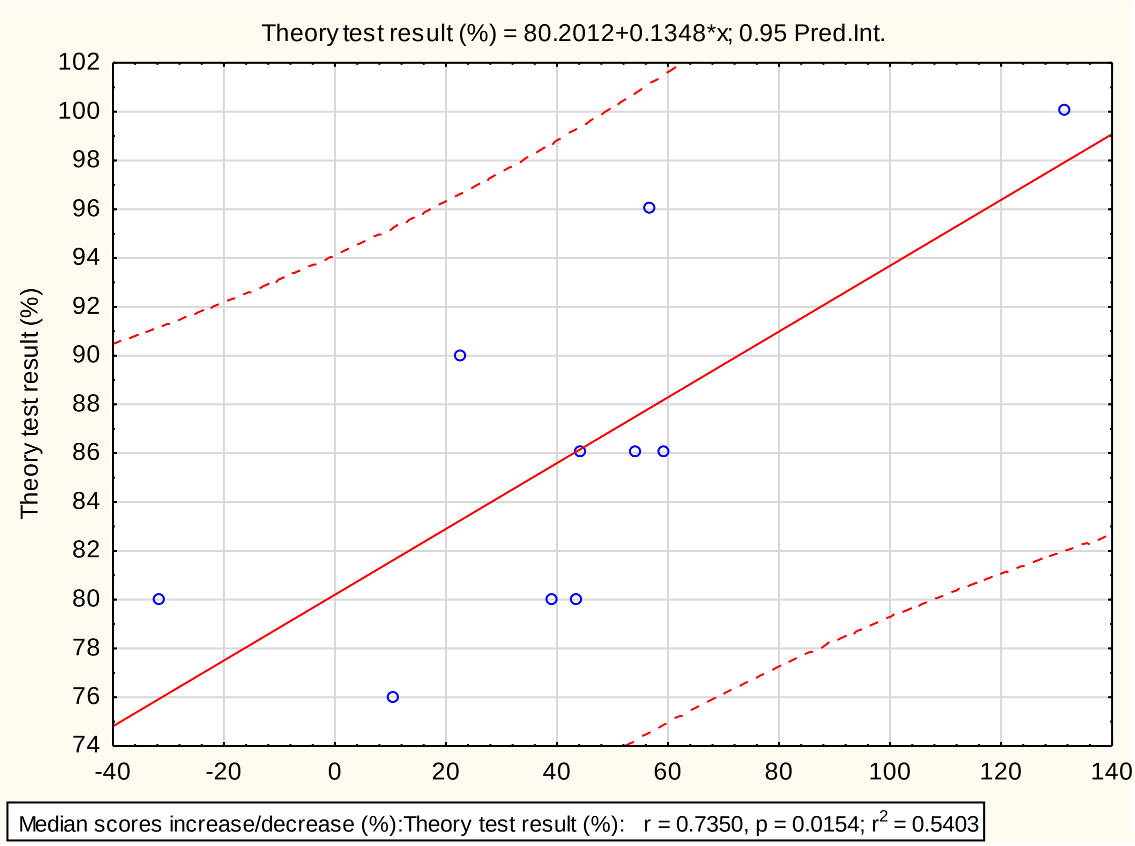

Figure F-7: Scatterplot of median score increase vs. theory test with confidence interval

11. Multiple regression results for the increase in average scores versus the theory test results of players after five rounds played respectively:

Table F-10: Regression results: average score increase vs. theory test results (Group 1)

Statistic	Summary Value
Multiple R	0.573281514
Multiple R²	0.328651694
Adjusted R²	0.244733156
F(1,8)	3.91631815
p	0.0831813365
Std.Err. of Estimate	6.60587919

Table F-11: Regression summary of average score increase vs. theory test results (Group 1)

N=10	Regression Summary for Dependent Variable: Theory test result (%) (DATA GAMES 2 20191018) R= .57328151 R²= .32865169 Adjusted R²= .24473316					
	b*	Std.Err. of b*	b	Std.Err. of b	t(8)	p-value
Intercept			79.51825	3.884772	20.46922	0.000000
Average score increase (%)	0.573282	0.289687	0.18384	0.092896	1.97897	0.083181

12. Multiple regression results for the increase in median scores versus the theory test results of players after five rounds played respectively:

Table F-12: Regression results: median score increase vs. theory test results (Group 1)

Statistic	Summary Value
Multiple R	0.735020855
Multiple R²	0.540255657
Adjusted R²	0.482787614
F(1,8)	9.40097538
p	0.015438973
Std.Err. of Estimate	5.46656952

Table F-13: Regression summary of median score increase vs. theory test results (Group 1)

N=10	Regression Summary for Dependent Variable: Theory test result (%) (DATA GAMES 2 20191018) R= .73502085 R²= .54025566 Adjusted R²= .48278761 F(1,8)=9.4010 p<.01544 Std.Error of estimate: 5.4666					
	b*	Std.Err. of b*	b	Std.Err. of b	t(8)	p-value
Intercept			80.20119	2.562269	31.30084	0.000000
Median scores increase/decrease (%)	0.735021	0.239725	0.13481	0.043968	3.06610	0.015439

13. Normal probability plots for an ANOVA analysing the variance between JRA's completed by the supervisors' teams before and after their attendance to the A2 RMT programme.

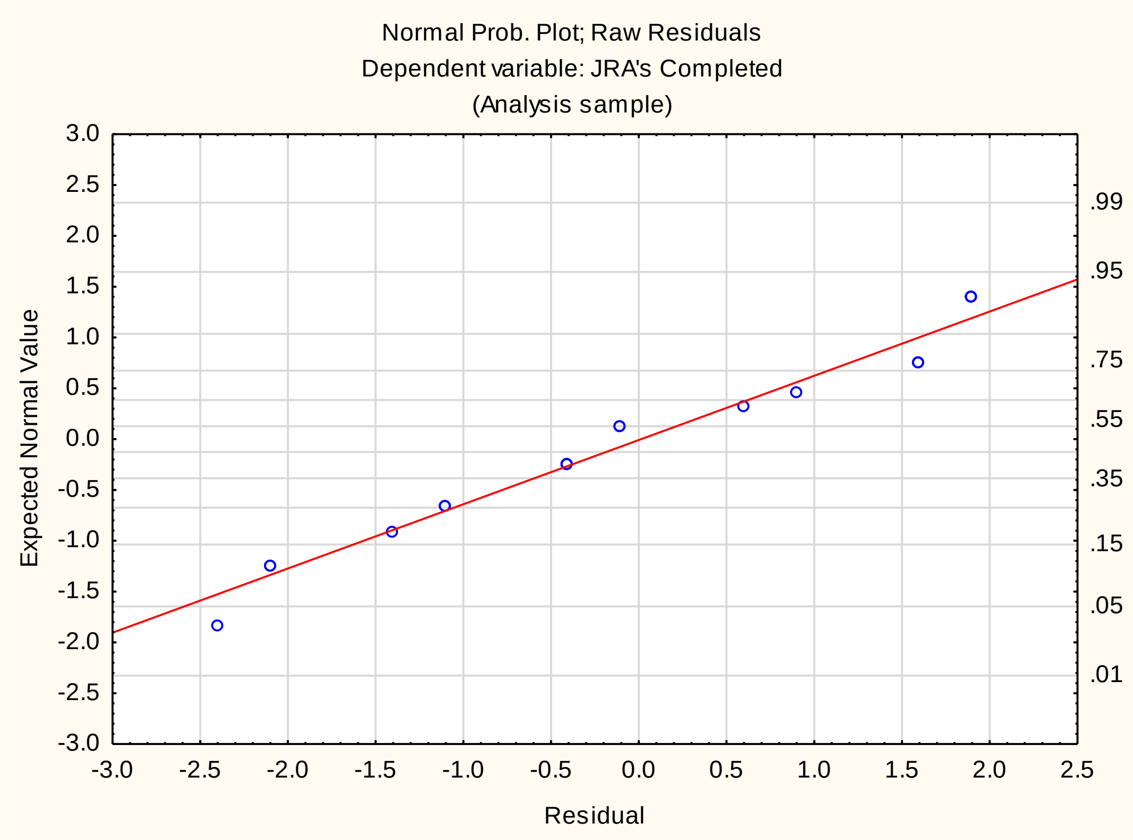

Figure F-8: Q-Q plot of JRAs completed as dependent variable (Group 1)

14. Least squares means test for the JRA's completed before and after attendance to the A2 RMT programme.

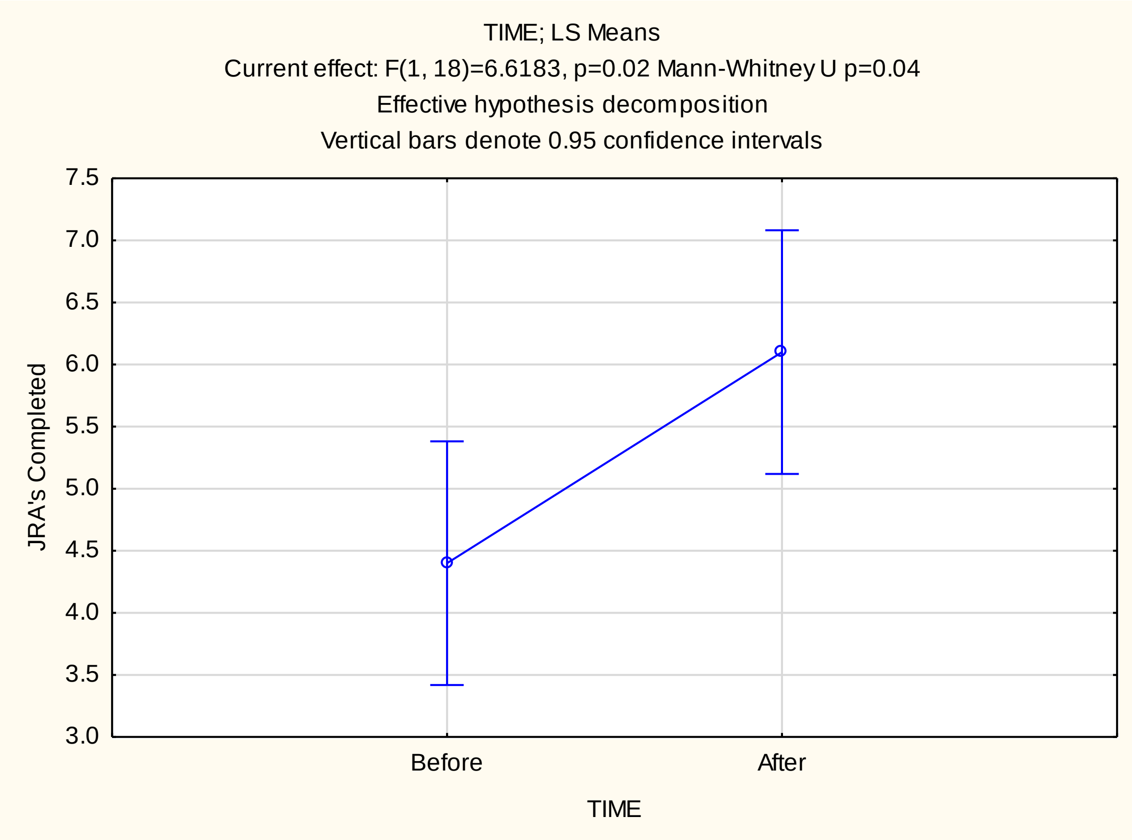

Figure F-9: LS-means test for calculation of p-values for difference in JRAs completed (Group 1)

15. Levene's test for homogeneity of variances of JRA's completed before and after attendance to the A2 RMT programme.

Table F-14: Levene's test results for homogeneity of variances for JRA's completed (Group 1)

	Levene's Test for Homogeneity of Variances (DATA GAMES 3 20191018) Effect: TIME			
	MS Effect	MS Error	F	p
JRA's Completed	0.288000	0.567333	0.507638	0.485297

16. Least squares means test for the number of JRA's completed before and after attendance to the A2 RMT programme.

Table F-15: LS-means test results for JRA;s completed (Group 1)

	TIME; LS Means (DATA GAMES 3 20191018) Current effect: F(1, 18)=6.6183, p=.01917 Effective hypothesis decomposition					
Cell No.	TIME	JRA's Completed Mean	JRA's Completed Std.Err.	JRA's Completed -95.00%	JRA's Completed +95.00%	N
1	Before	4.400000	0.467262	3.418320	5.381680	10
2	After	6.100000	0.467262	5.118320	7.081680	10

17. Non-parametric comparison of two groups dialog using the Mann-Whitney U Test

Table F-16: Mann-Whitney U test results for JRA's completed comparison (Group 1)

	Mann-Whitney U Test (w/ continuity correction) (DATA GAMES 3 20191018) By variable TIME Marked tests are significant at p <.05000									
variable	Rank Sum Before	Rank Sum After	U	Z	p-value	Z adjusted	p-value	Valid N Before	Valid N After	2*1sided exact p
JRA's Completed	77.00000	133.0000	22.00000	-2.07880	0.037636	-2.12986	0.033184	10	10	0.035463

Group 1 and 2 combined analysis:

1. Fixed effect test for Average scores obtained by players over five rounds played each:

Table F-17: Fixed effect test to calculate p-values: average scores (Combined)

	Fixed Effect Test for AV (DATA in DATA GAMES 4 20191108) Restricted Maximum Likelihood (REML) Type III decomposition grouping vars: PLAYER, Round Fixed: Round Random: PLAYER(Round)			
Effect	Num. DF	Den. DF	F	p
Round	4	120	15.47	0.00

2. Least significance difference (LSD) test for the average scores obtained by the players over five rounds played:

Table F-18: Least-squares means test between rounds: average scores (Combined)

Comparisons Cell {#1}-{#2}	LSD test; variable AV (DATA in DATA GAMES 4 20191108) Simultaneous confidence intervals 1st Mean	2nd Mean	Mean Differ.	Standard Error	p
{1}-{2}	1	2	-2.40	2.75	0.38
{1}-{3}	1	3	-8.25	2.75	0.00
{1}-{4}	1	4	-12.57	2.75	0.00
{1}-{5}	1	5	-18.88	2.75	0.00
{2}-{3}	2	3	-5.85	2.75	0.04
{2}-{4}	2	4	-10.17	2.75	0.00
{2}-{5}	2	5	-16.48	2.75	0.00
{3}-{4}	3	4	-4.32	2.75	0.12
{3}-{5}	3	5	-10.63	2.75	0.00
{4}-{5}	4	5	-6.31	2.75	0.02

3. Descriptive statistics obtained from the average score's analysis:

Table F-19: LS-means test descriptive statistics: average scores (Combined)

Effect	Descriptive Statistics (DATA in DATA GAMES 4 Level of Factor	Level of Factor	N	AV Mean	AV Std.Dev.
Total			125	64.30	11.77
Round	1		25	55.88	8.55
Round	2		25	58.28	11.17
Round	3		25	64.13	8.49
Round	4		25	68.45	10.20
Round	5		25	74.76	9.91

4. Fixed effect test for median scores obtained by players over five rounds played each:

Table F-20: Fixed effect test to calculate p-values: median scores (Combined)

Effect	Fixed Effect Test for MEDIAN (DATA in DATA GAMES 4 20191108) Restricted Maximum Likelihood (REML) Type III decomposition grouping vars: PLAYER, Round Fixed: Round Num. DF	Den. DF	F	p
Round	4	120	14.23	0.00

5. Least significance difference (LSD) test for the median scores obtained by the players over five rounds played:

Table F-21: Least-squares means test between rounds: median scores (Combined)

	LSD test; variable MEDIAN (DATA in DATA GAMES 4 20191108) Simultaneous confidence intervals				
Comparisons Cell {#1}-{#2}	1st Mean	2nd Mean	Mean Differ.	Standard Error	p
{1}-{2}	1	2	-2.12	3.31	0.52
{1}-{3}	1	3	-9.68	3.31	0.00
{1}-{4}	1	4	-13.56	3.31	0.00
{1}-{5}	1	5	-21.80	3.31	0.00
{2}-{3}	2	3	-7.56	3.31	0.02
{2}-{4}	2	4	-11.44	3.31	0.00
{2}-{5}	2	5	-19.68	3.31	0.00
{3}-{4}	3	4	-3.88	3.31	0.24
{3}-{5}	3	5	-12.12	3.31	0.00
{4}-{5}	4	5	-8.24	3.31	0.01

6. Descriptive statistics obtained from the median score's analysis:

Table F-22: LS-means test descriptive statistics: median scores (Combined)

	Descriptive Statistics (DATA in DATA GAMES 4				
Effect	Level of Factor	Level of Factor	N	MEDIAN Mean	MEDIAN Std.Dev.
Total			125	64.63	13.99
Round	1		25	55.20	12.60
Round	2		25	57.32	11.88
Round	3		25	64.88	10.07
Round	4		25	68.76	12.04
Round	5		25	77.00	11.83

7. LS-means test for difference in average scores of two groups tested:

Table F-23: LS-means test results descriptive statistics comparing groups

Cell No.	Group*Round; LS Means (DATA in DATA GAMES 4 20191108) Current effect: F(4, 92)=2.0647, p=.09181 Type III decomposition Group	Round	AV Mean	AV Std.Err.	AV -95.00%	AV +95.00%	N
1	G1	1	56.40000	3.075575	50.29164	62.50836	10
2	G1	2	61.03333	3.075575	54.92498	67.14169	10
3	G1	3	64.56667	3.075575	58.45831	70.67502	10
4	G1	4	64.06667	3.075575	57.95831	70.17502	10
5	G1	5	75.10000	3.075575	68.99164	81.20836	10
6	G2	1	55.53333	2.511196	50.54588	60.52079	15
7	G2	2	56.44444	2.511196	51.45699	61.43190	15
8	G2	3	63.84444	2.511196	58.85699	68.83190	15
9	G2	4	71.37778	2.511196	66.39033	76.36523	15
10	G2	5	74.53333	2.511196	69.54588	79.52079	15

8. LSD test results for average scores obtained with simultaneous confidence intervals:

Table F-24: LSD test results comparing groups and rounds: average scores (Combined)

	LSD test; variable AV (DATA in DATA GAMES 4 20191108) Simultaneous confidence intervals				
Comparisons Cell {#1}-{#2}	1st Mean	2nd Mean	Mean Differ.	Standard Error	p
{1}-{2}	G1*1	G1*2	-4.63	3.32	0.17
{1}-{3}	G1*1	G1*3	-8.17	3.32	0.02
{1}-{4}	G1*1	G1*4	-7.67	3.32	0.02
{1}-{5}	G1*1	G1*5	-18.70	3.32	0.00
{1}-{6}	G1*1	G2*1	0.87	3.97	0.83
{1}-{7}	G1*1	G2*2	-0.04	3.97	0.99
{1}-{8}	G1*1	G2*3	-7.44	3.97	0.06
{1}-{9}	G1*1	G2*4	-14.98	3.97	0.00
{1}-{10}	G1*1	G2*5	-18.13	3.97	0.00
{2}-{3}	G1*2	G1*3	-3.53	3.32	0.29
{2}-{4}	G1*2	G1*4	-3.03	3.32	0.36
{2}-{5}	G1*2	G1*5	-14.07	3.32	0.00
{2}-{6}	G1*2	G2*1	5.50	3.97	0.17
{2}-{7}	G1*2	G2*2	4.59	3.97	0.25
{2}-{8}	G1*2	G2*3	-2.81	3.97	0.48
{2}-{9}	G1*2	G2*4	-10.34	3.97	0.01
{2}-{10}	G1*2	G2*5	-13.50	3.97	0.00
{3}-{4}	G1*3	G1*4	0.50	3.32	0.88
{3}-{5}	G1*3	G1*5	-10.53	3.32	0.00
{3}-{6}	G1*3	G2*1	9.03	3.97	0.03
{3}-{7}	G1*3	G2*2	8.12	3.97	0.04
{3}-{8}	G1*3	G2*3	0.72	3.97	0.86
{3}-{9}	G1*3	G2*4	-6.81	3.97	0.09
{3}-{10}	G1*3	G2*5	-9.97	3.97	0.01
{4}-{5}	G1*4	G1*5	-11.03	3.32	0.00
{4}-{6}	G1*4	G2*1	8.53	3.97	0.03
{4}-{7}	G1*4	G2*2	7.62	3.97	0.06
{4}-{8}	G1*4	G2*3	0.22	3.97	0.96
{4}-{9}	G1*4	G2*4	-7.31	3.97	0.07
{4}-{10}	G1*4	G2*5	-10.47	3.97	0.01
{5}-{6}	G1*5	G2*1	19.57	3.97	0.00
{5}-{7}	G1*5	G2*2	18.66	3.97	0.00
{5}-{8}	G1*5	G2*3	11.26	3.97	0.01
{5}-{9}	G1*5	G2*4	3.72	3.97	0.35
{5}-{10}	G1*5	G2*5	0.57	3.97	0.89
{6}-{7}	G2*1	G2*2	-0.91	2.71	0.74
{6}-{8}	G2*1	G2*3	-8.31	2.71	0.00
{6}-{9}	G2*1	G2*4	-15.84	2.71	0.00
{6}-{10}	G2*1	G2*5	-19.00	2.71	0.00
{7}-{8}	G2*2	G2*3	-7.40	2.71	0.01
{7}-{9}	G2*2	G2*4	-14.93	2.71	0.00
{7}-{10}	G2*2	G2*5	-18.09	2.71	0.00
{8}-{9}	G2*3	G2*4	-7.53	2.71	0.01
{8}-{10}	G2*3	G2*5	-10.69	2.71	0.00
{9}-{10}	G2*4	G2*5	-3.16	2.71	0.25