Design and Evaluation of a "Gamified" System for Improving Career Knowledge in Computing Sciences

Brenda Scholtz
Head of Department, Department of Computing Sciences, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa

Larissa Raga
Student, Department of Computing Sciences, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa

Gavin Baxter
Lecturer, School of Engineering and Computing, University of the West of Scotland

Abstract
"Gamification", or the use of game elements outside the gaming context, is a recent trend in learning approaches and has been used to digitally engage and motivate people to accomplish their learning objectives. The study described in this article investigated components of a gamification system and the impact of these components on user experience, usability and education usability. The Mechanics, Dynamics and Aesthetics (MDA) classification framework for gamification design was used to guide the authors' design of a gamification system intended to improve learners' knowledge of careers in computing sciences (CS). Criteria for evaluating e-learning systems were derived from literature and used to extend the MDA framework via addition of criteria for evaluating usability, user experience (UX) and educational usability of a gamification system. The extended MDA framework was found to be successful in guiding the design, development and evaluation of the system prototype, and the results gathered from the summative usability evaluation indicated that positive UX and educational usability were achieved. The results suggest that gamification designed for UX and educational usability can potentially play an important role in equipping young people in South Africa with a knowledge of CS-related careers.

Keywords
computing sciences (CS); gamification; Mechanics, Dynamics and Aesthetics (MDA) classification framework; usability; user experience (UX); educational usability

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1. Introduction

A recent Employment Projections report by the United States Bureau of Labor predicted that jobs listed under Computer Occupations were set to increase by 17.7 %, from 3,682,000 in 2012 to 4,333,000 in 2022 (US Bureau of Labor Statistics, 2015). The report also predicts that there will be 1,240,000 job openings due to growth and replacements over this period. The four fastest-growing industries in dollar terms are forecast to be in information and communications technology- (ICT-) related industries. In South Africa, similar predictions have been made. The 2014 Joburg Centre for Software Engineering (JCSE) ICT Skills Survey estimated that there were about 40,000 ICT job vacancies in South Africa, and 59% of respondents said that the skills shortage was affecting company viability (Schofield, 2014). The 2014 Financial Services Sector Assessment Report (Western Cape Government, 2014) also showed that there was a large shortage of ICT skills in South Africa.

Within the broad range of ICT fields, "computing sciences (CS)" is an umbrella term that refers to both Computer Science and Information Systems disciplines at universities, faculties and departments worldwide (NMMU Computing Sciences, n.d.). Zwang (2010) states that CS has the highest job demand by employers among Science, Technology, Engineering and Mathematics (STEM) job disciplines. Schnabel and White (2014) concur, reporting a large number of STEM jobs in ICT, particularly in CS.

Morrison and Preston (2009) found that while the demand for CS graduates grew between 2000 and 2009, the number of applicants for CS-related career fields experienced a significant drop during the same period. An international drop in the number of enrolments for degrees in CS documented by Jacobs and Sewry (2009) suggested that there may at times be a scarcity of learners interested in these fields (Jacobs & Sewry, 2009). According to Calitz (2010), the primary reasons for the shortage of CS learners are negative perceptions about the ICT field, lack of sufficient ICT career information, and limited knowledge of the job opportunities available in the ICT industry. Meanwhile, Carcary, Sherry, McLaughlin and O'Brien (2012) found that a challenge experienced by learners at educational institutions was that they did not receive proper guidance in selecting a career path that matched their desired field of study.

The study outlined in this article sought to examine whether "gamification" could be used to broaden learners' knowledge of CS careers and expertise. According to Ernst and Clark (2012), in the science discipline learning systems that promote enthusiasm and engagement among learners, while improving their skills and abilities, have become a priority. Since its introduction, gamification has evolved into a common learning tool to enhance classroom tasks and has been proven to improve development in visual knowledge amongst learners (Ernst & Clark, 2012; Gee, 2003). And the use of gamification can have potential benefits for education scenarios where learners need to be driven to participate in learning activities (Harman et al., 2014).

The term gamification was derived from the industry of digital media (Deterding et al., 2011b). The first known use of the term stems back to 2008, and more widespread use began in 2010 (Deterding et al., 2011a). Landers (2014, p. 752) defines gamification as “the use of game attributes […] outside the context of a game with the purpose of affecting learning-related behaviours or attitudes”. According to Erenli (2013, p. 7), “gamification is the use of game elements in contexts that had originally no link to game related elements”. Domínguez et al. (2013) define gamification as the use of game elements and design in non-game environments to influence user engagement. Gartner, a company that specialises in IT research, has redefined this definition as the application of both experience design and game mechanics to motivate and engage people to accomplish their objectives (Burke, 2014; Growth Engineering, 2015).

A related concept to gamification is “serious games”. A serious game is a fully-fledged game for non-leisure purposes, including serious applications such as training or learning (Deterding et al., 2011a). While these two terms “gamification” and “serious games” are fundamentally different, the dissimilarity can at times be slightly blurred. According to Deterding et al. (2011a, p.12), while serious games fulfil all the conditions for being a game, “gamified” applications merely use some of the design elements of games.

An explosion of interest has occurred in recent years in using gamification to make non-game applications more enjoyable and engaging (Reeve, 2014). Gaming strategies can now be seen in a wide range of contexts, including business (gamified marketing campaigns and loyalty programmes), health (the gamification of fitness through programmes like Wii Fit and Nike+), government (the application of gamified “nudge” tactics and behavioural economics), and military (war games and simulations).

Game-based learning is not a new concept. Effective teachers and instructors have always understood the power of games to motivate and inspire. Whether via use of chess to develop strategic thinking, backgammon and Monopoly for mental arithmetic, Scrabble for spelling and vocabulary, or driving and flight simulators for an understanding of how to control sophisticated machines, games make learning fun and more effective than non-game approaches. The concepts of gamification have also been used in the design of systems for learners who wish to learn academic subjects and skills as preparation for an external test, or to explore the content for their own enjoyment (Ibáñez et al., 2014; Iosup & Epema, 2014; Lee & Hammer, 2011).

However, gamification systems that provide career knowledge and advice are limited.

Plotr is one system that has included aspects of gamification for users seeking career advice (Plotr, 2016). Plotr includes a set of real-life, working-world simulations that users can explore to find out more about the industries they are interested in, by means of showing the their progress towards attaining certain levels through gamification. In addition, they earn titles for each level completed and a leader board then displays recommended careers. Hunicke, LeBlanc and Zubek (2004) established the usefulness of levels to measure progress and accomplishment in gamification.

Gamification is now quite an acknowledged term in the academic literature. However, there is a lack of empirical evidence regarding gamification, gamification methods used and the effectiveness of gamification (Hamari et al., 2014). While many studies report successful implementation of gamification in learning environments, one study – the implementation of a serious game for increasing a player's understanding and awareness of flood issues – proved a particularly difficult endeavour and was unsuccessful (Rebolledo-Mendez et al., 2009). The components and elements of serious games and gamification systems need to be planned and designed very carefully (Deterding et al., 2011a; Deterding et al., 2013). Guidance, based on empirical evidence of the user experience (UX) of these systems (Beier, 2014; Knaving & Björk, 2013), is needed regarding which components to include. The satisfaction of students with e-learning has been reported as depending on a good UX (Urh et al., 2015), where UX, as defined by International Organisation for Standardisation (ISO) 9241-210, represents a person's perceptions and responses that result from the use and/or anticipated use of a product, system or service (ISO, 2009).

While some guidelines on how to make learning activities more motivating and engaging have been provided (Knaving & Björk, 2013), these are limited and need to be extended and empirically validated in different settings. A learning environment is not just a digital product; it is also an educational product aimed at achieving learning goals and objectives (Ssemugabi & De Villiers, 2010). Therefore, when designing and evaluating such environments, it is important to also consider the usability and educational usability of such systems (Squires & Preece, 1999; Ssemugabi & De Villiers, 2010). Usability has been defined by the ISO as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO, 1997). This standard therefore identifies the three usability criteria as *effectiveness, efficiency* and *satisfaction* with which users are able to achieve their tasks.

There is a need to understand the effect of gamification mechanics, and elements, on different individuals (Codish & Ravid, 2014). Research has been done (Mekler et al., 2013) on how different elements of gamification affect human behaviour. However, additional research is required to investigate the elements that contribute to improved UX, usability and education usability, and the criteria that can be used for evaluating gamified systems (Ašeriškis & Damaševičius, 2014; Urh et al., 2015).

In our study, we identified the components of a gamification system, and the criteria that can be used for evaluating UX, usability and education usability of such a system. In addition, we developed and implemented the gamified system, within the context of a South African educational environment, in order to investigate the possible role of gamification in providing youth with knowledge about career choices in CS-related disciplines.

The next section discusses literature related to the gamification domain and proposes an extended gamification design classification framework. This is followed by a description of the research methodology used in the study, and then an outline of the usability evaluation's criteria and processes. The results of the evaluation are then outlined, followed by conclusions and recommendations for further study.

2. Components of gamification

The key to successful gamification is appropriate choice of elements of game mechanics to incorporate into the system (Meder & Jain, 2014). A theoretical model that is commonly used to describe how gamification works and the components that should be included in the design of a gamification system, is the Mechanics, Dynamics and Aesthetics (MDA) classification framework (Hunicke et al., 2004). The MDA framework enables one to consider the views of both the game's designer and player. The framework describes how the three layers (mechanics, dynamics and aesthetics) are perceived by designer and player on the grounds that both their perspective needs to be considered. Each of the three layers of the MDA framework can be thought of as a lens (i.e., perspective) on the game. Whilst the layers are separate, they are also causally linked. A small change in one of the three layers can impact on the other two. According to Hunicke et al. (2004), thinking about the player, who is the user, encourages experience-driven rather than feature-driven design. This approach is in line with the principles of UX, where devices are designed to fit the user and not the task (ISO, 2009). Accordingly, for the MDA framework discussion that follows, we give primacy to the user perspective, followed by that of the designer, beginning with aesthetics, and then moving on to dynamics and mechanics

Aesthetics

In the MDA framework, aesthetics refers to "the desirable emotional responses evoked in the player, when she interacts with the game system" (Hunicke et al., 2004). Users perceive aesthetic elements as ultimate goals that they would like to achieve from the system, while game designers use aesthetic elements to determine the emotional state generated by users. According to Raymer (2011), aesthetics correspond with the experiences of users and are intended to be fun. Schell (2015) refers to aesthetics as a combination of game mechanics and dynamics that produce emotions for the user from the game play. Goals are one aspect of aesthetics and need to be spread across the system as stages that the learner needs to complete by using their knowledge (Raymer, 2011). Aesthetics use game mechanics and dynamics to provoke an emotional response from the user. When describing the aesthetics of a game, it is necessary to use a more specific vocabulary than generalised words such as "fun" and "gameplay". Some examples of this vocabulary are:

- sensation: the game as a sense-pleasure
- fantasy: the game as make-believe
- narrative: the game as a drama
- challenge: the game as an obstacle course
- fellowship: the game as a social framework
- discovery: the game as unchartered territory (e.g., adventure/role-playing)
- expression: the game as self-discovery
- submission: the game as a pastime.

Each game pursues multiple aesthetic goals in varying degrees (Hunicke et al., 2004). For example, the computer game The Sims includes discovery, fantasy, expression and narrative, while the game of charades includes fellowship, expression and challenge. While both games are "fun", it is more informative to consider the aesthetic components that create the player experience. Reiners and Wood (2015) suggest that most games obtain the fun aspect from the thrill of the competition and challenge characteristics that have been incorporated. According to Reiners and Wood (2015), the inclusion of a social component/framework, or "fellowship", serves as a strong motivator for users to continue playing a game. Discovery relates to a sense of wonder that is experienced by the user when finding something new in a game and can include an adventure or role-playing scenario. Users can also often express themselves and their personalities through playing a game. Expression is sometimes referred to as "self-expression" and refers to allowing people the opportunity to express their uniqueness and differentiate themselves from others (Da Rocha Seixas et al., 2016). An example is the use of an avatar of a person. Submission focuses on developing an interaction whereby the game becomes a hobby for the user, instead of the user only playing the game once (Hunicke et al., 2004).

Dynamics

Dynamics are the "run-time behaviour of the mechanics acting on player inputs and each other's outputs over time" (Hunicke et al., 2004). Dynamics work to create the aesthetic experiences, and are the aspects of a game that develop and maintain a desired UX. A key dynamic model identified by Hunicke et al. (2004) is challenge, which can be initiated by elements like time pressure and opponent interaction. Urh et al. (2015) identify elements of game dynamics as: status, competition, achievement and response (Urh et al., 2015). Achievement physically represents an accomplishment, whereas a response is an action that is expected from a user (Schonfeld 2010). Dynamics can also be thought of as guaranteeing that the user will experience activity loops that include feedback, action and emotion (Ibáñez et al., 2014; Werbach & Hunter, 2012).

Mechanics

Mechanics are the "particular components of the game, at the level of data representation and algorithms" (Hunicke et al., 2004). Mechanics appear as rules of the game for users, while designers perceive them as indications of the user's actions. They are the agents and objects, as well as the elements and their relationships in the game. Examples of mechanics are the shuffling of the cards in a card game, or the balls, clubs and water hazards in a golf game.

According to Hunicke et al. (2004), together with the content of the game, mechanics support the game's overall dynamics. The mechanics' components can include both gaming elements and rules (Ašeriškis & Damaševičius, 2014). Gaming elements make the game challenging and satisfying for the user, whereas the rules are supported by the elements to create a sense of accomplishment for users trying to reach certain levels of achievement. For example, the element could be points and the rule would be the set of conditions required in order to be awarded the points.

Raymer (2011) explains that one needs to include feedback and rewards to develop a successful gamification learning system. Feedback is used to inform the learners of the progress that they have made, to prevent them from getting confused, and can also foster a player's engagement (Petrović & Ivetić, 2012). Rewards can be used as one type of feedback to acknowledge learners for their effort (Raymer, 2011). Codish and Ravid (2014) propose that mechanics that are used for feedback can be classified as either personal feedback (such as points, badges and rewards), or comparative feedback (such as progress bars and leader boards). The following components are examples of mechanics:

- points: represent achievements that are obtained (Beier, 2014; Iosup & Epema, 2014; Mekler et al., 2013; Schonfeld, 2010).
- levels: represent stages or milestones that a player has reached in a task (Hunicke et al., 2004). Levels can also be used to measure progress and accomplishment (Hunicke et al., 2004), and are a direct way of accumulating experience/points (Iosup & Epema, 2014).
- badges: are awarded on the successful completion of a task or challenge (Hunicke et al., 2004) and can serve as goals that users wish to achieve (Beier, 2014; Iosup & Epema, 2014).
- virtual goods (Urh et al., 2015): points can sometimes be used to purchase virtual items (Kim, 2015).
- multiple lives and life loss: are used to provide users with the sense of empowerment to experiment with different approaches, secure in the knowledge that if they get something wrong, they can try again (Kim, 2015; Reiners & Wood, 2015).
- stories: themes, stories or scenarios that implement the narrative aesthetics goal (Darejeh & Salim, 2016).
- leader boards and progress bars: are used to display a comparison of a user's achievements (Beier, 2014; Iosup & Epema, 2014; Werbach & Hunter, 2012).

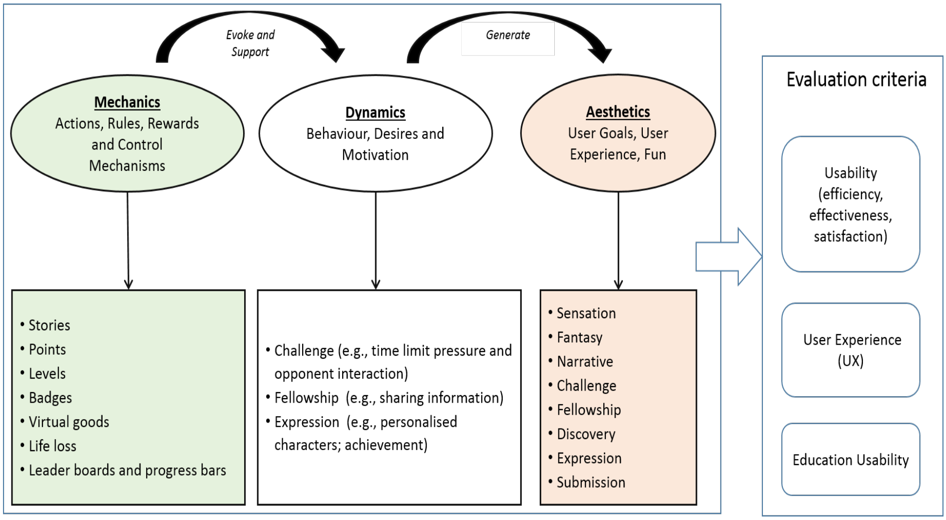
Several studies (Amir & Ralph, 2014; Codish & Ravid, 2014; Ibáñez et al., 2014; Zichermann & Cunningham, 2011) have incorporated the MDA framework into gamification systems. Some of these systems (Ibáñez et al., 2014) have been implemented in higher education contexts. Table 1 provides a summary of the elements recommended by several authors (Beier, 2014; Darejeh & Salim, 2016; Hunicke et al., 2004; Raymer, 2011; Schonfeld, 2010; Urh et al., 2015) for consideration for inclusion in a gamification system. These are classified according to the three MDA layers from the top down.

Table 1: Recommended gamification elements

Layer and component	Reference
Aesthetics	
Sensation, fantasy, narrative, challenge, fellowship, discovery, expression and submission	Darejeh and Salim (2016); Hunicke et al. (2004); Raymer (2011)
Dynamics	
Challenge (e.g., time pressure and opponent interaction) Fellowship (e.g., sharing information) Expression (e.g., achievement, personalised characters)	Darejeh and Salim (2016); Hunicke et al. (2004); Reiners and Wood (2015); Schonfeld (2010); Urh et al. (2015)
Mechanics	
Stories Points, levels, badges, virtual goods and multiple lives/life loss (personal feedback) Leader boards and progress bars (comparative feedback)	Beier (2014); Codish and Ravid (2014); Schonfeld (2010); Urh et al. (2015)

The MDA classification framework for gamification proposed by Hunicke et al. (2004) does not include criteria for evaluating these systems. Thus, we extended the framework (see Figure 1 below) to include evaluation criteria: (1) usability, in terms of efficiency, effectiveness and satisfaction (IS0, 1997); (2) UX (Beier, 2014; Deterding et al., 2011a; Knaving & Björk, 2013; Harpur & De Villiers, 2015; Urh et al., 2015) and (3) education usability (Harpur & De Villiers, 2015; Squires & Preece, 1999; Ssemugabi & De Villiers, 2010).

Figure 1: Extended MDA classification framework for gamification



Source: Adapted fromHunicke et al. (2004)

3. Research process and design

Questions and methodology

The primary research questions of our study were:

1. What are the components of gamification systems that improve usability, UX and education usability?
2. What are the UX, usability and education usability of students using a gamification system designed to improve knowledge of CS careers?

In order to answer these questions, a Design Science Research (DSR) methodology was used. The DSR methodology involves the procedure of designing an artefact to solve a problem, to contribute to research, to evaluate designs, and to deliver results to a suitable audience (Hevner et al., 2004). The DSR has been used in several learning studies, including use by El-Masri and Tarhini (2015) to develop a theoretical artefact (a set of design principles) for educational games. The artefacts of our study were the CS Careers gamification system that we developed, and our theoretical framework (the extended MDA framework outlined in Figure 1), which guided the design and evaluation of CS Careers. In line with the DSR methodology, we conducted several iterations for the literature review, the development of the artefacts, and the evaluation of these artefacts.

System design

Our extended MDA classification framework for gamification (Figure 1) was used to guide the design and development of the CS Careers system at Nelson Mandela Metropolitan University (NMMU), by one of the authors of this paper. CS Careers is an interactive, web-based system that contains information about a selection of CS careers. The system enables learners to view CS career content, perform a set of related pre-defined tasks and, as a result, earn a set of rewards (for example, points and badges) for the tasks that they successfully complete (Figure 3). The system therefore implements various gamification elements with the aim to motivate learners to use, and encourage their engagement and participation with, it, and ultimately improve their knowledge of CS careers. The MDA framework recommends deciding on aesthetics first, then design mechanics required to achieve the aesthetic goals, and finally dynamics.

The primary *aesthetics* goals of the CS Careers system were identified as expression, narrative, discovery and challenge. Expression was identified as a key goal since the objective of the game was to be a voyage of self-discovery to learn more about the various careers in the CS industry. The narrative goal was implemented by the job profiles and story created for each employee character that was presented to the user, either through audio or a text bubble. The discovery aesthetic related to the role of the player as one of the various employees in a typical IT office. Examples of these employees/characters in CS Careers are a Web Developer, Project Manager and/or Programmer. Challenge was incorporated into the design of the system by allowing the player to perform simple tasks that a typical CS employee would be expected to do. For example, as part of his/her job function, a Web Developer would need to know how to design a web page; thus that would be one of the tasks in the CS Careers system that the player would need to complete.

The *dynamics* elements of the MDA framework were implemented with the expression goal playing a key role in the form of personalised characters that represent the various employees in a typical IT office. The home page of the CS Careers system is the environment of a typical IT department or IT company. The users can explore this IT office environment and interact with each of the employees in various locations of this environment. Each character encounters "challenges" that are linked to a specific set of tasks that are typical of that employee (e.g., Web Developer), and these tasks are activated by clicking on or hovering over the employee. For example, the Project Manager's tasks require the user to select the various activities necessary for IT project planning. If the user selects the correct activities in the right order, he/she is rewarded with various gamification elements and in this way the achievement goal is supported.

The *mechanics* elements of the MDA framework were implemented in CS Careers through points, badges and life loss. The user can earn points for each office area visited and badges for each set of tasks completed, but loses a life for each unsuccessful task attempted. As determined by the MDA framework, the success or failure of these tasks and the use of the MDA mechanics are then expected to result in emotions experienced by the user in the aesthetics layer. For example, a reward such as a badge will provide the user with recognition for the correctness of his/her actions and contribute to the challenge aesthetic. He/she can also view the recreational area of the office environment, which displays a summary of his/her achievements based on the results of tasks performed in the system.

Figure 2: CS Careers home page

In accordance with the iterative nature of DSR, an evolutionary prototyping process was applied to the design and development of the CS Careers system. Formative evaluations were performed during the process, on the basis of which the prototype was improved over three iterations, before the fourth and final one was developed. The final prototype was then evaluated by means of a final summative usability evaluation involving NMMU students, as described below, for which ethical clearance was obtained from NMMU.

Usability evaluation

Participants, environment, procedures

No fewer than eight participants should be involved in a usability study to ensure that valid summative statistical analyses are produced (Scholtz, 2000). For this reason, 12 students at NMMU were selected to participate in the usability evaluation. Systematic sampling was used, whereby a specific sample of participants was identified (Tullis & Albert, 2013), based on the criteria of age and programme of study. Students between the ages of 18 and 20 years were selected to represent the target group of the study. (Studies have shown that early adults are those between 17 and 22 years of age, and that it is during this stage that they make choices about adult life, such as career choices (Levinson, 1994). Since the intended users are scholars in the final year of high school who are in the process of making a career choice, the age profile of the selected participants was similar to the intended profile of the user). It was assumed that the students enrolled for the CS qualifications at NMMU would be more familiar with the content of the CS Careers site. Therefore, the sample of participants included non-CS students in order to avoid bias towards CS students. The participants were first-year students from the Departments of CS and Business Management at NMMU.

For the purpose of evaluation, participants were required to complete five tasks on the CS Careers system. (They were required to complete an online consent form prior to the commencement of performing the list of tasks.) The evaluation was conducted in the controlled setting of a computer laboratory situated in the NMMU CS Department, as a controlled setting allows the evaluator to control the users' activity while using a system (Rodgers et al., 2011). The participants were encouraged to ask the evaluator (who is one of the authors of this article) for assistance should they require any throughout the evaluation.

Instruments, metrics

The objective of the summative usability evaluation was to evaluate the (1) usability, (2) UX and (3) education usability of the system, in terms of the extended MDA framework (Figure 1).

In order to measure usability, two metrics were recorded by the evaluator: effectiveness and efficiency. Task success was used as a measure of effectiveness, and time-on-task was used to measure efficiency (Tullis & Albert, 2013). Task success was based on how many of the tasks were successfully completed by each participant. Participants were informed that they were being monitored but were not given any time constraints for completion of the tasks. They were asked to write down answers to certain questions on a printed task list. The correctness of these answers as well as the scores they obtained for each task within CS Careers determined their task success. Time-on-task was measured to determine the amount of time the participants took to complete the set of tasks.

For evaluation of UX and education usability, we initially considered using the Learning Object Review Instrument criteria (Leacock & Nesbit, 2007). This was then rejected, because it did not address aspects of engagement and motivation, which we had determined needed to be measured to ascertain the success of a gamification system. Harpur and De Villiers (2015) propose criteria specifically designed to evaluate learning environments, and their criteria incorporate aspects of UX and education usability. Accordingly, we adopted a subset of the Harpur and De Villiers criteria for the evaluation: four UX criteria (and their sub-criteria) and three education usability criteria (and their sub-criteria), as outlined in Table 2 below.

Table 2: UX and education usability criteria and sub-criteria

User experience (UX)
1. *Emotional issues*
1.1. The tasks within the system are motivating to learn more about CS careers
1.2. The tasks within the system are fun
1.3. The system encourages participation
1.4. This way of learning about CS careers is exciting
1.5. This way of learning about CS careers is interesting
2. *User-centricity/engagement*
2.1. The gamification elements enhanced my engagement with the system
2.2. The visual representations of the CS roles enhanced my engagement with the system
2.3. The auditory information about the CS roles enhanced my engagement with the system
2.4. The textual information about the CS roles enhanced my engagement with the system
3. *Appeal*
3.1. I was encouraged to explore the system
3.2. The experience was visually appealing
4. *Satisfaction*
4.1. The experience added fun to the learning opportunity
4.2. This way of learning about CS careers is motivating
4.3. A satisfying sense of achievement was felt
4.4. The system encouraged me to engage with the content
Education usability
1. *Clarity of goals, objectives and outcomes*
1.1. The goals are clearly set out and objectives and expected outcomes for learning are clear
2. *Error recognition, diagnosis and recovery*
2.1. Mistakes can be made, affording users the chance to learn from them
2.2. Help is provided to recover from errors
3. *Feedback, guidance and assessment*
3.1. Prompt feedback on assessment and progress is provided
3.2. Guidance is provided about the tasks and construction of knowledge going on
3.3. Activities are graded with grades providing instant feedback and correction

Source: Adapted from Harpur and De Villiers (2015)

The criteria selected from Harpur and De Villiers (2015) for the UX category were those oriented towards the ability to induce the emotive experiences of the user, namely (1) *emotional issues*, (2) *user-centricity/engagement*, (3) *appeal,* and (4) *satisfaction*.

According to Harpur and De Villiers (2015), *emotional issues* can be measured by the level of motivation, fun, participation, excitement and interest the users experience by performing the tasks within the system. The emotional aspect is also supported by the aesthetics layer in the MDA framework, which relates to the "emotional response" of the user (Hunicke et al., 2004). *User-centricity* relates to the user's personal judgment of the system and its components (Harpur & De Villiers, 2015). Another important criterion for evaluating gamification, related to user-centricity, is the level of *engagement* (Barata et al., 2013; Beier, 2014; Burke, 2014; Petrović & Ivetić, 2012). While there is evidence that gamification improves student engagement, this is not a guarantee of success and is one of the main challenges of gamification design (Ibáñez et al., 2014). Deterding et al. (2011a) explain that gaming elements can create an experience (UX) the user desires, and can also motivate user engagement while performing an activity. Therefore, the use of these elements can be used as an expedient approach for making gamification systems engaging and enjoyable to use. Other studies have also reported the successful adoption of gamification in learning environments by identifying increased engagement from learners with the learner tasks (Darejeh & Salim, 2016; Da Rocha Seixas et al., 2016; Ibáñez et al., 2014). User engagement contributes towards a motivated UX around the functionality and content of the system (Barata et al., 2013; Browne et al., 2014). However, gamification designers should provide a facility for educators to control the level of student engagement, in order to strike a balance between playfulness and educational needs (El-Masri & Tarhini, 2015). In other words, the game should acquire high task engagement from the player, but without complete immersion or addiction to the game. Game addiction refers to a pathological use of the game, while high engagement is defined as the non-pathological usage that can be controlled by the user. The researchers of this study therefore propose that engagement can be used as a criterion of UX for evaluating gamification systems. The impact of the gamification elements implemented in the design (for example visual, auditory and textual information) on the user's engagement with the system can be measured using criteria related to *user-centricity* and *engagement*.

Appeal can be measured by the user's opinion of visual elements and aesthetics of the system's user interface (Harpur & De Villiers, 2015). *Satisfaction* can be measured by the user's feelings of fun, motivation and achievement. In this way, the success of using gamification elements to encourage engagement and ultimately a motivated UX can be measured by these four categories.

In order to measure education usability, the criteria we took from Harpur and De Villiers (2015), were those focused on the relationship between the learning objectives and the content of the system, namely: (1) *clarity of goals, objectives and outcomes*, (2) *error recognition*, *diagnosis and recovery*, and (3) *feedback, guidance and assessment* (Harpur & De Villiers, 2015, p.10).

According to Ssemugabi and De Villiers (2010), effective feedback, guidance and assessment should be provided to the learner for the ultimate adaptation of learning content. The use of feedback as one of the criteria supports Petrović and Ivetić's (2012) argument that a learner's engagement can be fostered through providing the learner with feedback on progress.

The participants were required to rate each of the 21 statements (see Table 3 below) in the two categories (UX and education usability) from 1 to 5 (Likert scale), where 1 represented "strongly disagree" and 5 represented "strongly agree". The questionnaire also included two open-ended questions, which were used to allow the participants to express their opinions by stating the three aspects they found best, and the three aspects they found worst, about the system. In this way, both closed- and open-ended qualitative data were collected.

4. Evaluation results

Participant biographical information

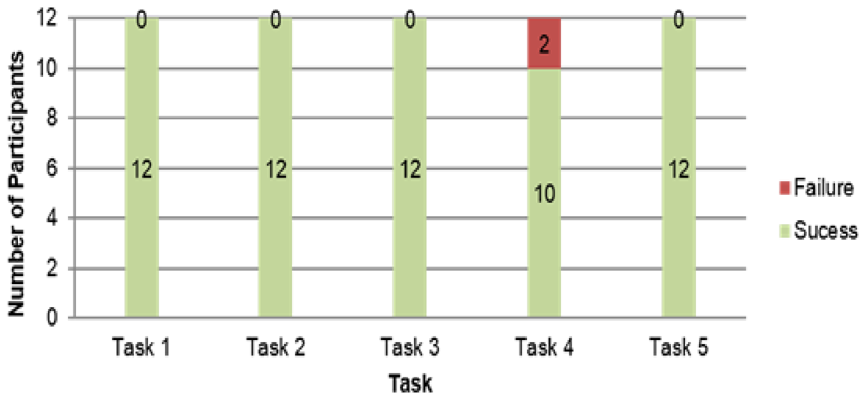
The participant sample consisted of 12 students, with an equal number of males and females. The majority (67%) of the participants were enrolled for CS qualifications, while the remaining students were enrolled for a business degree at NMMU.

Usability results: Effectiveness (task success) and efficiency (time-on-task)

A binary scale (1 = task success, 0 = task failure) was used to measure effectiveness. Task success is sometimes referred to as the completion rate of a task and is a fundamental usability metric (Tullis & Albert, 2013). This scale requires two different values to be assigned in a task: one for success and the other for failure. If users cannot accomplish their goals or tasks, then nothing else really matters. In this study successful completion meant that they could complete the task in the CS Careers system with or without assistance from the test facilitator. The success of Task 1 was measured by the participant's ability to open the provided link and navigate to the landing page of the CS Careers system. The participant passed Task 2 if he/she managed to complete Task 2 and proceed to Task 3. The success of Tasks 3, 4 and 5 were obtained by measuring correctness of the answers provided on the printed task list.

The only task that did not have 100% success was Task 4 (Figure 3 below). Task 4 had an 83% success rate, because two participants could not complete certain elements of the task. Task 4 required completion of all tasks within the system related to the role of CS employees. The participants were required to obtain a certain score in order to pass Task 4. The two participants who did not obtain the required score were not enrolled for a CS qualification and it could be deduced that these tasks were too difficult for this student profile.

Figure 3: Effectiveness (task success vs failure)



Efficiency (time-on-task) was measured by the amount of time (in minutes) it took for each participant to complete the entire task list. It was found that the longest a participant took to complete the tasks was 23 minutes. The least amount of time that a participant took to complete all of the tasks was 11 minutes. The average time that the participants took to complete the tasks stipulated was 15.6 minutes. This average time was considered acceptable, because it was less than the reasonable expected time (calculated by multiplying an expert's task time by 1.5). Therefore, it can be deduced that most of the participants were able to efficiently perform the tasks.

UX and education usability results

When analysing the Likert scale ratings for UX and education usability, the following statistical ranges were applied: negative (1 to 2.6), neutral (2.6 to 3.4), and positive (3.4 to 5). Each criterion's score was generated by averaging the statement scores for that criterion.

All four criteria in the UX category were rated positively. The criterion in the UX category that received the highest overall mean rating was *appeal* (μ=4.7) (Figure 4 below). The remaining three criteria for UX all received the same overall mean rating (μ=4.4). The positive results for the *appeal* category indicate that the participants found the experience visually appealing.

In the education usability category, all three criteria were rated positively (Figure 5 below). The criterion *clarity of goals, objectives and outcomes* received the highest overall mean rating (μ=4.7) in the education usability category, whereas the lowest-rated criterion was *error recognition, diagnosis and recovery* (μ=4.3).

Figure 4: User experience (UX) criteria results

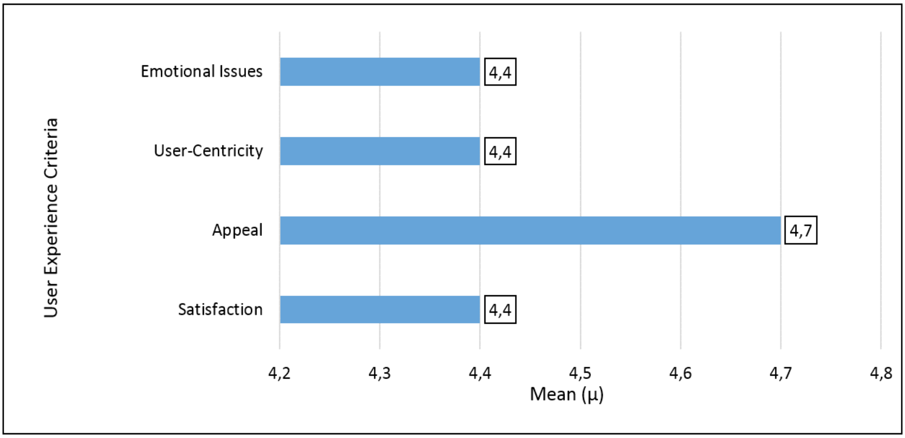
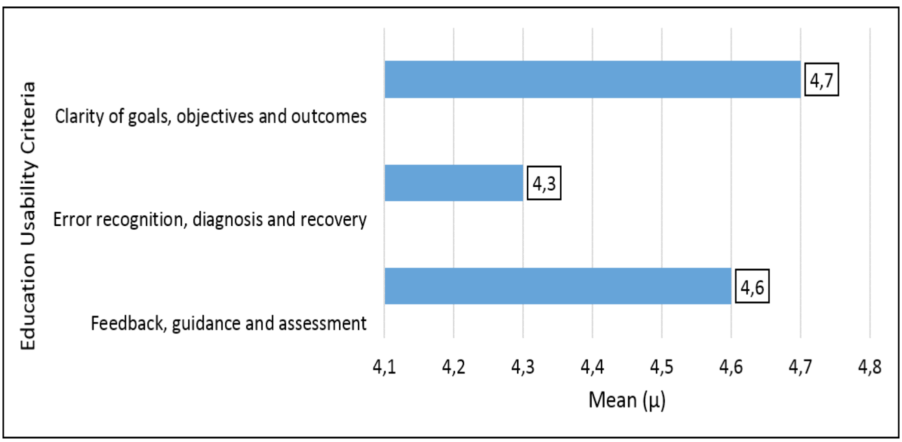


Figure 5: Education usability criteria results



All 21 of the sub-criterion statements – across the four UX criteria and three education usability criteria – had mean ratings in the positive range (see Table 3 below). In the UX category, the statement that obtained the highest positive response was "The experience was visually appealing" (μ=4.9), which falls under the *appeal* criterion. This result confirms the Harpur and De Villiers (2015) contention that visual appeal is an important criterion for evaluating UX. The second-highest-ranked statement (μ=4.8) in the UX category was "The gamification elements enhanced my engagement with the system", under the *user-centricity/engagement* criterion. The third-highest-ranked response (μ=4.7) in the UX category was for the statement "The experience added fun to the learning opportunity", under the *satisfaction* criterion. The participants also provided positive feedback (μ=4.6) in response to the statement "The visual representations of the CS roles enhanced my engagement with the system", under the *user-centricity/engagement* criterion. These positive responses confirm studies (Barata et al., 2013; Browne et al., 2014; Ibáñez et al., 2014) stating that gamification influences user engagement.

Table 3: UX and education usability sub-criteria results

User experience (UX)	Mean (μ)	Std. Dev. (σ²)	Min.	Max.
Emotional issues				
The tasks within the system are motivating to learn more about CS careers	4.2	0.39	4	5
The tasks within the system are fun	4.3	0.45	4	5
The system encourages participation	4.6	0.67	3	5
This way of learning about CS careers is exciting	4.4	0.67	3	5
This way of learning about CS careers is interesting	4.5	0.67	3	5
User-centricity/engagement				
The gamification elements enhanced my engagement with the system	4.8	0.45	4	5
The visual representations of the CS roles enhanced my engagement with the system	4.6	0.51	4	5
The auditory information about the CS roles enhanced my engagement with the system	3.8	1.03	2	5
The textual information about the CS roles enhanced my engagement with the system	4.3	0.78	3	5
Appeal				
I was encouraged to explore the system	4.5	0.52	4	5
The experience was visually appealing	4.9	0.29	4	5
Satisfaction				
The experience added fun to the learning opportunity	4.7	0.49	4	5
This way of learning about CS careers is motivating	4.2	0.39	4	5
A satisfying sense of achievement is felt	4.3	0.65	3	5
The system encouraged me to engage with the content	4.5	0.52	4	5
Education usability				
Clarity of goals, objectives and outcomes				
The goals are clearly set out; objectives and expected outcomes for learning are clear too	4.7	0.49	4	5
Error recognition, diagnosis and recovery				
Mistakes can be made affording users the chance to learn from them	4.6	0.51	4	5

Help is provided to recover from errors	4.1	0.90	3	5
Feedback, guidance and assessment				
Prompt feedback on assessment and progress is provided	4.5	0.80	3	5
Guidance is provided about the tasks and construction of knowledge going on	4.5	0.52	4	5
Activities are graded with grades providing instant feedback and correction	4.8	0.45	4	5

Within the *user-centricity/engagement* criterion of the UX category there were two statements related to textual and auditory presentation of the content. The participants rated the statement related to textual information, "The textual information about the CS roles enhanced my engagement with the system", higher (μ=4.3) than the statement "The auditory information about the CS roles enhanced my engagement with the system", which obtained the lowest mean rating (μ=3.8). Therefore, it can be deduced that the audio information within CS Careers was not completely successful in enhancing the participant's engagement with the system.

In the education usability category, the highest-rated statement (μ=4.8) was obtained from the statement "Activities are graded with grades providing instant feedback and correction", which is a metric of the *feedback, guidance and assessment* criterion. This confirms the findings of studies by Petrović and Ivetić (2012), who found that a learner's engagement can be fostered through feedback. The second-highest-ranked statement in the education usability category was "The goals are clearly set out, objectives and expected outcomes for learning are clear too" (μ=4.7). These results indicate that the system successfully provided the learners with the necessary learning outcomes, guidance, and feedback required to perform the tasks.

Results from responses to open-ended questions

The responses to the two open-ended questions at the end of the questionnaire - requiring the participants to list the three best and worst aspects of the CS Careers system - were analysed using thematic synthesis (Thomas & Harden, 2008). Based on the thematic synthesis, the participant responses were grouped and assigned to a set of positive and negative aspect categories. Thereafter, a frequency count (f) for each theme was calculated, in order to determine which aspects were most frequently mentioned by the participants.

In Table 4 below, the themes, frequency counts and sample comments are tabulated according to the most positive aspects of CS Careers. A total of seven themes were identified within the positive aspects category. The three most frequently identified positive themes were (1) *visual appeal and design* (f=10), (2) *CS career knowledge* (f=8) and (3) *gamification* (f=5). Out of the 12 participants, 10 reported positive issues related to the aesthetics of CS Careers and the *visual appeal and design* theme. The CS career knowledge theme related to improvement of knowledge of CS careers and the majority (eight out of 12 participants) made comments confirming that their knowledge was improved. The high count of comments in the *visual appeal and design* theme confirms the results of a positive (μ=4.9) response that was provided by the participants for the UX *appeal* criterion. One participant stated that "The game looked appealing". Another stated that he/she enjoyed learning about the job descriptions of the different careers in the CS field. *Ease of use*, *characters*, *feedback* and *audio* were the other aspects that the participants praised about the system. Two of the participants reflected positively on the feedback provided by the system, which confirmed the above-mentioned contention that learners' engagement can be fostered through feedback (Petrović & Ivetić, 2012). This response was also supported by the overall positive rating (μ=4.6) that the participants provided for the *feedback, guidance and assessment* criterion under education usability.

Table 4: Positive aspects of CS Careers

Theme	Frequency count (*f*)	Sample Comments
Visual appeal and design	10	"The game looked appealing."
CS career knowledge	8	"The fact that I learned more about the job descriptions of the different careers in the computer science field."
Gamification	5	"The gamification made the task of answering questions more fun than it normally would've been."
Ease of use	3	"Easy user interface."
Characters	3	"Fun characters that portray the different employees."
Feedback	2	"The instant feedback about each task and being able to access a report sheet."
Audio	2	"The audio in the programme was good."

As shown in Table 5 below, a total of seven themes were identified by participants as negative aspects of the CS Careers system. And it was found that most of those listed by the participants related to the CS employee *tasks* (f=6). One participant stated that "Some tasks were not explained well enough". Other negative aspects were associated with the *audio* (f=5), *information* (f=4) and *level of difficulty* (f=4) of CS Careers. One participant suggested that "The sound aspect of the game could have been better". This response could be seen as contradicting the positive mean rating for the statement "The auditory information about the CS roles enhanced my engagement with the system" under the UX *user-centricity* criterion, but it should at the same time be recalled that the *audio* statement was rated the lowest (μ=3.8) among the four sub-criterion statements used to measure *user-centricity*.

Table 5: Negative aspects of CS Careers

Theme	Frequency Count (*f*)	Sample Comments
Tasks	6	"Some tasks were not explained well enough."
Audio	5	"The sound aspect of the game could have been better."
Information	4	"Life loss is unclear."
Level of difficulty	4	"The game was quite short and relatively easy."
Instructions	3	"Instructions not so clear."
Task discovery/navigation	3	"The tasks were difficult to find."
User error	2	"Allow room for user error."

The citing of *level of difficulty* as a negative dimension could also been seen as slightly contradictory, given that four participants stated that they found the game too short and the tasks too easy. However, one of the participants not enrolled for either a CS or IT qualification stated that the questions within the system required IT knowledge. (During the formative evaluations, the experts from NMMU who evaluated the system highlighted that certain tasks might be too difficult for non-CS students. For this reason, some of the tasks were reduced in complexity.). *Task discovery* and *user error* were the remaining negative aspects that were identified in the participants' comments. For example, one participant stated that "The tasks were difficult to find."

5. Conclusions and recommendations

Our research results suggest that gamification could be a worthwhile tool for deployment in response to the demand from employers for CS skills and the resulting need for enhanced knowledge of CS-related careers among the youth.

The CS Careers system was designed and evaluated according to the elements of our extended MDA gamification classification framework. All three evaluation criteria - usability, UX, and education usability - received generally favourable ratings by the usability evaluation participants, suggesting that the gamification elements enhanced the CS Careers system. These results provide additional support for the findings of Browne et al. (2014) and Da Rocha Seixas et al. (2016), and suggest that the MDA framework is useful in guiding design of a gamification system with an educational intent. The study also showed that both difficulty level and task creation are critical parts that should be carefully considered in the design process in gamification systems for education purposes. Another area found to be important for designers of gamification for learning is audio. The results showed that the participants preferred textual over auditory information about the employees/roles. Additional studies should be conducted in order to determine the reasons for this and the specific design criteria for auditory learning objects. The role of video could also be investigated.

Designers of gamification systems for career learning can potentially use findings from this study to guide their efforts to optimise usability, UX and education usability.

Future research could extend the study into other contexts, and also investigate the longitudinal implications of gamification systems for career knowledge and advice. And more detailed analyses of the relationships between specific gamification elements and usability, UX and education usability criteria could also be attempted.

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