DOI NUMBER· 10.19255/JMPM01507

KEYWORDS
Project management • Project crashing • Serious games • Game-based learning • Simulation • Training, education • Complexity • Learning method preference • Learning style.

DAVID RUMESER
• Indonesia
• PT Pelabuhan Indonesia II
• The University of Manchester
• *david.rumeser@postgrad.manchester.ac.uk*

MARGARET EMSLEY
• United Kingdom
• The University of Manchester
• *margaret.emsley@manchester.ac.uk*

PROJECT MANAGEMENT SERIOUS GAMES AND SIMULATION:

A comparison of three learning methods

• ABSTRACT •

Background. Despite the popularity of applying serious games in project management education and their potential advantages in simulating complexity, their value compared to other methods is uncertain. Few studies compare project management games with other methods, and still fewer investigate how the increased project complexity levels in games affect the learning experience.
Aim. This study aims to examine students' preferred learning method when selecting between project management games and a simulation exercise. It also evaluates whether games which simulate more complex projects are preferred over those with less complexity. It further analyses the underlying reasons (i.e. mentioned and unmentioned) behind students' preference.
Methodology. An empirical study was conducted on a group of Master's degree students majoring in management of projects. Students were taught project crashing (acceleration) principles by implementing three learning methods. Their feedback in terms of preferred learning method and learning style was gathered using an online questionnaire.
Results. This research finds that there is no dominant preferred learning method between the games and the simulation exercise. Students who prefer the project management games tend to value fun, attractiveness and teamwork. Those who prefer the simulation exercise tend to value clarity and accessibility. Furthermore, the game that simulates a more complex project is preferred over the less complex one, as the first offers a desirable unique experience, which is complex, challenging and realistic, which the latter does not. Finally, this study also finds that students' learning style (i.e. intuitors vs sensors) affect their project management learning method preference.

1.INTRODUCTION

Serious games (SGs) offer a strong value proposition to Project Management (PM) educators as they have 'the advantage of enabling participants to be put into complex, realistic project situations …' (Al-Jibouri, 2005). PM education needs this since it struggles to educate project managers and team members to cope with the actual complexity in projects (Thomas & Mengel, 2008). Unlike in engineering or other technical subjects, PM students will probably not have the opportunities to implement their knowledge in practice (Al-Jibouri & Mawdesley, 2001). The implementation of SGs in PM education enables an experiential learning process without exposure to the costs and risks associated with real projects (Dantas, de Oliveira Barros, & Werner, 2004). In the words of Peter Drucker (Drucker, 1974), 'management is a practice not a science', thus management subjects should be learned through experience (Spowage, Chin, Chan, Ting, & Ieee, 2008). If conducted appropriately, the application of SGs can also contribute in developing intangible PM skills, such as communication and leadership, which are difficult to teach by traditional lecture-based methods (Khenissi et al., 2016).

Despite the vast number and variety of PM games and the potential benefits they offer to model project complexity, it is still uncertain whether they are effective and efficient educational methods (Al-Jibouri & Mawdesley, 2001). The problem is there are very few studies which compare one PM game with other PM games, or with other learning methods (e.g. simulations). One of the few is Martin's (2000a) work which compares a PM board game and a computer-based one. He finds that the computerised version appears to be a better tool for teaching, but the board game provides more social interaction for the participants. The fact that most PM SGs researchers evaluate their games in an isolated manner, and that most, if not all, conclude that their games are effective learning methods, could create a misinterpretation that games are the most effective and preferred learning methods in PM education. The question is, of course, are they?

Furthermore, comparing games with different levels of project complexity is crucial since simulating complexity of projects is the main motivation of SGs application in PM education. Raia's (1966) empirical work, conducted in a business (i.e. sales, production and finance) context, states that 'learning experience is not directly proportional to the degree of complexity of the simulated environment'. Wolfe (1978) considers decision types, number of decisions and executable computer program statements as elements of game complexity. His work suggests that although increased complexity in games is identical with greater decision-making comprehensiveness, increased challenge and lesser monotony, they are not directly proportional to the level of learning. Both Raia's (1966) and Wolfe's (1978) works, however, do not consider the interaction between teams as an element of increased complexity. In PM, this assumption is far from realistic as most projects (and project teams) are interrelated with each other within a collection of projects, often referred to as programs (Aritua, Smith, & Bower, 2009).

The unanswered question as to whether different PM learning methods and increased levels of simulated project complexity affect students' learning experience motivates us to compare three computer-based learning methods which we developed, namely: Project Crashing Game (PCG), Program Crashing Game (PgCG) and Project Crashing Simulation Exercise e-Learning (PCSEL). Our research questions are as follows:

(a) Do students prefer the serious games (the crashing games) or the simulation exercise (the PCSEL)?

(b) Do students prefer the less complex PM game (the PCG) or the more complex one (the PgCG)?

(c) What are the factors affecting students' preferences for (a) and (b)?

Research question (a) is aimed at comparing PM games to another learning method (i.e. simulation exercise). Research question (b) is aimed at comparing a PM game to a similar but more complex one. Research question (c) is aimed at investigating the underlying reasons behind students' preferences for both (a) and (b).

In addition, as there may be "umentioned" or latent reasons that can explain students' preferred PM learning methods, we also investigate the effect of students' learning style on their preference.

2. LITERATURE REVIEW

--- 2.1 Games, simulations, serious games ---

There is an interesting discussion in the literature on the use of the words games and simulations. Lundy (2003) suggests that the main difference between a game and a simulation is its main purpose. Games are for pure entertainment while simulations are for skill building. To learners, games may sound more appealing, although perhaps in the absence of learning (K. Jones, 1989; Lane, 1995). Simulations, on the other hand, typically support learning specific content (Martin, 2000) and they stress a more thoughtful and academic task (K. Jones, 1989). Simulations offer learners an opportunity to act and reflect which is not always inherent in a gaming or 'pure play' environment (Callanhan, 1999). In general, games are focused on competition and winning (Abt, 1968), whereas simulations are centred on the complex problems and real-life goals which a company has to cope with on a daily basis (Callanhan, 1999). Due to their competitive nature, games typically involve scoring, whereas most simulations do not have scoring (J. K. Jones, 1973). Games are primarily people-oriented, whilst simulations are primarily computer-centred (Shubik, 1983) as games are considerably more interactive compared to simulations (Lane, 1995).

Serious games (SGs) or educational games sit somewhere between games and simulations. Unlike pure games, SGs are designed not only for entertainment (Hendrix, Al-Sherbaz, & Victoria, 2016). These games are designed for learning and behaviour change purposes (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012). More specifically, SGs help participants to learn about a particular subject, assist them in learning new skills, expand existing concepts and reinforce development as they play (Dempsey, Lucassen, & Rasmussen, 1996). Similar to simulations, SGs model real world problems (Calderón & Ruiz, 2015). They can have multiple interactions, such as the Virtual Construction Negotiation (VCON) game (Yaoyuenyong, Hadikusumo, Ogunlana, & Siengthai, 2005), or they can only be played individually, such as the Virtual Construction Simulator (VCS) game (Nikolic, Lee, Messner, & Anumba, 2010). **Table 1** synthesises the characteristics of pure games, serious games and simulations.

The crashing games (PCG and PgCG) discussed in this study are more associated with serious games than with simulations and pure games. They offer players the opportunity to communicate, compete and learn (i.e. act and reflect) in a fun way. The simulation exercise e-Learning (PCSEL), on the other hand, is much less about fun and much more about learning. This simulation exercise does not offer interaction between learners. Both the PM learning methods (i.e. serious games and simulation) simulate some degree of complexity in a real project.

Characteristics	Games	Serious Games	Simulations
Main Objective	Pure entertainment (Lundy, 2003)	Learning and behaviour change (Connolly et al., 2012; Dempsey et al., 1996)	Learning and skill building (K. Jones, 1989; Lundy, 2003; Martin, 2000)
Learning mechanism	None	Action-reflection (Callanhan, 1999; Von Wangenheim, Savi, & Borgatto, 2011)	
Focus	Winning, competition, and fun (Abt, 1968)	Complex, real-life situations, and fun (Al-Jibouri & Mawdesley, 2001; Calderón & Ruiz, 2015)	Complex, real-life situations (Callanhan, 1999)
People or Computer Oriented	People centred (Lane, 1995; Shubik, 1983)	Can be both people and computer centred or a mixture of these (Nikolic et al., 2010; Yaoyuenyong et al., 2005)	Computer centred (Lane, 1995; Shubik, 1983)

TABLE 1. Comparison of games, serious games and simulations

--- 2.2 Project complexity and project management serious games ---

2.2.1 Project complexity

Project management (PM) is 'the application of knowledge, skills, tools and techniques to project activities to meet the project requirements' (PMI, 2013, p. 4). It is about making something complex happen on time, within budget and to specification through other people (Dh, 1987). Project complexity is a key theme in PM literature since projects have become more complex and managing complexity has become a key requirement to avoid failure in managing projects (Bakhshi, Ireland, & Gorod, 2016).

Project complexity is characterised by several factors. First, it correlates positively with ambiguity or uncertainty (Cicmil & Marshall, 2005). Complexity is determined by how well-defined the goals and delivery methods are (Turner & Cochrane, 1993). It is directly proportional to the degree of the interaction between project elements and number of activities and decisions in the project (Aritua et al., 2009; Bakhshi et al., 2016; Vidal & Marle, 2008). In programs (i.e. collections of projects), complexity increases due to the interactions between multiple projects within the programs as well as between the elements within the projects (Aritua et al., 2009). This is crucial since most projects are delivered in a multi-projects context (Payne, 1995).

In this study, the complexity levels of the simulated projects in the crashing games are intentionally differentiated in order to investigate whether students prefer the more complex or the less complex game. The Program Crashing Game (PgCG) models a multi-projects scenario where each project interrelates with other projects. In this game, each project team needs to communicate with other teams to achieve the objective of the game. Therefore, it is more complex compared to the PCG which only simulates a single project. A more detailed explanation on the characteristics of both PM learning methods is provided in Section 3.2.1.

2.2.2 Project management serious games

To deliver a PM education which models real-life project complexity, many studies propose the application of SG. The Project Scheduling Game (Vanhoucke, Vereecke, & Gemmel, 2005) models the complexities in real-life project scheduling. The focus of the game is on the time/cost relationship for project activities and on problems of critical path network. Shtub (2005) proposes a scheduling game (i.e. under resource constraints) for both single- and multi-project environments. The Incredible Manager game (Barros, Dantas, Veronese, & Werner, 2006) is another game that simulates project planning and control.

In another game, Maratou et al. (2014) simulate collaboration of teams in confronting risk events which occur in project execution. The game had a positive impact on improving players' collaboration. The Project Execution Game, developed by Ofer and Amnon (2007), is another game which simulates risk events occurring in project execution. This game is perceived as effective in teaching the unstructured area of project execution. Von Wangenheim et al. (2011) evaluate DELIVER!, a game designed to train participants in measuring and controlling project performance by implementing the Earned Value Management technique.

An interesting phenomenon is that most of the games focus on the project planning and control phase. This is aligned with the fact that these two phases are crucial in determining the success of a project (C. Jones, 1996). The PM learning methods proposed in this study also focus on these two phases. Furthermore, it sharpens the focus of existing studies by simulating a specific planning and control problem (i.e. project "crashing" or acceleration) as crashing has been a "business as usual" need in PM practice due to the fact that most projects are behind schedule (Gerk & Qassim, 2008).

--- 2.3 Learning method evaluation ---

Due to the complexity of effective learning concepts, a single mechanism to measure learning method effectiveness and efficiency perhaps does not exist (Harris, 1998). Raia (1966) proposes several evaluation criteria to measure the effectiveness of a learning method: knowledge and skills, interest and motivation, and attitude. In line with this, Norman and Spohrer (1996) suggest that the traditional evaluation method of measuring pre- and post-tests is not necessarily appropriate as it

does not take account of the depth of understanding and acquired skills. Kirkpatrick and Kirkpatrick (2006) propose four evaluation criteria: reaction (i.e. how the learner felt about their learning experience), learning (i.e. knowledge and capability improvement), behaviour (i.e. implementing learning on the job) and result (i.e. students' learning impact on the environment).

This study compares several PM learning methods (i.e. PCG, PgCG, and PCSEL) by evaluating students' learning method preference. Although the preferred learning method may not be their most effective way to learn (Kirschner, 2017), providing the right method for the right person could lead to a better learning experience (Khenissi et al., 2016), and therefore could enhance students' motivation to learn. Motivation is a key factor as it may be the difference between success and failure in learning (Norman & Spohrer, 1996). Moreover, the choice of learning method preference as the evaluation criteria enables us to build on Raia's (1966) work, which suggests that students strongly prefer games as an instructional aid to other methods.

--- 2.4 Learning style: definitions, controversies and types ---

Learning style is a preferred method of an individual in acquiring, retaining and processing information (R. M. Felder, 1988). It can also be defined as the preferred way of an individual in gathering, processing and putting data for later use with regards to 'concrete experience, reflective observation, abstract conceptualization and active experimentation' (Kolb, 1976).

Some studies (Kirschner, 2017; Rogowsky, Calhoun, & Tallal, 2015) question the usefulness of learning styles as research suggests that there is a lack of proof of the relationship between learning styles and learning effectiveness. Nevertheless, Khenissi et al. (2016) argue that in game-based learning, providing the right method for the right person could lead to a better learning experience and increased learning motivation. While it may not contribute directly towards the effectiveness of learning, learning style is arguably an important factor in driving learners' motivation to learn, which is a key principle to designing a game (Chua & Balkunje, 2012).

Among various proposed models of learning style, there are only a few that have been implemented in computer-based learning and which have been tested for both validity and reliability (Khenissi et al., 2016). The Felder-Silverman Index of Learning Style (ILS) is one of the few and it is regarded as a generalised model. This model is synthesised from several studies and represents elements of most of available learning style models (Soflano, Connolly, & Hainey, 2015).

The ILS model consists of four dimensions: active vs reflective, intuitive vs sensing, global vs sequential, and visual vs verbal. The characteristics of each dimension are described below (Richard M. Felder & Soloman, 2000):

- Active learners understand and retain knowledge better by performing tasks (e.g. discussing or explaining them to others). They prefer working in groups. Reflective learners tend to think through the problems first and work independently or with someone close.

- Sensing learners (sensors) learn best from factual data. They prefer well-established methods as opposed to complexities and surprises. This type of learner prefers details and hands-on work. Intuitive learners (intuitors), on the other hand, like to discover relationships and possibilities. They tend to be better at understanding new concepts and they are comfortable with math formulas and abstractions. These learners tend to be less practical than the sensors and they dislike repetitions (e.g. repetitive calculations).

- Visual learners learn best from what they see (e.g. films, charts, pictures). Verbal learners tend to memorise words (i.e. both written and spoken) better.

- Sequential learners follow logical steps to solve problems. Global learners, on the other hand, learn randomly (i.e. in large jumps) by absorbing materials without seeing their connections. They can quickly solve complex problems after understanding the big picture, but they tend to struggle in explaining the process to identify the solution.

3. METHODOLOGY

--- 3.1 Research design ---

To answer the research questions discussed earlier, the design of this research follows both quantitative (i.e. hypotheses testing) and qualitative (i.e. content analysis) methods (Crowther & Lancaster, 2012). The quantitative aspects of this research are needed to measure tendencies (Malhotra & Peterson, 2006) of PM learning method preference and to examine whether learning styles affect students' PM learning method preference. The qualitative aspect (i.e. content analysis) of this research is to explore other underlying reasons behind students' preference. The quantitative data analysis techniques used in this study are the proportion test (Section 4.1) and chi-square test of independence (Section 4.3). The qualitative data were analysed using the content analysis method (Section 4.2). These methods will be further explained in Section 4.

--- 3.2 Research procedure ---

Data were collected from MSc Management of Projects students at the University of Manchester who have completed three learning sessions, namely: Project Crashing Game (PCG), Program Crashing Game (PgCG), and Project Crashing Simulation Exercise e-Learning (PCSEL).

3.2.1 Project Crashing Games (i.e. PCG and PgCG)

As introduced in the previous sections, the crashing games consist of: Project Crashing Game (PCG) and Program Crashing Game (PgCG). The objective of these games is to help students in understanding basic project crashing principles (Pinto, 2009). In the experiment, students needed to select activities to crash by considering the time-cost trade-off and criticality of the activities. In the PgCG session, students were grouped into five "project teams" per program. Each team needed to communicate with other teams within the same program to achieve the goal (i.e. to crash / accelerate the program within the budget and schedule constraints). Some teams assigned project managers and program managers to lead the project and program respectively. In the PCG session, students, also in teams, were only assigned to tackle their own project. They were not required to interact with other "project teams" since their task was only to crash activities in a single project. In both games, teams (i.e. project teams in the PCG and program teams in the PgCG) competed with other teams. The winner was the team which achieved the objective first. Both games were played in real-time and were time-constrained. The state of the project (or program) performance (i.e. time, cost, critical path, network diagram) changed after each decision. Hence, teams needed to adjust their decisions in the next iteration / round and could experience failure (i.e. project delay and/or over budget) if they made wrong decisions (e.g. crashing non-critical activities). When playing these games, students were given limited instructions and they had to discover and learn the concepts by themselves.

The PgCG is a more complex version of the first as it requires more interaction between teams in order to crash the overall program (i.e. collection of projects), it consists of significantly more activities and decisions (see **Table 2**). The content of both games is narrow and shallow as students were only required to make crashing-specific decisions without having to calculate project attributes (e.g. earliest start, latest start, float, direct and indirect costs, etc).

Criteria*	Project Crashing Game (PCG)	Program Crashing Game (PgCG)	Project Crashing Simulation Exercise e-Learning (PCSEL)
Number of projects	1	5	1
Number of activities	8	30	8
Number of crashing decisions per round / iteration	1	5	1
Number of team members	2-3	10-15	1
Participant interaction(s)	Face-to-face within a small group	Face-to-face within a large group	Not possible within the experience
Roles	Absolute, non-changing role as project manager	Self-chosen role(s) i.e. project team members, project manager, and program manager	Absolute, non-changing role as project manager
Feedback information immediacy	Continual decision reviews	Continual decision reviews	Continual reviews with advice
Challenge source content	Situation is altered by participant actions/randomness	Situation is altered by participant actions/randomness	Situation and scenario pre-programmed and never-changing
Content width and depth	Narrow and shallow	Narrow and shallow	Narrow and deep
Didactic goal(s)	Conceptual skills, Hard/Technical skills, Soft human skills	Conceptual skills, Hard/Technical skills, Soft human skills	Conceptual skills, Hard/Technical skills

*Note: the criteria displayed in the above table are adapted from the dimensions of project complexity (Vidal & Marle, 2008) and the serious games typology project (available at http://seriousgames.online/).

TABLE 2. Characteristics of the three learning methods (i.e. PCG, PgCG, PCSEL)

3.2.2 Project Crashing Simulation Exercise e-Learning (PCSEL)

In the PCSEL, students were asked to tackle the same problem as in the PCG. However, the format of the exercise was in an asynchronous simulation e-Learning exercise rather than in a competitive game. Unlike in the games, students did not compete with other students. They were not assigned to groups. Furthermore, in each step of the simulation exercise, students received direct and detailed instructions and feedback. Students could not experience failure (i.e. project delay or cost overrun) as direct feedback (i.e. correct answer) was given for each step and the scenario was pre-programmed and never-changing. This simulation can be done anywhere and at any time. The content in this exercise was narrow and deep as students were required to make crashing-specific decisions and calculate project attributes (e.g. earliest start, latest start, float, direct and indirect costs, etc.)

3.3 Data collection

After playing the games and completing the simulation exercise, students were given a link to an online questionnaire (see **Figure 1)** where they were asked about:

- their preferred learning method (out of the three methods / sessions they

had completed);

• the reason (explanation) as to why they preferred a particular learning method to the other methods.

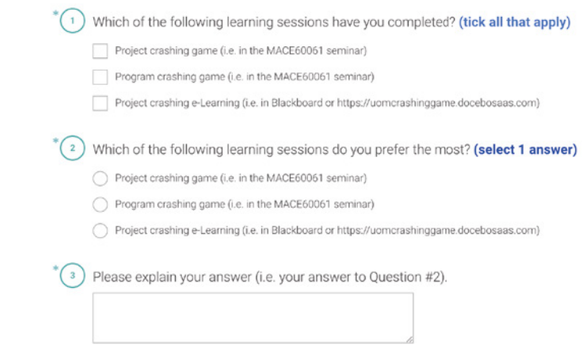

FIGURE 1: Questionnaire questions on project management learning method preference

In addition, students were also asked to complete a standard learning style online questionnaire (see **Figure 2**) namely the Index of Learning Style (ILS) proposed by Soloman and Felder (2005). This questionnaire was used to identify learners' learning styles. It consists of 44 questions (Soloman & Felder, 2005). ILS was used for two reasons. First, it is based on a generalised model as it is synthesised from multiple studies and represents elements of most models (Soflano et al., 2015). Furthermore, it is one of a few questionnaires that have been applied in technology-enhanced learning applications and which have been tested for reliability and validity (Khenissi et al., 2016).

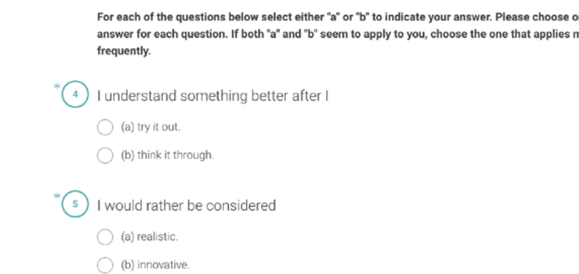

FIGURE 2: Sample questions of the ILS learning style questionnaire (Soloman & Felder, 2005)

4. DATA ANALYSIS AND RESULTS

In total, 133 students played the games and completed the simulation exercise, all of which submitted their feedback on their learning method preference and 126 of them submitted their responses on the ILS (Learning Style) questionnaire. These responses were used as the basis for data analysis in the next sub-sections.

--- 4.1 Preferred learning method ---

4.1.1 No dominant learning method between the games and simulation exercise

The result shows an interesting phenomenon whereby half of the students prefer the crashing games (PCG or PgCG) and the other half prefers the simulation (see **Figure 3**). This indicates that there is no dominant preferred learning method when choosing between the project crashing games and the simulation.

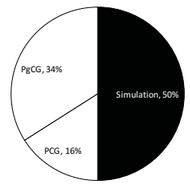

FIGURE 3. Proportion of learning method preference To ensure that this result is not due to chance, we tested the following hypotheses:

To ensure that this result is not due to chance, we tested the following hypotheses:

H_o : p = 0.5

H_a : p ≠ 0.5

H_o: there is no difference between the proportion of students who prefer the project crashing simulation (PCSEL) and the games (PCG and PgCG)

H_a: the proportion of students who prefer the simulation (PCSEL) is different to the proportion of students who prefer the project crashing games (PCG and PgCG)

The proportion test (one sample) was used to test the hypothesis as it aligns with the objective of the test and nature of data, which is to examine whether two proportion values in a single sample are different or not (Levine, Berenson, & Stephan, 1999; Shao, 1976). Test statistic z was calculated as follows:

$$z = \frac{\hat{p}\text{-}p_0}{\sqrt{\frac{p_0(1-p_0)}{n}}} \qquad (1)$$

p̂: the sample proportion of students who prefer the project crashing games (PCG and PgCG)

p_o: the hypothesised population proportion of students who prefer the project crashing games (PCG and PgCG)

n: sample size

To check if the sampling distribution of the proportion follows the binomial distribution and if the normal distribution can be used to approximate the binomial distribution, the following assumptions were examined (Levine et al., 1999; Shao, 1976):

• Is n x p ≥ 15? Yes, 133 x 0.5 ≥ 5.

• Is n x (1-p) ≥ 15? Yes, 133 x 0.5 ≥ 5.

As the assumptions were satisfied, we proceeded with testing the hypothesis. Based on equation (1), we find that:

$$z = \frac{0.5 - 0.5}{\sqrt{\frac{0.5(1-0.5)}{133}}}$$

$$z = 0$$

P-value for z > 0 or z < 0 (two-tailed) is 0.999. Because the p-value is larger than the significance level (i.e. 0.05), at 95% confidence, we reject our alternative hypothesis and conclude that there is no difference between the proportion of students who prefer the project crashing simulation (PCSEL) and the games (PCG and PgCG).

--- 4.1.2 Students prefer the more complex PM game to the less complex PM game ---

Another interesting phenomenon we found was that students tended to prefer the more complex PM game (i.e. the PgCG) to the less complex one (i.e. the PCG). **Figure 1** shows that those who prefer the PgCG (34%) are more than double those who prefer the PCG (16%).

To ensure that this result is not due to chance, we tested the following hypotheses:

H_o : p = 0.16

H_a : p ≠ 0.16

H_o : there is no difference between the proportion of students who prefer the less complex PM game (PCG) and the more complex PM game (PgCG)

H_a : the proportion of students who prefer the more complex PM game (PgCG) is more than the proportion of students who prefer the less complex PM game (PCG), i.e. more than 16% (or 0.16)

By applying the same method as in the previous section, we found that the z score for this test is 5.662 and the p-value (one-tailed) for z > 5.662 is 0.0005. As this is less than the significance level of 0.05, at 95% confidence, we accept our alternative hypothesis and conclude that the proportion of students who prefer the more complex PM game (PgCG) is more than the proportion of students who prefer the less complex game (PCG).

4.2 Learning method preference: exploring the "mentioned" reasons

The next question is of course: "why?" As described in Section 3.3, students were asked to explain their preference of a learning method over other methods. We received 35 unique reasons which were mentioned 189 times in total.

In order to explore these reasons and provide more meaning to the obtained qualitative data (i.e. reasons) we followed the procedure of content analysis method, which is a part of the qualitative research method (Crowther & Lancaster, 2012). By applying the method, students' mentioned reasons for selecting a PM learning method were categorised on the basis of their similarity and measured on the basis of their mentioned frequency, hence dominant themes (reasons) could be identified. We classified similar reasons into themes / categories (**Table 3**). For example, one of the students who prefer the Program Crashing Game (PgCG) explains his/her reason: "lots of new things learned in [the] Program Crashing Game, especially [on] how to work as a team". This response was categorised into the 'teamwork' sub-theme and then further categorised into the broader 'collaboration' theme (see **Table 3**).

Reasons to select one learning method over another	Category / theme
Freedom to repeat learning, unlimited attempts, learn from anywhere	Accessibility (unlimited attempts, from anywhere, at anytime)
Depth, clear explanation (instruction), clear explanation (step by step), quicker to understand learning points, feedback, comprehensiveness, clear explanation (more detailed), clarity, less confusing, easier to understand	Clarity
Communication, interaction, teamwork, team cooperation, learn from others	Collaboration
Longer time to think, self-controlling of learning pace	Longer time to think and analyse the problem
More complex, challenging, more realistic, contextual, practical	Complexity, challenge, and realism
More interesting, fun, attractive	More fun and attractive
Boost learning confidence, experiencing the problem instead of just knowing, independent learning (learn the concept by themselves), individual learning, more competitive, more suitable with students' basic project management understanding, problem solving experience	Other reasons (uncategorised)

TABLE 3. Reasons to select one learning method over another and their categories (themes)

After identifying the categories, we then measured the size of each category (or theme) based on the number of mentions (**Table 4**). This enabled us to identify dominant themes (reasons to select one learning method over the others).

As can be seen in **Table 4**, the first four themes constitute more than

Category / Theme	Number of mentions	Number of mentions (%)
Clarity	66	35%
Collaboration	45	24%
Complexity, challenge, and realism	42	22%
More fun and attractive	18	10%
Longer time to think and analyse the problem	6	3%
Accessibility (unlimited attempts, from anywhere, at anytime)	4	2%
Other	8	4%
Total	189	100%

TABLE 4. Reasons to select one learning method over other alternatives (measured by number of mentions in students' responses)

Category / Theme	Number of mentions	Number of mentions (%)
Fun and attractiveness	6	46%
Clarity	3	23%
Collaboration	2	15%
Independent learning	1	8%
Complexity, challenge, and realism	1	8%
Total	13	100%

TABLE 5. Reasons of students who prefer Project Crashing Game (PCG)

Category / Theme	Number of mentions	Number of mentions (%)
Collaboration	40	43%
Complexity, challenge, and realism	39	42%
Fun and attractiveness	9	10%
Clarity	2	2%
Experiencing the problem	1	1%
More competitive	1	1%
Total	92	100%

TABLE 6. Reasons of students who prefer Program Crashing Game (PgCG)

Category / Theme	Number of mentions	Number of mentions (%)
Clarity	61	73%
Longer time to think and analyse the problem	6	7%
Accessibility	4	5%
Collaboration	3	4%
Fun and attractiveness	3	4%
Individual learning	2	2%
Complexity, challenge, and realism	2	2%
Boost learning confidence	1	1%
More suitable with students' basic project management knowledge	1	1%
Problem solving experience	1	1%
Total	84	100%

TABLE 7. Reasons of students who prefer Project Crashing Simulation Exercise e-Learning

90% of the reasons mentioned for choosing one learning method over the other methods. **Tables 5, 6 and 7** provide a breakdown view of **Table 4** as they display the reasons for choosing each specific learning method (i.e. the PCG, PgCG, or PCSEL). They also show how many times (i.e. in numbers and percentages) these themes were mentioned in students' responses.

4.3 Learning styles: investigating the "unmentioned" reasons

Students' learning styles were then identified based on their responses to the standard ILS questionnaire (Soloman & Felder, 2005). In total, 126 students participated in this survey. Tables 8-11 categorise the students on the basis of their learning style (i.e. activist/reflector, intuitive/sensing, global/sequential, and verbal/visual) and their preferred learning method (i.e. PgCG, PCG, or PCSEL).

The chi-squared test of independence was applied to test the relationship between students' learning style and their preferred learning method on the basis of the data presented in Tables 8-11. This method is used when examining whether two or more categorical variables are related or independent (Levine et al., 1999). In this study, it was applied to test whether students' learning style (i.e. independent variable) affects their preferred learning method (i.e. dependent variable). Alternative tests (i.e. Fisher's and McNemar's) were not applied since the first is for testing small-sized sample and the latter for paired samples (Fisher, Marshall, & Mitchell, 2011). The result of this test is shown in **Table 12**.

At 95% confidence, we accept Hypothesis 2 (i.e. the intuitive vs sensing learning style dimension affects learners' PM learning method preference) and reject the other hypotheses.

5. DISCUSSION

There are three key findings in our study. First, in the context of selecting between project crashing games and the simulation exercise, our study finds that there is no dominant preferred learning method. This finding does not align with Raia's (1966) work, which indicates that games are preferred over other learning methods. This could be due to the fact that the learning methods examined in this study (i.e. simulation and games) are different to those examined in Raia's (1966) work (i.e. games, readings and cases). Furthermore, our study also discovered that students tend to prefer the more complex PM game (PgCG) to the similar but simpler one (PCG). This is consistent with Wolfe's (1978) findings which indicate that simple games tend to be "unmotivating".

We propose that the two findings can be explained by the uniqueness level of the value offered by each learning method. With regards to the first finding, we find that the crashing games and simulation methods have different appeals which tend to be mutually exclusive. Students who prefer the crashing games tend to highlight:

- how fun and attractive these games are;
- how the games provide them the opportunity to collaborate with each other.

This finding supports the notion that SGs have the advantage in that they are enjoyable and they provide practice in communication (Heyman, 1975). On the other hand, those who prefer the simulation tend to stress:

- how clear the explanation in the simulation exercise is for them;
- other advantages which e-Learning offers, such as accessibility from anywhere at any time (Welsh, Wanberg, Brown, & Simmering, 2003), hence providing flexibility in thinking through the problem.

These mutually exclusive appeals split the students into two equal-sized groups: those who prefer clarity and need more time to think through the problem (i.e. the simulation "voters"), and those who prefer fun, complexity, realism, a challenge and the opportunity to collaborate (i.e. the crashing games "voters").

Learning Style	Preferred Learning Method			Total
	PgCG	PCG	PCSEL	
Activist	24	11	34	69
Reflector	20	10	27	57
Total	44	21	61	126

TABLE 8 · Active vs reflective learning styles and learning method preference

Learning Style	Preferred Learning Method			Total
	PgCG	PCG	PCSEL	
Intuitive	11	7	5	23
Sensing	33	14	56	103
Total	44	21	61	126

TABLE 9· Intuitive vs sensing learning styles and learning method preference

Learning Style	Preferred Learning Method			Total
	PgCG	PCG	PCSEL	
Global	20	12	22	54
Sequential	24	9	39	72
Total	44	21	61	126

TABLE 10· Global vs sequential learning styles and learning method preference

Learning Style	Preferred Learning Method			Total
	PgCG	PCG	PCSEL	
Verbal	6	4	9	19
Visual	38	17	52	107
Total	44	21	61	126

TABLE 11· Verbal vs visual learning styles and learning method preference

Hypothesis	P-value	Reject/Accept
Hypothesis 1: The *active vs reflective* dimension affects learners' PM learning method preference	0.964	Reject
Hypothesis 2: The *intuitive vs sensing* dimension affects learners' PM learning method preference	0.013	*Accept*
Hypothesis 3: The *global vs sequential* dimension affects learners' PM learning method preference	0.221	Reject
Hypothesis 4: The *verbal vs visual* dimension affects learners' PM learning method preference	0.846	Reject

TABLE 12· Hypothesis test results (chi-square test)

The second finding also offers an interesting insight. Unlike in the case of comparing between the crashing games and the simulation exercise, both of the crashing games are similar but one is more complex than the other. As a result, Tables 6 and 7 show that both the PCG (the less complex game) and the PgCG (the more complex game) offer common appeals to students. Both are perceived as fun and both are preferred because they offer the opportunity for players to communicate with each other. Applying a marketing theory as an analogy, when two products have a similar position in the perception of their customers, one of the products will be preferred over the other if it offers a unique feature not offered by the other product (Myers, 1996). This underlines the importance of "finding the hole" (cherchez le creneau) in the customer's perception in order to be desirably unique. In our case, the PgCG differentiates itself from the PCG (and from the simulation exercise) by offering a unique feature which the "customers" want: complexity, challenge and realism.

The third finding (see **Table 12**) suggests that students' learning styles could affect their PM learning method preference. This finding aligns with the findings of Khenissi et al. (2016) which indicate a relationship between game genres and learning styles. In our study (see **Table 9**), those who have a sensing learning style tend to prefer the simulation exercise (PCSEL). This could be due to the fact that the characteristics of PCSEL fit their style of learning (i.e. prefer detail-oriented task, less-complex problem and well-established methods). Intuitive learners, on the other hand, tend to prefer the PCG and PgCG which have a higher level of uncertainty as instructions and feedback provided in these methods are not as clear as in the PCSEL. Our finding is consistent with the characteristics of both intuitive and sensing learn-

ing styles (Richard M. Felder & Soloman, 2000). However, we could not find enough evidence to suggest that students' learning styles affect their preference between the less complex PM game (i.e. PCG) and the more complex one (i.e. PgCG).

6. CONCLUSIONS AND RECOMMENDATIONS

The aim of this research is to investigate students' learning method preferences and the underlying reasons by applying three learning methods: Project Crashing Game (PCG), Program Crashing Game (PgCG) and Project Crashing Simulation Exercise e-Learning (PCSEL). We find that there is no dominant preferred learning method between the crashing games and the simulation. We argue that this is because both methods appeal uniquely to two equal-sized groups of students which have different learning "tastes". Students who prefer the crashing games tend to value fun, attractiveness and team working (collaboration) opportunity more than clarity and accessibility. On the other hand, students who prefer the simulation exercise tend to value clarity and accessibility. However, between the more complex and the less complex crashing games (i.e. the PgCG and PCG respectively), we find that the first is preferred over the latter as, despite their similarities, the first offers a desirable unique learning experience which the latter does not: complexity, challenge and realism.

Furthermore, our study also finds that students' learning styles could affect their PM learning method preference. Students whose learning style is sensing tend to prefer the less-ambiguous simulation exercise (PCSEL). The intuitors, on the other hand, tend to prefer the crashing games (PCG and PgCG) where detailed instructions and feedback are not provided and project crashing concepts are learned independently by trial and error. We could not find any evidence that supports a relationship between learning styles and preference between the less complex (i.e. PCG) and more complex (i.e. PgCG) PM games.

This study suggests that project management educators need to realise that games are not always the preferred learning method. Some students prefer clarity and step-by-step detailed explanation which they usually cannot have by playing serious games. Educators are also advised to consider the complexity level of the simulated project in their serious games and their students' learning styles as both affect students' learning experience.

7. LIMITATIONS AND FUTURE RESEARCH

The scope of this study is limited to examining students' learning method preferences and their underlying reasons (i.e. both mentioned and unmentioned) in the context of project management serious games and simulations. Another dependent variable (e.g. learning effectiveness) can be considered to complement this study since students' preference may not be an accurate predictor on how effective these methods are in helping students to learn project crashing (Kirschner, 2017). Both learning attributes (i.e. effectiveness and preference) are in fact significant (Raia, 1966), but this study focuses on the latter for two reasons. First, learning method preference has been a gap (i.e. often neglected) in PM SGs literature. Moreover, students' preference affects their learning motivation. This is an important aspect since learning motivation has been one of the main drivers in applying simulations and games for education (Jeong & Bozkurt, 2014).

Furthermore, the complexity factors considered when differentiating PCG and PgCG are limited to the number of project decisions, interactions, activities and teams. Limiting the complexity factors is needed as games are not effective for learning when they are too complex (Al-Jibouri & Mawdesley, 2001; Baird & Flavell, 1981). For further research, other complexity factors (e.g. diversity of staff, availability of resources due to sharing) could be considered (Vidal & Marle, 2008). However, one must be careful not to overcomplicate the simulation or serious game, as this can deteriorate learners' understanding of the project crashing concepts (Al-Jibouri & Mawdesley, 2001; Baird & Flavell, 1981).

ACKNOWLEDGEMENT

The authors gratefully acknowledge the Indonesia Endowment Fund for Education (LPDP) as the main author's PhD sponsor.

• AUTHORS •

DAVID RUMESER is a Management of Projects PhD student at The University of Manchester. David also works as a Teaching Assistant at The University of Manchester, United Kingdom and a Project Controlling Officer at PT Pelabuhan Indonesia II, Indonesia. He is an awardee of the Indonesia Endowment Fund for Education (LPDP), which is one the most prestigious scholarships in Indonesia.

MARGARET EMSLEY is a civil and structural engineer who is currently a Reader (senior academic) at The University of Manchester, UK, where she is the Programme Director for the MSc Management of Projects Groups of Programmes. She has supervised many PhD students in a wide range of project management related topics.

• REFERENCES •

Abt, C. C. (1968). Games for learning. Simulation games in learning, 65-84.

Al-Jibouri, S. (2005). The use of a simulation model as a game for teaching management of projects in construction. The International journal of engineering education., 21(6), 1195.

Al-Jibouri, S. H., & Mawdesley, M. J. (2001). Design and experience with a computer game for teaching construction project planning and control. Engineering, Construction and Architectural Management, 8(5/6), 418-427. doi:10.1108/eb021201

Aritua, B., Smith, N. J., & Bower, D. (2009). Construction client multi-projects – A complex adaptive systems perspective. International Journal of Project Management, 27(1), 72-79. doi:10.1016/j.ijproman.2008.02.005

Baird, A. N., & Flavell, R. (1981). A project management game. Computers and Education, 5(1), 1-18. doi:10.1016/0360-1315(81)90022-1

Bakhshi, J., Ireland, V., & Gorod, A. (2016). Clarifying the project complexity construct: Past, present and future. International Journal of Project Management, 34(7), 1199-1213. doi:https://doi.org/10.1016/j.ijproman.2016.06.002

Barros, M. D. O., Dantas, A. R., Veronese, G. O., & Werner, C. M. L. (2006). Model- driven game development: experience and model enhancements in software project management education. Software Process: Improvement and Practice, 11(4), 411-421. doi:10.1002/spip.279

Calderón, A., & Ruiz, M. (2015). A systematic literature review on serious games evaluation: An application to software project management. Computers and Education, 87, 396-422. doi:10.1016/j.compedu.2015.07.011

Callanhan, M. R. (1999). Simulation and role play. Alexandria, VA.: American Society for Training & Development.

Chua, A. Y. K., & Balkunje, R. S. (2012). An exploratory study of game-based m-learning for software project management. Journal of universal computer science, 18(14), 1933-1949.

Cicmil, S., & Marshall, D. (2005). Insights into collaboration at the project level: complexity, social interaction and procurement mechanisms. Building Research & Information, 33(6), 523-535. doi:10.1080/09613210500288886

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

Crowther, D., & Lancaster, G. (2012). Research methods: Routledge.

Dantas, A. R., de Oliveira Barros, M., & Werner, C. M. L. (2004, 2004). A Simulation-Based Game for Project Management Experiential Learning.

Dempsey, J. V., Lucassen, B., & Rasmussen, K. (1996). The instructional gaming literature: Implications and 99 sources: University of South Carolina, College of Education.

Dh, H. (1987). Management: Principles and practices.

Drucker, P. (1974). Management: Tasks, Responsibilities and Priorities: Heinemann: London.

Felder, R. M. (1988). Learning and Teaching Styles in Engineering Education. Learning and Teaching Styles in Engineering Education, 674-681.

Felder, R. M., & Soloman, B. A. (2000). Learning styles and strategies. At URL: http://www/. engr. ncsu. edu/learningstyles/ilsweb. html.

Fisher, M. J., Marshall, A. P., & Mitchell, M. (2011). Testing differences in proportions. Australian Critical Care, 24(2), 133-138.

Gerk, J. E. V., & Qassim, R. Y. (2008). Project Acceleration via Activity Crashing, Overlapping, and Substitution. Engineering Management, IEEE Transactions on, 55(4), 590-601. doi:10.1109/TEM.2008.927786

Harris, A. (1998). Effective teaching: A review of the literature. School Leadership & Management, 18(2), 169-183.

Hendrix, M., Al-Sherbaz, A., & Victoria, B. (2016). Game based cyber security training: are serious games suitable for cyber security training? International Journal of Serious Games, 3(1), 53-61.

Heyman, M. (1975). Simulation games for the classroom: Phi Delta Kappa Educational Foundation.

Jeong, K. Y., & Bozkurt, I. (2014). Evaluating a Project Management Simulation Training Exercise. Simulation and gaming, 45(2), 183-203. doi:10.1177/1046878113518481

Jones, C. (1996). Patterns of software system failure and success: Itp New Media.

Jones, J. K. (1973). Simulations and communication skills in secondary schools. Educational Research, 15(2), 144-149.

Jones, K. (1989). Running, or Stumbling Through, Simulations. Simulation/Games for Learning, 19(4), 160-167.

Khenissi, M. A., Essalmi, F., Jemni, M., Kinshuk, Graf, S., & Chen, N.-S. (2016). Relationship between learning styles and genres of games. Computers & Education, 101, 1-14. doi:http://dx.doi.org/10.1016/j.compedu.2016.05.005

Kirschner, P. A. (2017). Stop propagating the learning styles myth. Computers & Education, 106, 166-171. doi:https://doi.org/10.1016/j.compedu.2016.12.006

Kolb, D. A. (1976). Learning style inventory: Technical manual. Boston: McBer. Kolb, DA (1984). Experiential learning: Experience as the source of learning and development: Englewood Cliffs, NJ: Prentice-Hall.

Lane, D. C. (1995). On a resurgence of management simulations and games. Journal of the Operational Research Society, 46(5), 604-625.

Levine, D. M., Berenson, M. L., & Stephan, D. (1999). Statistics for managers using Microsoft Excel (Vol. 660): Prentice Hall Upper Saddle River, NJ.

Lundy, J. (2003). E-learning simulation: Putting knowledge to work. Paper presented at the Gartner US Symposium.

Malhotra, N. K., & Peterson, M. (2006). Basic marketing research: a decision-making approach: Pearson/Prentice Hall.

Martin, A. (2000). The design and evolution of a simulation/ game for teaching information systems development. Simulation and gaming, 31(4), 445-463.

Myers, J. H. (1996). Segmentation and Positioning for Strategic Marketing Decisions: American Marketing Association.

Nikolic, D., Lee, S., Messner, J. I., & Anumba, C. (2010). The virtual construction simulator: Evaluating an educational simulation application for teaching construction management concepts. Paper presented at the CIB W78 2010: 27th International Conference, Cairo, Egypt.

Norman, D. A., & Spohrer, J. C. (1996). Learner-centered education. Communications of the ACM, 39(4), 24-27.

Payne, J. H. (1995). Management of multiple simultaneous projects: a state-of-the-art review. International Journal of Project Management, 13(3), 163-168. doi:10.1016/0263-7863(94)00019-9

Pinto, J. K. (2009). Project management : achieving competitive advantage (2nd ed., International ed. ed.). Upper Saddle River, N.J. ; Harlow: Upper Saddle River, N.J. ; Harlow : Pearson Education.

PMI. (2013). A Guide to the Project Management Body of Knowledge (5th ed. ed.). Newton Square, PA: Project Management Institute.

Raia, A. P. (1966). A Study of the Educational Value of Management Games. The Journal of Business, 39(3), 339-352.

Rogowsky, B. A., Calhoun, B. M., & Tallal, P. (2015). Matching learning style to instructional method: Effects on comprehension. Journal of educational psychology, 107(1), 64.

Shao, S. P. S. P. (1976). Statistics for business and economics. Retrieved from Columbus, Ohio:

Shubik, M. (1983). Gaming: A state of the art survey. Operational gaming: An international approach, 13-22.

Soflano, M., Connolly, T. M., & Hainey, T. (2015). An application of adaptive games-based learning based on learning style to teach SQL. Computers & Education, 86, 192-211. doi:https://doi.org/10.1016/j.compedu.2015.03.015

Soloman, B. A., & Felder, R. M. (2005). Index of learning styles questionnaire. NC State University. Available online at: http://www/. engr. ncsu. edu/learningstyles/ilsweb. html (last visited on 14.05. 2010), 70.

Spowage, A. C., Chin, C. M. M., Chan, K. Y., Ting, K. N., & Ieee. (2008). Educating Engineers in the art, science and practice of Project Management: - A New Course.

Thomas, J., & Mengel, T. (2008). Preparing project managers to deal with complexity - Advanced project management education. International Journal of Project Management, 26(3), 304-315. doi:10.1016/j.ijproman.2008.01.001

Turner, J. R., & Cochrane, R. A. (1993). Goals-and-methods matrix: coping with projects with ill defined goals and/or methods of achieving them. International Journal of Project Management, 11(2), 93-102. doi:http://dx.doi.org/10.1016/0263-7863(93)90017-H

Vanhoucke, M., Vereecke, A., & Gemmel, P. (2005). THE PROJECT SCHEDULING GAME (PSG): SIMULATING TIME/COST TRADE-OFFS IN PROJECTS. Project Management Journal, 36(1), 51-59.

Vidal, L.-A., & Marle, F. (2008). Understanding project complexity: implications on project management. Kybernetes, 37(8), 1094-1110.

Von Wangenheim, C. G., Savi, R., & Borgatto, A. F. (2011). DELIVER! – An educational game for teaching Earned Value Management in computing courses. Information And Software Technology. doi:10.1016/j.infsof.2011.10.005

Welsh, E. T., Wanberg, C. R., Brown, K. G., & Simmering, M. J. (2003). E-learning: emerging uses, empirical results and future directions. international Journal of Training and Development, 7(4), 245-258.

Yaoyuenyong, C., Hadikusumo, B. H. W., Ogunlana, S. O., & Siengthai, S. (2005). Virtual construction negotiation game–an interactive learning tool for project management negotiation skill training. (13), 2.