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A systematic review of

PROJECT MANAGEMENT SERIOUS GAMES:

Identifying gaps, trends, and directions for future research

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• ABSTRACT •

Project management education struggles to aid learners in coping with complexity. A potential solution is the application of serious or educational games that are often used to help learners in dealing with complex problems. To expand and improve serious games application in project management, we conducted a systematic review that was centered on identifying gaps, trends, and directions for future research. Our study recommends researchers and educators to move toward simulating "soft" project knowledge areas, multiple projects scenarios in a multiplayer mode, and a complete project life cycle. We recommend adopting triangulation methods to minimize evaluation bias and improve design.

1. INTRODUCTION

The main challenge in project management (PM) education is helping project managers and team members in dealing with complex project problems (Thomas and Mengel, 2008). To cope with complexity, having PM knowledge (know what) is not enough. PM students and training participants need to have the ability to apply their knowledge (know how) in the right situations (know when) and for the right reasons (know why). This requires experience rather than just knowledge. However, the problem is that experience can be expensive (Caulfield, Veal, & Maj, 2011). There is an interesting story about a young IBM executive who made an innocent mistake that cost his company $10 million. The contrite executive offered his resignation to his formidable boss, who then replied, "You must be kidding! We've just spent ten million dollars training you" (Awad & Ghaziri, 2008).

Another key challenge in PM education is concerned with its broad knowledge areas (McCreery, 2003). The Project Management Institute (PMI), for instance, identifies ten knowledge areas (PMI, 2017) that comprise managing integration, scope, time, cost, quality, human resource, communication, risk, procurement, and stakeholders. As projects are becoming more complex, a comprehensive capability in dealing with issues related to each area and their combinations is required.

The application of serious games is a potential answer to these challenges. Serious games or educational games are the games that are designed to teach and/or modify behavior (Connolly et al., 2012) and not only for entertainment purposes (Hendrix, Al-Sherbaz, & Victoria, 2016). By playing serious games in the context of PM, students can "be put into complex, realistic project situations ..." (Al-Jibouri, 2005). Unlike in traditional lectures, the games provide students or training participants an opportunity of experiencing the consequences of performing or neglecting PM principles, confronting themselves with complex PM problems, and testing different approaches to solve the problems (Barros, Dantas, Veronese, & Werner, 2006). Furthermore, unlike in the IBM story, serious games' players can gain PM experience without having to risk a $10 million loss.

An increasing number of PM games have been proposed in the literature since their introduction in 1974 (Estes & Herring, 1974). This indicates a growing interest in serious games research in the domain of PM. Responding to this interest, Caulfield et al. (2011) conducted a systematic literature review (or systematic review) that evaluated 36 software engineering papers from 1990 to 2011. However, the scope of their review was limited to an experimental method (e.g., experimental design, sample size, and data collection tool), learning outcomes, and Software Engineering Body of Knowledge (SWEBOK) areas (Bourque, Dupuis, Abran, Moore, & Tripp, 1999). A similar systematic literature review (Calderón & Ruiz, 2015) was conducted to summarize the current state of art in software PM games. Calderón and Ruiz (2015) focused their review on how the games were assessed (e.g., data collection technique, game quality attribute, and population size). Other serious games' review studies (Boyle, Connolly, Hainey, & Boyle, 2012; Boyle et al., 2016; Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012) are not PM-specific as they do not assess the games based on project-related attributes (e.g., project types, knowledge areas, settings, and phases).

In this study, we attempt to expand the scope

of the previous PM serious games' reviews by systematically reviewing serious games' studies in the broader PM context (i.e., including engineering, construction, procurement, and Information Technology or IT/software projects). Furthermore, not only do we focus our review on project-related attributes but also discuss several gaming attributes that are relevant to PM. Our aim is to expand and improve the application of serious games in PM by identifying gaps, trends, and areas for future research in the subject area.

The structure of this paper is as follows: In the next section, the methodology of the systematic review is outlined. Then, the results (i.e., gaps and trends in PM serious games) are presented and discussed. Subsequently, we propose directions for the future research based on the identified gaps and trends. Then, we conclude our study by discussing our findings against the aims proposed in this section and outlining the research limitations. Due to the nature of this research, the literature review is not discussed in a separate "Literature Review" section but is elucidated in the "Results and Discussion" and "Direction for Future Research" sections.

2. METHODOLOGY

A systematic literature review is a means to identify, evaluate and interpret all available researches that are relevant to a particular subject area, research question, or phenomenon of interest (Calderón & Ruiz, 2015). It is mainly concerned with the task of aggregating the empirical works that may have been obtained by other researchers in various contexts. These empirical works are often referred to as primary studies (Brereton, Kitchenham, Budgen, Turner, & Khalil, 2007). A systematic review method can be applied to identify research gaps and suggest areas for future research (Ghaffari & Emsley, 2015). In addition, the review provides a quick reference for other researchers who are interested in the subject area (Calderón & Ruiz, 2015). This systematic literature review comprises the following several stages:

- Game evaluation questions' identification
- Search strategy implementation
- Inclusion and exclusion criteria setting
- Data collection
- Data analysis

We discuss each stage in the following sub-sections.

--- 2.1 Game evaluation questions' identification ---

To achieve the aim mentioned earlier, we set seven Evaluation Questions (EQs) that were mainly concerned with PM attributes (EQ1–EQ4). These questions were identified based on A Guide to the Project Management Body of Knowledge, Sixth Edition, e-book (PMI, 2017). Some of the gaming attributes that are related to PM were also identified (EQ5–EQ7). All the evaluation questions were then used as a basis to review each PM serious game in the literature. The questions are as follows:

- EQ1. Which project type (Engineering, procurement and construction (EPC), Information Technology/IT/software, or general projects) was simulated in the game?
- EQ2. Which project knowledge areas (integration, scope, time, cost, quality, human resource, communication, risk, procurement, and/or stakeholder management) were covered in the game?
- EQ3. Which project setting (single project, multiple projects, or flexible) was applied to contextualize the game?
- EQ4. In which project phase (initiation, planning, execution, control, and/or closing) was the game played?
- EQ5. Which game mode (multiplayer or single player) was applied?
- EQ6. Which game medium (digital, paper-based, or mixed) was applied?
- EQ7. In which context (university, industry, or both) was the game implemented and evaluated?

--- 2.2. Search strategy implementation ---

A systematic procedure was implemented to identify the search terms (Brereton et al., 2007) as follows:

- The main concepts were identified to derive the key terms.
- The synonyms and alternative spellings of the key terms were identified.
- The keywords in the relevant papers were considered.
- Boolean OR was applied to add synonyms and alternative spellings.
- Boolean AND was applied to link the key terms.

As a result, we identified three categories of search terms (see **Table 1**). In October 2016, we started the article search process in four major academic databases (i.e., Scopus, ISI Web of Science, ScienceDirect, and IEEE Xplore) by using the following search string: A1 AND (B1 OR B2 OR B3 OR B4) AND (C1 OR C2 OR C3 OR C4). The codes are described in **Table 1**.

A1. PM	B1. Simulation game B2. Serious game B3. Game B4. Simulation	C1. Learning C2. Teaching C3. Training C4. Education

TABLE 01. Systematic review search term

The searches were limited to the title, abstract, and keywords. EndNote™ was used for data collection (e.g., year of publication, title, the name of the author, publisher, and abstract). These preliminary data were then transferred to MS Excel™ for data consolidation, paper selection, and data analysis purposes.

To ensure that more recent articles were also included in this review, we set a search alert in each database using the same search string. The cut-off date of these alerts was 26th January 2018. Furthermore, a snowballing technique (Calderón & Ruiz, 2015) was also applied to minimize the risk of not including the relevant papers that did not use the search string in their titles, abstracts, or keywords. This technique was applied by reviewing other PM serious games' papers that were referred to in several papers found in the initial search.

--- 2.3. Inclusion and exclusion criteria setting ---

To improve the effectiveness and efficiency of the review process, inclusion and exclusion criteria were set (**Table 2**). These criteria were used as a basis to decide whether to include or exclude each paper for further analysis.

--- 2.4. Data collection ---

Data collection was conducted in two stages. In the first stage, the papers found during the search process were assessed for their relevance on the basis of their titles and/or abstracts. The inclusion and exclusion criteria were then used to decide whether the papers should be included for further analysis. In the second stage, a more thorough analysis (i.e., reading the full text) was performed to assess whether the papers should be included or excluded from the review. Simultaneously, each included paper was coded with respect to the evaluation questions (EQ1–EQ7). As suggested by Calderón and Ruiz (2015), all the collected data was stored in one location (i.e., a spreadsheet) as this allowed us to easily analyze and compare the extracted data.

--- 2.5. Data analysis ---

The gaps and trends in the literature were then analyzed by applying descriptive statistical methods, such as percentages, bar charts, pie charts, and radar charts, with respect to EQ1–EQ7. Furthermore, to capture the diversity of games, we adopted a narrative synthesis (Boyle et al., 2012) in which several examples of the PM games were described.

3. RESULTS AND DISCUSSIONS

In the following sub-sections, we present and discuss the following topics:

- The search and selection results.
- The overall trend in PM serious games.
- The gaps and trends in PM games based on project-related and gaming-related attributes.

--- 3.1. Search and selection results ---

The initial search performed in October 2016 yielded 1,277 papers. After removing the duplicate papers, 1,054 unique papers were identified in February 2017. Then, we performed the first phase of paper selection by reviewing the title and/or abstract against the inclusion and exclusion criteria. In June 2017, we completed this phase and found 278 (potentially) relevant papers. Consequently, we proceeded with the second phase (i.e., reviewing the full text of each paper) and identified 67 relevant papers. The snowballing technique was applied, and additional papers from the search alerts were reviewed. As a result, 13 papers were added and 80 relevant papers in total were included for analysis in the following sections. **Figure 1** summarizes the process and the results of the literature search and selection stages.

Inclusion criteria	• The paper discusses PM games or simulation for training purposes. • The concept, game play, and features of the game or simulation are clearly outlined. As an indicator, the papers that provide sufficient information to answer EQ2 (Project knowledge areas) were included.
Exclusion criteria	• Not applicable in the PM context. • The game has some PM features but those are not its main features. • Not applicable for training/educational purposes. • Not applicable for discussing games. • The abstract or title is available but not the full text. • Not written in English. • Propose games that were already reviewed in other papers. • Duplicate papers (same paper from different databases). • In order to ensure the quality of the reviewed papers, papers found via the snowballing technique were excluded if they were not listed in the academic databases.

TABLE 02. Inclusion and exclusion criteria

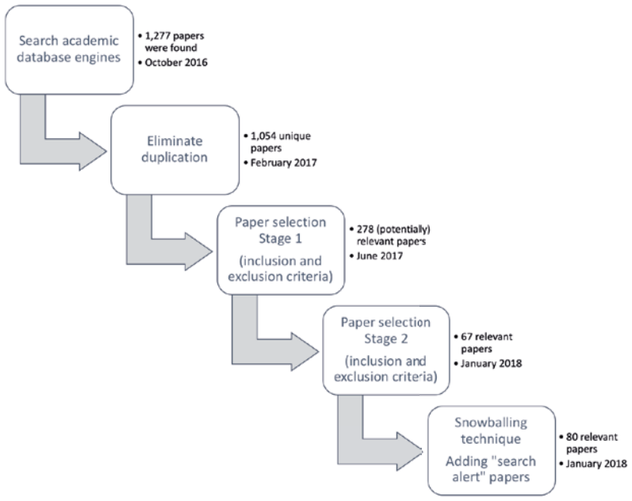

FIGURE 01. Literature search and selection stage

-- 3.2. Overall trend in project management serious games --

Overall, the number of PM serious games proposed in the literature has increased exponentially in the last two decades (**Figure 2**). We propose the following three key factors that could explain this phenomenon: technology, people, and a shift in PM training and educational perspectives.

Technology is an important factor in serious games' application in PM. The significant growth of the internet in the last two decades (Bekkerman & Gilpin, 2013) partially explains the exponential curve as most PM games (75%) are digital-based and more than 40% of digital PM games are web-based. Furthermore, with the availability of more user-friendly game development software tools, game designing has become easier. Complex PM games can be developed without the need for sophisticated programming skills.

The people effect is not mutually exclusive with the technology effect. Most stu-

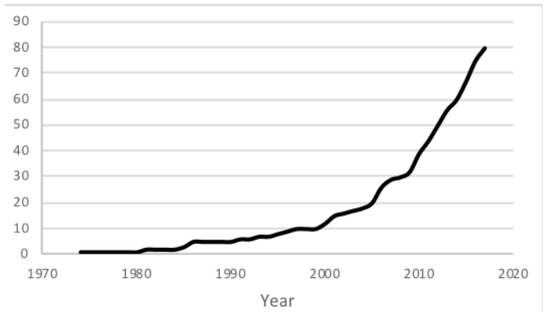

FIGURE 02.Cumulative number of project management serious games in the literature.

dents in university (i.e., where most PM serious games are applied) are Generation Y students who tend to face more difficulty in "maintaining enthusiasm for some traditional learning methods" (Goedert, Cho, Subramaniam, Guo, & Xiao, 2011). The exponential rise of digital PM games, in general, and online PM games, in particular, could be partially explained by the need for a more sophisticated learning method to motivate and engage these so-called "Internet generation" students.

A shift in PM training and educational perspectives is another potential factor that affects the exponential growth in PM serious games' application. For instance, in 2006, UK's Engineering and Physical Sciences Research Council (ESPRC) identified the need to change the aim of PM training and development (Winter, Smith, Morris, & Cicmil, 2006). The newly proposed aim is to train reflective practitioners who can adapt to complex situations by implementing their PM knowledge appropriately. The old aim that centered on training people to follow the procedures outlined by PM techniques and tools was deemed ineffective as it did not reflect the actuality of projects. Serious games' application is aligned with the transformed training aim as these games are experiential learning methods (Kolb, 2014) that can provide students with the experience of dealing with complex project issues.

--- 3.3 Project-related attributes ---

3.3.1. Project type

During the systematic review process, we identified the following three types of simulated project in the games: games with no specific project type (general), games that simulate Information Technology (IT/software) projects, and games simulating Engineering, Procurement and Construction (EPC) projects. **Figure 3a** shows that most PM games (43%) simulate EPC projects, 35% of games are played in an IT/software project context, and 23% have no project context.

In terms of the trends (**Figure 3b**), we can see that EPC project games were dominant before 1997. In this period, several PM themes were introduced in the games such as construction bidding in the SuperBid game (Rizk, 1993) and time-cost trade-off in PAMSIM (Estes & Herring, 1974). Most of these earlier games also allowed players to cope with unexpected events in their game play.

Between 1998 and 2007 (i.e., the period when the internet boomed),

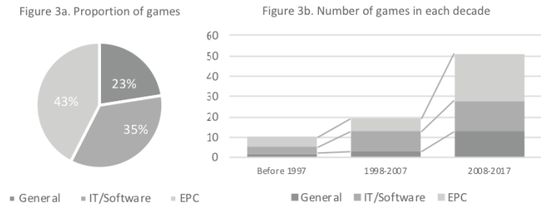

FIGURE 03. Proportion and trend of PM games based on simulated project type.

there was a surge in the number of games in the context of IT/software projects. For example, PEG (Ofer & Amnon, 2007), Problems and Programmers (Baker, Navarro, & Van Der Hoek, 2005), and a software engineering game (Taran, 2007) were developed to teach risk management skills. Another key PM theme that was simulated in these games was resource allocation. For instance, this theme was simulated in the following games: SESAM (Mandl-Striegnitz, 2001) and SIMSE (Navarro & Van Der Hoek, 2004).

A substantial increase in the number of EPC and general PM games highlights the PM serious games' trend in the last decade (**Figure 3b**). This was affected by a significant growth in the number of virtual world PM games in the last decade, particularly in the EPC context. Virtual world games enable "users to represent themselves as 3D animations (known as avatars); communicate with other users' avatars; and build, change, and travel within their 3D computer-game-like environments" (Messinger et al., 2009; Robbins & Butler, 2010). Most of the PM virtual world games (70%) identified in this review are simulated in EPC projects as the requirement for realistic visualization is more prominent in this project type. Examples of such games are as follows: Virtual Coach (Dossick, Mukherjee, Rojas, & Tebo, 2010), VIRCON (Jaafari, Manivong, & Chaaya, 2001), ManuBuild (Goulding, Nadim, Petridis, & Alshawi, 2012), VCS3 (Lee, Nikolic, & Messner, 2015), and VICE (Goedert et al., 2011).

Another interesting finding is that researchers seem to realize the importance of applying games without a specific project context (e.g., EPC or IT/software) as not all students may be familiar with the context. This is shown in the surge of decontextualized PM serious games in the last decade (**Figure 3b**). **Table 3** categorizes the primary studies (games) based on their simulated project types.

3.3.2. Project knowledge area

The following analysis is based on the PM knowledge areas that are proposed by PMI (PMI, 2017) and comprise project integration management (PIM), scope management (SCOPE), time management (TIME), cost management (COST), quality management (QUALITY), human resource management (HR), communication management (COMM), risk management (RISK), procurement management (PROC), and stakeholder management (SM). As shown in **Figure 4**, since the first introduction of PM serious games in 1974, all project knowledge areas have been covered in the games.

Some knowledge areas (i.e., integration, time, and cost management) are more covered than the others (i.e., more than 80% games cover these areas). "Softer" knowledge areas (i.e., procurement, communication, scope, quality, and stakeholder management) are covered much less (i.e., less than 50% of the games cover the areas). Scope management, in particular, receives the least attention (i.e., only 25% PM games simulate scope management). Another interesting finding is that all games cover an element of project integration management. This is a positive indication as, such as in real projects, these games require the players to adopt a holistic (or integrated) view that incorporates multiple PM aspects.

Project type	Primary studies
General	(Baird & Flavell, 1981; Bourgault et al., 2010; Davidovitch, Parush, & Shtub, 2006; Geithner & Menzel, 2016; Hartman, Watts, & Treleven, 2013; Hussein, 2011; Hussein & Ravna, 2015; Larson, 2013; McCreery, 2003; Pamukcu & Pruett, 1985; Poehler & Schumacher, 2007; Rumeser & Emsley, 2017, 2018, in press; Sanchez-Gordon, O'Connor, Colomo-Palacios, & Sanchez-Gordon, 2016; Seager, Ruskov, Sasse, & Oliveira, 2011; Von Wangenheim, Savi, & Borgatto, 2013; Wang & Zhang, 2015; Yusof, Radzi, Din, & Khalid, 2016)
IT/Software	(Baker et al., 2005; Barros et al., 2006; Alejandro Calderón, Ruiz, & Orta, 2017; Caulfield, Maj, Xia, & Veal, 2012; Chua & Balkunje, 2012; Collofello, 2000; De Souza, Seabra, Ribeiro, & da S Rodrigues, 2017; Fernandes & Sousa, 2010; Galvao, Neto, Bonates, & Campos, 2012; Garratt, 1995; Hofer, 1996; Jain & Boehm, 2006; Jeong & Bozkurt, 2014; W. L. Lee, 2011; Lino et al., 2015; Mandl-Striegnitz, 2001; Maratou, Chatzidaki, & Xenos, 2016; May, York, & Lending, 2016; Merrill, Collofello, & Ep, 1997; Navarro & Van Der Hoek, 2004; Pfahl, Klemm, & Ruhe, 2001; Ramingwong, Ramingwong, & Ieee, 2014; Sonchan, Ramingwong, & Ieee, 2015; Tachikawa & Nakamura, 2013; Taran, 2007; Taylor & Chi, 2006; Von Wangenheim, Savi, & Borgatto, 2012; Zwikael & Gonen, 2007)
Engineering, Procurement and Control (EPC)	(Bots, 2006; Bourgault & Lagacé, 2002; Cohen, Iluz, & Shtub, 2014; Denholm & Stewart, 2016; Dossick et al., 2010; Dzeng, Lin, & Wang, 2014; Dzeng & Wang, 2017; Estes & Herring, 1974; Ghatala, Lee, & Song, 2009; Goedert et al., 2011; González et al., 2015; Goulding et al., 2012; Hegazy, Abdel-Monem, Saad, & Rashedi, 2013; Jaafari et al., 2001; Korman & Johnston, 2010; S. Lee et al., 2015; Martin, 2000; Mawdesley, Long, Al-Jibouri, & Scott, 2011; Miettinen et al., 2016; Misfeldt, 2015; Mohamed & Ali, 2013; Oo & Lim, 2016; Perng, Juan, & Chien, 2006; Rizk, 1993; Robbins & Butler, 2010; Rounds, Hendrick, & Higgins, 1986; Saenz & Cano, 2009; Soetanto, 2010; Vanhoucke, Vereecke, & Gemmel, 2005; Veshosky & Egbers, 1991; Wall & Ahmed, 2008; Wautelet & Kolp, 2012; Zohar, 1986)

TABLE 03. Primary studies categorized based on project type

More attention having been directed toward the "soft" areas of PM (i.e., communication, scope, and stakeholder management) in the last two decades is a positive sign (see **Figure 5a**). It indicates that PM serious games' researchers are exploring other PM knowledge areas while developing their games. In respect to scope management, the Problems and Programmers game (Baker et al., 2005), for instance, simulates the importance of having a clear scope (requirement) before proceeding to the next phase. Stakeholder management, on the other hand, is simulated in the EPCM game (Miettinen et al., 2016) that simulates the interaction between a project manager and his/her clients to manage change request and specification. The PgCG (Rumeser & Emsley, 2017, 2018, in press) is an example of the multiplayer games that simulate communication management as it facilitates interactions between project teams within the same program (or collection of projects) via a chat box or by assigning project and program managers.

Figure 5b displays the knowledge area concentration in each project type (i.e., general, IT/software, and EPC). Engineering, Procurement and Construction (EPC) games, as the name suggests, are more dominant in the procurement management knowledge area in comparison with the other project types. For instance, the C-Negotiation game (Dzeng & Wang, 2017) simulates a negotiation process in the procurement stage of a construction project. On the other hand, other games such as COINS (Korman, 2016), EMAT (Perng et al., 2006), MERIT (Wall & Ahmed, 2008), The Bidding Game (Oo & Lim, 2016), and SuperBid (Rizk, 1993) simulate the construction bidding process.

The IT/software project game is interestingly more dominant in the human resource, quality, and communication management knowledge areas. The reason behind it is that most of the IT/software project games were designed based on the standard "rework cycle" (Cooper, 1993) and/or the software engineering principles that focus on human resource and quality management. Games such as The Incredible Manager (Barros et al., 2006) and Simsoft (Caulfield et al., 2012) are some examples. The recent surge in agile PM games that simulate communication processes such as Play Ball (May et al., 2016) and the increasing trend of online multiplayer games are potential contributing factors to the dominance of communication management knowledge areas' coverage of this project type.

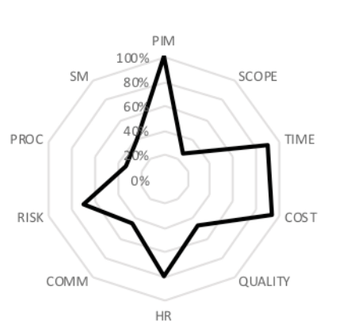

FIGURE 04. Percentage of games simulating specific project knowledge areas.

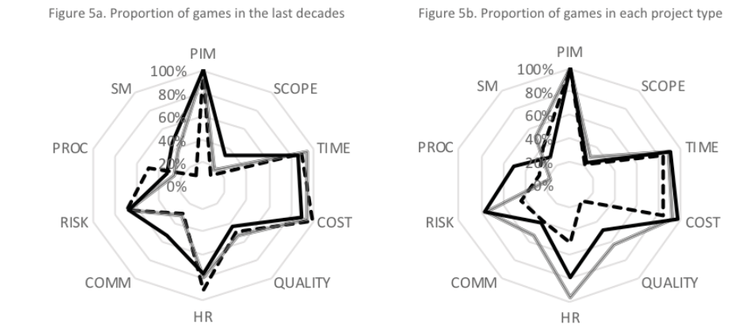

FIGURE 05. Proportion trend of games covering each project knowledge area.

As can be seen in **Figure 5b**, the knowledge areas covered by the general PM games (or PM games without context) tend to be restricted to time, cost, and integration management. These games tend to be less complex than the IT-based or EPC-based PM games. Although this can seem like a disadvantage, simple PM games tend to be more effective for teaching basic PM concepts to less experienced PM students or practitioners (Rumeser & Emsley, 2018).

3.3.3. Project setting

As shown in **Figure 6a**, most PM games (86%) are played in a single project setting.

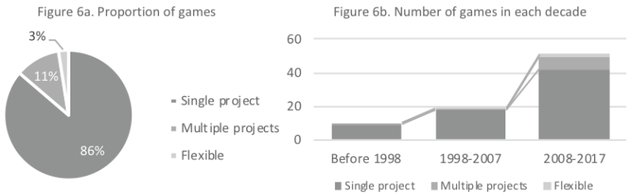

FIGURE 06. Proportion and trend of PM games based on project setting.

There are only a few games that simulate multiple projects (11%). Some games such as PMT (Davidovitch et al., 2006) and PTB (Cohen et al., 2014) allow the players to switch settings. These statistics indicate that researchers tend to ignore the application of serious games in PM training in multiple projects' context. However, we identified a positive indication in the last decade, as researchers have begun to introduce some PM games in a multi-project (or program management) setting (**Figure 6b**). This shift, however, has only occurred in the EPC and general projects and not in the IT/software projects (see **Figure 7**).

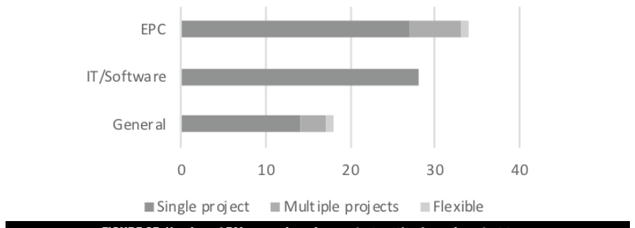

FIGURE 07. Number of PM games based on project setting in each project type.

3.3.4. Project phase

PM games are mainly played in one of or a combination of the following three project phases: planning, execution, and control (**Figure 8a**). The proportion of PM games that simulate these phases is evenly spread. In the recent years, however, researchers have begun to simulate other phases such as initiation and closing (**Figure 8b**).

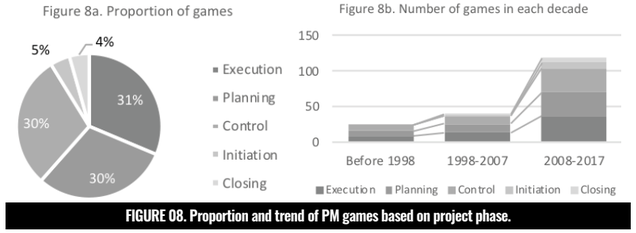

FIGURE 08. Proportion and trend of PM games based on project phase.

In the MAPLE game (Chua & Balkunje, 2012), for instance, the players are asked to create project charters to initiate a software project. The Go For It! game (Sanchez-Gordon et al., 2016), on the other hand, is an example of a card game that simulates a more complete project life cycle (i.e., project planning, execution, control, and closing).

Simulating project initiation and closing phases remains a gap in the current PM serious games' state of art as the activities in these phases are only simulated by less than 10% of the games. Project initiation and closing activities such as identifying stakeholders, reassigning personnel, identifying the lessons learned, and measuring the stakeholders' satisfaction (PMI, 2017) tend to be ignored in the existing PM games.

--- 3.4. Gaming-related attributes ---

3.4.1. Game mode

As can be seen in **Figure 9a**, the majority of PM games (64%) are single-player games. In the recent years (**Figure 9b**), researchers have started addressing this gap by introducing more multiplayer games that simulate different roles.

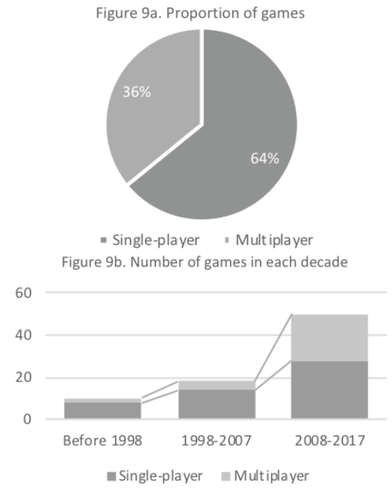

FIGURE 08. Proportion and trend of PM games based on project phase.

SCURMIA (Von Wangenheim et al., 2013), for instance, is an agile PM board game that simulates the interaction between the scrum master, product owner, auditor, and the project's team members. Another example is a multiplayer online game named VICE (Goedert et al., 2011) that simulates the interaction between multiple roles in a construction project such as that between the field engineer, superintendent, and the project manager.

3.4.2. Game medium

Most PM games (87%) are digital-based or computer-based games (**Figure 10a**). In general, digital games are preferred as they are considerably more effective in enhancing learning motivation compared with the paper-based games (Ke, 2008). Furthermore, digital games allow the players to focus on decision-making as they are released from performing tedious calculations, which are calculated automatically by the computer (Martin, 2000). In PM education, this is a key feature as educators do not want their students to waste their time and efforts on manually drawing Gantt charts and performing other administrative work whilst missing the key learning points.

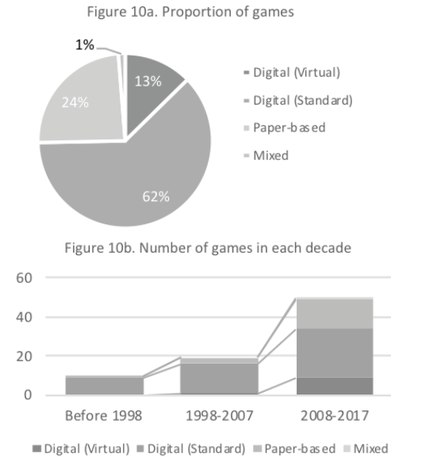

FIGURE 10. Proportion and trend of PM games based on game medium.

Although digital games remain the most popular, we have identified a significant rise in the number of paper-based PM games in the recent years **(Figure 10b)**. These games are advantageous in terms of practicality, interactivity, and flexibility in game play and design modification (Taran, 2007). Card games such as ARMI (Ramingwong & Ramingwong, 2014), SCRUMIA (Von Wangenheim et al., 2013), and TACT (Denholm & Stewart, 2016) are some examples. Other paper-based games such as LEBSCO (González et al., 2015), C2-Camshaft (Geithner & Menzel, 2016), and Task Manager (Yusof et al., 2016) involve playing with Lego bricks. Furthermore, another interesting trend in the last decade has been the rise of virtual world PM games, especially in the EPC project type. This was discussed earlier in the previous section (i.e., the project type section).

3.4.3. Game development and evaluation context

As can be seen in **Figure 11a**, most PM games (74%) are designed, implemented, and evaluated in an academic context (i.e., universities). This phenomenon has occurred since the introduction of PM serious games a few decades ago (**Figure 11b**).

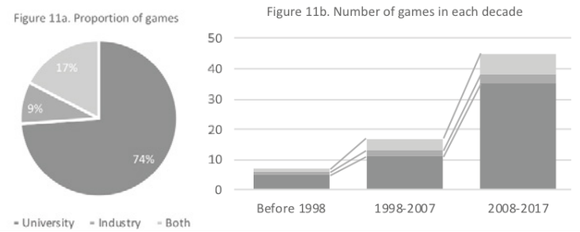

FIGURE 11. Proportion and trend of PM games based on development and evaluation context.

Only a handful of PM games involve both the PM academics and practitioners in their design and/or evaluation stages. Some examples are Contract and Construct (Martin, 2000), ManuBuild (Goulding et al., 2012), e-SPM (Wautelet & Kolp, 2012), and Excavation (Sherif & Mekkawi, 2010).

With respect to game evaluation, we identified another gap in which most of the PM games are evaluated in a silo. In the game evaluation process, most researchers did not compare their games with other PM games or learning methods. They tended to conclude their work by showing that their games have improved the students' PM knowledge and/or skills. However, what they failed to show is how much more or less effective their games were compared with other similar PM games and learning methods. In fact, only 15% of the studies compared their PM games with other games or learning methods. One of the few examples is the work of Taylor and Chi (2006) that compared the Project Challenge game with a text-based learning method. They found that both methods improved abstract knowledge, but the game was more effective in improving the students' ability to deal with contextualized (or case-based) assessment.

4. DIRECTIONS FOR FUTURE RESEARCH

In this section, we propose several directions for future PM games' research based on the gaps and trends discussed in the previous section.

--- 4.1. Toward simulating "soft" project management aspects ---

Earlier PM games were dominated by technical or "hard" knowledge areas (e.g., time and cost). "Soft" or non-technical factors such as stakeholder, scope, and communication management were relatively ignored. However, in the last decade, PM games' educators and researchers have become aware of this gap and have caused a significant shift by developing more games that simulate these "soft" PM elements.

We argue that, in this context, educators and researchers are moving toward the right direction. Few projects fail because of a mistake in the critical path method analysis or an error in the cost charts (Belzer, 2001). More often, projects fail because of problems in communication, motivation, and stakeholder management. This shift is also aligned with the findings from "Rethinking Project Management" research project (Winter et al., 2006), which suggest move in PM training aims toward training "reflective practitioners" who can intuitively and pragmatically adapt to complex project scenarios rather than guiding "trained technicians" who can only follow technical PM procedures.

--- 4.2. Toward simulating multiple projects scenarios in a multiplayer game mode ---

Most PM games in the earlier decades tended to put too much focus on simulating

single projects and ignored the fact that most projects are conducted in a multi-project (or program) setting (Payne, 1995). This gap is even more prominent in the IT/software domain despite the increasing number of applications of program management in complex IT projects (Gierra, 2004). There seems to have been a slight shift in the EPC and general PM games toward multiple project settings in the last decade, but the single-project setting is still dominant. We advise researchers to fill this gap by designing and implementing more program management games, particularly (but not exclusively) in the IT sector.

The gap in multiple project games aligns with the lack of multiplayer PM games, particularly in the earlier decades. This is an important gap in the PM serious games' literature for two reasons. First, most single-player games only allow the players to perform one role (i.e., in most cases, as the project manager or team member). In reality, however, there is more than one role in most projects (e.g., project managers, team members, sponsors, customers, environmental representatives, clients, and contractors). These stakeholders play a significant role in completing the project (Karlsen, 2002). Furthermore, as the games are mostly single-player, communication between stakeholders is not simulated. This is a critical issue as stakeholder communication is an important aspect in PM. Failure in managing communication between stakeholders could cause problems such as scope creep, schedule and cost overrun, and lack of customer satisfaction in projects (Naqvi & Aziz, 2011).

Our study found that in the last decade researchers have developed significantly more multiplayer PM games that address this gap. In consideration of this gap, the lack of program management games, and the advancement in gaming technology, we envision a Massively Multiplayer Online Role-Playing Game or MMORPG (Fuchslocher, Gerling, Masuch, & Krämer, 2011) that will not only be played at a program level (collection of projects) but also at a portfolio level (collection of programs), virtually simulating interactions between the numerous project parties who perform different roles (e.g., project sponsor, stakeholders, funding organizations, contractors, consultants, project managers, and team members) and play the games from various locations around the globe. To bring this vision to reality, PM educators and researchers need to "catch up" with the advancement in gaming technology and involve experienced PM practitioners and serious game designers.

--- 4.3. Toward simulating a complete project life cycle ---

Researchers tend to put too much focus on the planning, execution, and control phases and ignore the project initiation and closing phases in their PM games. These two phases are crucial factors that affect the project's performance. The initiation phase is a key stage that defines the scope of the project and identifies stakeholders. Failure in this stage could cause scope creep, which along with uninvolved stakeholders are the major reasons why projects fail (Verner, Overmyer, & McCain, 1999). Therefore, we advise researchers and educators to add this phase in their PM games. For instance, this can be done by simulating interactions between the stakeholders and the project manager in order to clarify the project's scope.

The closing or termination phase seems simple, but it is actually complex. First, it comprises post-project activities such as reassigning personnel, identifying the lessons learned, and measuring stakeholders' satisfaction. Furthermore, there are many cases in which failing projects (i.e., megaprojects in particular) were not terminated despite their underperformance due to a bias in decision-making (Meyer, 2014). As serious games can be applied for behavior-changing purposes (Connolly et al., 2012), we suggest that PM researchers and educators should simulate a failing project scenario in which the decision makers would be exposed to decision-making bias in the projects' closing stage.

--- 4.4. Toward adopting a triangulation method in game design and evaluation ---

The design, application and evaluation of PM games tend to be conducted in an "academic silo" in which most games are only applied and evaluated in universities. Consequently, there is a potential gap between the PM skills needed in the real world and the skills taught by PM games in the universities. As stated by Hussein (2011), designing a game "should begin with identifying concrete challenges, solutions and tactics that are used by project managers in real projects and then mirror these issues into the design." To fill this gap, we suggest that researchers should adopt a triangulation method (Grix, 2010; Saunders, Lewis, & Thornhill, 2012) in which the cyclical stages of game design and evaluation involve at least the following three entities: the users (students or training participants), experienced PM practitioners, and educational game designers. Additional inputs from PM practitioners and professional educational game designers are necessary to design a realistic PM game without sacrificing its educational aspect.

Furthermore, our study also suggests that most PM games are evaluated in a "one-game silo." In other words, PM serious games' researchers tend to ignore their games' relative learning effect compared with that of other games or other learning methods. Consequently, evaluation is at the risk of bias. To minimize this bias, we recommend applying a triangulation method in which students or training participants are not only asked to evaluate a PM game but also to compare the game with other similar PM games or with other learning methods (e.g., text-based or lecture-based learning) that have the same learning objectives.

5. CONCLUSIONS

At the beginning of this study, we identified two key challenges in the current PM education. The first is to provide learners with experience in coping with complex PM problems. The second challenge is to cover the broad PM knowledge areas. Serious or educational games offer a strong value proposition as they can provide the learners with experience in coping with complex PM problems. To expand and improve the application of serious games in PM, we conducted a systematic review that focused on identifying the gaps and trends in current PM serious games and suggesting areas for future research. Our findings suggest that "soft" or non-technical PM knowledge areas such as stakeholders, scope, and communication management were relatively ignored in the earlier PM games. PM researchers and educators, however, have made improvements in the last decade by developing more games that have covered these knowledge areas. Furthermore, we suggest a move toward simulating multiple projects or program management scenarios as most games do not simulate this despite most real-world projects being conducted in a multi-project setting. Simulating multiple projects means simulating interactions between different roles. Hence, we recommend directing more focus toward developing multiplayer games.

We also advise researchers and educators to add project initiation and closing phases in their PM games. Despite the importance of these two stages, they have relatively been "untouched" in the existing PM serious games. Another gap is that most games were only tested in a university or academic context but not by PM practitioners and professional serious game designer. This is a crucial gap to be addressed to match the skills acquired in education with the skills needed in PM practice and to improve the design quality of the games. We also identified a risk of evaluation bias as most PM serious games were not evaluated by comparisons with other similar games and/or learning methods. To minimize the bias, we recommend applying a triangulation method in which learning effectiveness is measured by applying multiple methods.

6. LIMITATIONS

In identifying the emphases and gaps in the project knowledge areas, this research does not measure the extent of emphasis on each knowledge area. To provide more depth to the analysis, future research should measure and compare how much emphasis is given to each knowledge area. This could be undertaken by involving a panel of PM serious games' experts (i.e., practitioners and academic researchers), as suggested by Tranfield, Denyer, & Smart, (2003). However, the current approach should be sufficient as the aim of this study is to identify the gaps, trends, and directions for future research in the subject area and should not require the comparison of the extent of emphasis of each individual research paper. Another limitation is that this research only serves as a "compass" that suggests areas for future research. In other studies, we have developed PM games to address the several gaps identified in this study.

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