Can Serious Games Improve Project Management Decision Making Under Complexity?

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Can serious games improve project management decision-making under complexity?
Abstract:
The existing literature on the application of serious (or educational) games in project management and decision-making tends to ignore the effect of project complexity levels on decision-making performance. This research fills this gap by conducting an experiment whereby two similar project management decision-making games with different complexity levels are applied in teaching students. Our findings suggest that these games can improve players’ decision-making skills both in the less complex and in the more complex project scenarios. We also discover that the simulated project complexity levels do not affect players’ decision-making performance improvement.

Keywords: Project management, complexity, decision-making, skill acquisition, game-based learning, serious games, computer-based games, education
Introduction

The importance of decision-making skills in managing complex projects

The Hudson Miracle aircraft emergency landing (Pasztor, 2010) teaches us about the importance of experience in decision-making (DM), particularly in complex circumstances. Captain Chesley “Sully” Sullenberger was flying US Airways Flight 1549 when his plane was hit and damaged by birds. Instead of landing at the nearest airport, Capt. Sully decided to land on the Hudson River. The decision saved the lives of hundreds on board. However, by recreating the incident using flight simulators, the National Transportation Safety Board (NTSB) found that four attempts to return to the closest La Guardia runway were all successful. Three of nine additional attempts were also successful. Those who landed them safely were pilots who immediately decided to head towards La Guardia after the simulated engine problems. Unlike in reality, these pilots had already known the problem beforehand and did not spend time deciding on the course of action. Mr. Sullenberger “could have made a different call,” according to Kitty Higgins, a former NTSB member, “but his decision used the best information he had . . . and was based on his experience and instincts” (Pasztor, 2010).

Like in the world of aviation, DM under complexity is an important subject in project management (PM). Modern PM decisions are often characterized by the complexity and subjectivity of decision makers (Attri & Grover, 2014). In fact, one major reason that complex projects fail is bad DM (Flyvbjerg, 2014). Either in private or public projects, effective and efficient PM practice requires DM in selecting projects, choosing project managers, evaluating bids, selecting vendors and so forth (Mian & Dai, 1999). In most projects, decisions which take account of a trade-off between time, cost, quality and other intangible factors are common.
DM, amongst other soft skills needed in managing projects, is regarded as “the missing link,” crucial to project success (Belzer, 2001). It is something a project manager does on a daily basis as he/she manages schedule, quality, risks and resources. Few projects fail because of an error in Gantt chart/PERT/CPM analysis, incorrect role mapping, or a mistake in creating cost charts. More often projects are unsuccessful because of project managers’ failure in communicating problems, working within the culture of the organization, motivating their team, managing stakeholders, understanding strategic objectives, solving issues effectively and making the right decisions. Belzer (2011) suggests that experience is required to improve these skills. Aligning with this, Lansiti’s (2000) work finds that the accumulated project experience is directly proportional to project performance. In DM in particular, it is widely accepted that DM skills should be trained in an environment in which decision makers are able to learn experientially (Caird-Daley, Harris, Bessell, & Lowe, 2007).

Despite the importance of DM skills in projects, and in complex projects in particular, very little guidance on DM, let alone on improving project managers’ DM skills through experiential learning, can be found in PM literature (Deguire, 2010). If anything, the importance of DM seems to be accepted as the common knowledge needed by a project manager. DM is only mentioned a couple of times and is not carefully explored in A Guide to the Project Management Body of Knowledge (PMBOK® Guide) – Fifth Edition (PMI, 2013). Many project managers continue to struggle with the concept of DM (Deguire, 2010). This may be one of the key factors which prevents project success.

Serious games application in project decision-making: Identifying gaps in current research

Wateridge (1997) recognizes experiential learning and its key contribution to PM education. As an illustration (Rubin, Johnson, & Yourdon, 1994), a project manager is similar to a pilot
who plans the course, tracks progress continually, monitors his plane’s condition and reacts to problems he encounters. Flight simulators are often used to train pilots to master these skills, as they provide them with experience in various scenarios without exposing them to the risk and cost of flying a real plane. Pilots could not learn aviation skills from a textbook or instructor alone, since they need hands-on experience to do this. Similarly, project managers need active and hands-on experience to develop their DM skills.

Serious games (SGs), or games for educational purposes (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012), can act as “flight simulators,” as they provide students with an experiential learning experience without exposure to the risks and costs associated with managing actual projects (Dantas, de Oliveira Barros, & Werner, 2004). The games have “the advantage of enabling participants to be put into complex, realistic project situations …” (Al-Jibouri, 2005). This is needed in PM education because of its struggle in educating project managers to deal with project complexity (Thomas & Mengel, 2008).

If appropriately conducted, SGs can also contribute to developing intangible PM skills (Khenissi et al., 2016) such as DM, which is considerably difficult to teach with a traditional (or lecture-based) method. First, unlike the traditional method, SGs provides opportunities for learners to interact with each other in the DM process (Chen & Lin, 2010). Second, SGs are interwoven with numerous DM opportunities for the learners (A. Turner & Martinek, 1995), in which they can explore and develop various DM and problem-solving skills. Furthermore, SGs can simulate the stress and pressure of making time-constrained PM decisions (Chow, Woodford, & Maes, 2011). Finally, these games can be used to develop students’ critical thinking, which is the reason-based reflective thinking needed in making decisions (Ennis, 1991).
a. Gaps in existing studies: Serious games application in simulating/training for decision-making

There are many studies which propose the use of SGs to simulate/train for DM skills. For instance, Linehan et al. (2009) designed a game to improve the group DM skills of people whose role is to manage real-world emergencies such as volcano eruptions, floods, fires and chemical spills. The game is designed to encourage players to engage in the kinds of behaviors which are often associated with those of successful DM groups. Fenton-O'Creevy et al. (2015) propose a financial game to improve DM abilities of traders in regulating emotions during trading. Wolfe and Chacko (1983) investigate the effect of team size on game performance and DM behavior. Other studies (Iwai & Morita, 2016; Morita, Horiuchi, Iwai, Oshima, & Yu, 2014) analyze the effect of culture/origin on DM process and behavior. Lamiraud and Vranceanu (2015) evaluate the effect of gender on DM performance in games. Similar to the previous studies, Bragge et al. (2017) examine the characteristics of the DM groups (e.g. gender, education, cultural orientation and group size) and their effect on group performance in an SG.

An interesting pattern is that these studies focus on either result (i.e. DM performance) or process. Furthermore, most of them evaluate specific independent variables which affect the result or process of DM, such as gender, cultural orientation, emotion, team size and education. Interestingly, none of the studies has assessed complexity level as a factor affecting decisions.

Few DM games are conducted in a PM context. One of the few is a research conducted by Urbaczewski and Kleitsch (2011) which proposes the application of Tetris as a tool for improving PM and DM skills. However, their research relies on analogies and reflections and
therefore lacks PM context, which is an important factor that determines complexity level (Marques, Gourc, & Lauras, 2011). Chen and Lin (2010), in contrast, present a role-playing game in a PM context to train for DM. Their approach, however, measures perceived learning, which tends to be subjective. Therefore, this needs to be complemented by a more objective measurement (e.g., performance improvement). As suggested by Raia (1966): “although impressions and opinions are admittedly of some value, there is a need to appraise the effectiveness of games in terms of more objective criteria”. Furthermore, like in the other contexts discussed previously, studies in the PM context have not considered complexity as a factor that affect DM performance.

b. Gaps in existing studies: Serious games application in simulating/training for project management

In their attempt to deliver a PM education that offers an experiential learning experience, many studies propose the application of SGs. A project scheduling game (Vanhoucke, Vereecke, & Gemmel, 2005), for instance, simulates scheduling complexity in projects. It focuses on the time/cost relationship and on critical-path network problems. Similar to this, Shtub (2005) proposes a scheduling game in both a single-project and a program (i.e., multiple projects) scenario.

In the project implementation phase, Maratou et al. (2014) simulate team-working activities in coping with risk events during project execution. The project-execution game, which was developed by Ofer and Amnon (2007), is another game that simulates risk events in the project-execution phase. Von Wangenheim et al. (2011) propose DELIVER!, an educational game that trains students to monitor and control project performance by applying the earned value management technique.
Although most of the games simulate DM activities, none of these games measures how decisions are improved when playing the games. Furthermore, none of the research assesses the impact of simulated project complexity levels on DM performance. Our review of PM and DM literature indicates that there is a gap between what is true in the real world (i.e. the importance of DM skill in managing complex projects) and what is true in the serious gaming world (illustrated by Figure 1).

![Diagram showing the gap between reality and the serious gaming world in addressing DM under project complexity](image)

**Figure 1** A gap between reality and the serious gaming world in addressing DM under project complexity

Existing work which could offer insights into addressing this gap was conducted by Raia (1966). His work suggests that learning experience and the degree of simulated-environment complexity are not directly proportional. However, Raia’s (1966) work is conducted in a general business (i.e. sales, production and finance) context and does not consider the interaction between teams as a component of increased project complexity. In PM, this
assumption is unrealistic, as most projects (and teams who manage them) are interrelated in a multi-project (or program) context (Aritua, Smith, & Bower, 2009; Payne, 1995).

**Research questions**

The gaps discussed in the previous section prompt us to investigate the effect of PM serious games application on DM performance under different levels of project complexity. More specifically, we aim to answer the following questions:

(a) Can DM performance in project management be improved by playing SGs?

(b) Does project complexity level affect players’ DM performance improvement when playing SGs?

In order to answer the questions, we conduct an experiment using two similar project DM games which have different complexity levels, namely project crashing game (PCG) and program crashing game (PgCG).

The structure of this study is as follows. Theories on project complexity, key decisions in project life-cycle phases, project crashing, games, SGs and simulation, and DM are examined in the next section. Following this, details on the experimentation (i.e. data collection, measurement and analysis) and results are presented. The study concludes by discussing findings, implications (i.e. theoretical and practical) and limitations.

**Theory**

**Project complexity**

PM is “the application of knowledge, skills, tools and techniques to project activities to meet the project requirements” (PMI, 2013, p. 4). A project is a transient and temporary organization which is surrounded by intrinsic uncertainty (J. R. Turner & Müller, 2003). It is

With regard to complexity, PM is about making something complex happen through other people within the time, budget and quality constraints (Dh, 1987). In PM literature, project complexity is a key theme, as projects have become more complex and the capability to cope with complexity has become a need to avoid failure (Bakhshi, Ireland, & Gorod, 2016). Complexity is an increasingly important point of reference to grasp modern projects’ managerial demands and actual problems which are often encountered in projects (Kähkönen, 2008).

There are several factors that characterize project complexity. First, complexity is strongly correlated to the degree of the interaction between elements in a project (Aritua et al., 2009; Bakhshi et al., 2016; Vidal & Marle, 2008). In a program (or multi-projects) context, the level of complexity is higher, as it is affected by both the interaction between the projects in the program and the interaction between the elements within the projects (Aritua et al., 2009). Project complexity is also affected by the level of ambiguity and uncertainty in the project (Cicmil & Marshall, 2005) in a way that it is determined by how clear the objectives and methods are (J. R. Turner & Cochrane, 1993). It is also directly proportional to the number of decisions which need to be made (Vidal & Marle, 2008).

Geraldi and Adlbrecht (2007) introduce two types of project complexity, namely “complexity of faith” and “complexity of fact”. The first, on the one hand, underlines the effect of uncertainty levels on project complexity (e.g. developing something unique or dealing with new problems, where past data/information is limited). The second, on the other hand, is
affected by the huge amount of interdependent information that needs to be analyzed. Too much information could have a detrimental effect on projects, as project managers only need the relevant information at the right time (Strait & Dawson, 2006). The challenge here is not to get lost in the details, but to maintain a holistic view of the problem.

*Types of key decisions in the life cycle of a project*

In most cases, a typical project life cycle consists of four phases/stages: conceptualization, planning, execution, and termination (Adams & Barnd, 2008). These are referred to by PMI (2013) as “process groups” instead of “phases,” since they define “phases” as project subcomponents (e.g. concept development, design, build, test, etc.). However, the elements within each “phase” (or “process group”) are similar. In this study, we use the term “phase” due to the widespread use of the four-phase life cycle (Mian & Dai, 1999).

Mian and Dai (1999) study decisions which are often made in each project life-cycle phase. The first phase is *conceptualization*, in which projects are evaluated and selected. This is a critical phase, as the uncertainty level is at its peak as a result of the limited amount of available information and the severe consequences of making wrong decisions (Williams & Samset, 2010). The credibility of the DM process in this phase is often questioned, as decision makers’ individual or political interests could degrade DM quality (Flyvbjerg, Holm, & Buhl, 2002). The *planning* phase is conducted after the project has been selected (Samset, 2008). Decisions are mainly on team and organization form selection, bid evaluation and determining budgets. In the *execution* phase, the role of the project manager is to monitor and control the project. Examples of decisions in this stage would include selecting equipment and PM software, and deciding on the crashing/accelerating/compressing options if the project needs to be completed earlier or if it experiences anticipated delay and therefore additional resources and/or working hours are needed (Pinto, 2009). The *termination* phase
concludes the project. Decisions on team reassignment are usually made in this stage. A project can be terminated because its objectives have been achieved or because they cannot or will not be met (PMI, 2013). DM failure in this phase is usually caused by decision makers’ inability to stop projects despite their underperformance (Meyer, 2014; Staw & Ross, 1987).

An interesting phenomenon is that most educational games in PM literature simulate DM in project planning and execution phases (e.g. Vanhoucke, Vereecke, & Gemmel, 2005, Von Wangenheim, Savi, & Borgatto, 2011, Ayk, 2012). None of these games, however, specifically focuses on simulating crashing (i.e. acceleration) decisions despite the fact that it is often applied in practice, as most projects are late (Gerk & Qassim, 2008).

*Serious games: A combination of games and simulations*

The literature provides an interesting discussion on the distinction between *games* and *simulations*. The key determining factor is their main purpose (Lundy, 2003). Games are only for entertainment, whilst simulations are developed to train or develop certain skills. To students, games may sound more attractive than simulations, although perhaps in the absence of learning (Jones, 1989; Lane, 1995). Simulations, in contrast, underline tasks which require more practical or academic thinking (Jones, 1989). Aligning with this, simulations offer participants with the opportunity of acting and reflecting (Callanhan, 1999). This is not always inherent in a pure gaming environment. Furthermore, games focus on winning/competition, whilst simulations center on complex situations and realistic objectives that normally need to be dealt with on a daily basis (Callanhan, 1999). Games are mostly people-oriented (Shubik, 1983), as they enable more human interactions compared to simulations (Lane, 1995).
SGs, or educational games, combine the characteristics of a game and a simulation. They are developed not only to entertain players (Hendrix, Al-Sherbaz, & Victoria, 2016) but also to help them learn and/or change their behavior (Connolly et al., 2012). Specifically, by playing these games, participants are expected to learn new skills, expand existing knowledge and learn a specific topic (Dempsey, Lucassen, & Rasmussen, 1996). Like pure games, they can not only stimulate interactions but also be played individually.

**Decision-making definitions and types**

DM is a broad subject which has been studied since the mid-eighteenth century (Edwards, 1954). Different definitions on the subject and what it involves abound in the literature and spread across most, if not all, disciplines (Shull, Delbecq, & Cummings, 1970). DM can be viewed in terms of the event, i.e. selecting between two or more options (Lehto & Nah, 2006) using two or more criteria (Korhonen, Moskowitz, & Wallenius, 1992). It can also be seen in terms of the process leading to committed action which aims to yield satisfying results (Salas & Klein, 2001).

There are two types of DM: logical and judgmental/intuitive (Mian & Dai, 1999; Simon, 1987). In *logical DM*, on the one hand, objectives and options are made explicit, the effects of selecting other alternatives are quantified, and these effects are appraised by how close they are to the objectives. These structured decisions can be resolved relatively easily using a mathematical method or formula, such as operations-research-based decisions on the best production mix to achieve optimum profit. In *judgmental/intuitive* DM, on the other hand, decisions are often unstructured and subjective (e.g. decisions on employee selection and promotion). These types of decisions are usually difficult to quantify and are more common in the real world. In making these decisions, decision makers need to rely on their experiences and emotional inputs (Burke & Miller, 1999).
Although intuitive DM is seen as an increasingly viable approach in today’s business (Burke & Miller, 1999), many decision analysts still question its credibility (Deguire, 2010). Therefore, it is not surprising that PM literature is still dominated by the logical DM approach (Powell & Buede, 2006). By interviewing 60 experienced professionals who have significant positions across various industries, Burke and Miller (1999) find that a majority of these professionals “felt that intuition led to better decisions.” However, their work also suggests that, in some cases, DM by intuition can “get you into trouble” when accuracy is of importance (e.g. when conducting quality control). Burke and Miller (1999) further argue that intuitive DM should be applied when decisions are to be made unexpectedly or quickly, when coping with uncertainty or novel situations and when dealing with situations that lack explicit cues. However, if the time pressure and uncertainty is low, all information is available and problems are relatively simple with few DM options, the logical or analytic DM approach tends to be more effective (Pascual & Henderson, 1997).

As managers do “not have the luxury of choosing between analytic and intuitive approaches to problems,” they need to have both DM skills and apply them appropriately (Simon, 1987). This is also true in projects, as project managers “need to make decisions fast, yet accurately” (Urbaczewski & Kleitsch, 2011). The other challenge is that, in most cases, project decision makers are unable to make fully rational decisions, since projects are characterized by uncertainties and complexities (Miller & Hobbs, 2009). Hence, such decision makers tend to make decisions which are merely “satisficing” or “good enough” (Isenberg, 1991).


**Experimentation**

**Data collection**

Data were collected from 285 students who attended an MSc Management of Projects seminar at The University of Manchester. In the seminar, students played two PM games sequentially, namely a PCG and a PgCG. Before playing the games, players were randomly assigned into teams (i.e. project teams and program teams).

The instrument used to collect the data was an automatic data collection system embedded in the computer-based games. This system recorded teams’ decisions (i.e. crashed activities) and resulting project performance (i.e. cost and time) after each DM attempt. Computer-based games are applied in this study because they record the events and decisions taken, which are useful for debriefing and analysis purposes (Martin, 2000). Moreover, under this method, players were released from tedious calculations required in the paper-based method. Instead of spending effort on drawing the network diagram and calculating activity attributes in each iteration (e.g. earliest start, earliest finish, etc.), players focused on making and improving their decisions.

**Game settings**

The settings of both games were designed on the basis of the literature review discussed in the previous section. Both analytical and intuitive DM skills were needed to achieve the game objective, as players were required to make structured decisions in a gaming environment where time and competition pressure took effect. Specifically, they needed to review the crashing options, calculate the effect of their decisions (i.e. the effect of crashing each project activity on time and cost), make decisions (i.e. select activities to crash), and evaluate
performance (i.e. actual time and cost to deliver the project) against the goal (i.e. project schedule and budget).

In the first game (i.e. the PCG), 102 project teams (i.e. 2 to 3 students per team) were given a case from a product development project. They were asked to crash/accelerate the project since their company was attempting to launch a product before a competitor did. Teams had to select activities to crash in order to achieve the new project target (i.e. accelerated schedule within a budget constraint). In order to provide experiential learning by which students could decide, reflect, and make improved decisions, multiple attempts were allowed. Each project team competed against other teams in order to be the first to achieve the objective. This game was designed to improve students’ DM skills in the execution stage, particularly in crashing activities which are on the critical path and are cheapest to accelerate (Pinto, 2009).

The second game (i.e. the PgCG) is similar to the first. However, unlike in the first game, each team was required to work together with other project teams in a larger program group in order to crash the overall program. There were 21 program teams in total. As they were given limited time, they could not achieve the game objective without effective and efficient communication and leadership. Some program groups decided to appoint a program manager who managed each project team’s manager, whilst others communicated via an online chat box embedded in the game. This game was more complex than the first (i.e. in terms of the number of decisions and interactions needed). Like in real and complex projects (Jankovic, Stal-Le Cardinal, & Bocquet, 2010), the decisions in the PgCG were made collaboratively because none of the team had the necessary information to decide alone.
Data measurement and analysis method

Instead of measuring a subjective parameter (i.e. perceived learning), this study measures a more objective parameter (i.e. project performance after each decision), as recommended by Raia (1966). The relationship of project complexity level and improved DM is analyzed quantitatively by applying the cross-tabulation (chi-squared test of independence) method (Levine, Berenson, & Stephan, 1999). This method is used when investigating whether two or more categorical variables are independent or related to each other (i.e. in this study, whether the number of teams who made improved decisions are affected by the complexity levels of the games they played). Alternative methods (i.e. Fisher’s and McNemar’s tests) were not selected because the first is for small sample sizes and the latter for matched (or paired) samples (Fisher, Marshall, & Mitchell, 2011).

Results

a. Game attempts and decision-making performance

![Figure 2a Decision performance in the PCG by number of attempts](image-url)
Figures 2a and 2b indicate DM performance improvement when playing the PCG and the PgCG respectively. Another interesting similarity is, in both games, the number of teams who achieved the objective tends to increase sharply after the first attempts, but this rate declines and reaches a steady state on the last attempts. It should be noted that a relatively high proportion of teams (i.e. 51% in PCG and 43% in PgCG) did not achieve the game objective after multiple attempts. At the end, more teams (i.e. in proportion) achieved the goals in the more complex game (PgCG) than in the simpler one (PCG). This is a potential indication that the more complex the simulated project is, the more impact it has on DM improvement. However, this needs to be further analyzed, as we have not considered those who did not achieve the objectives but made improved decisions.
b. Improved decisions: Less complex versus more complex project management games

**Figure 3a** Decision performance breakdown in the PCG

**Figure 3b** Decision performance breakdown in the PgCG
Figures 3a and 3b further indicate that decisions were improved by playing the games. In fact, the proportion of teams who made improved decisions in both games are strikingly similar (i.e. 59%, or 60 project teams, made improved decisions in the less complex game, i.e. PCG, and 57%, or 12 program teams, made improved decisions in the more complex game, i.e. PgCG – see black pie chart area in Figures 3a and 3b). This could cancel our initial premise on the effect of simulated project complexity levels on DM improvement discussed in the previous section (i.e. the more complex the simulated project is, the more impact it has on DM improvement). Hence, a hypothesis testing is needed:

- Null hypothesis \( (H_0) \) : the simulated project complexity level in games affects DM performance improvement.
- Alternative hypothesis \( (H_a) \) : the simulated project complexity level in games does not affect DM performance improvement.

Table 1 displays the variables (or categories) and their values (i.e. game complexity levels and number of teams who made/did not make improved decisions).

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Game complexity level} & \text{Number of teams who made} & \text{Number of teams who did not} & \text{Total} \\
& \text{improved decisions} & \text{make improved decisions} & \\
\hline
\text{PCG (less complex)} & 60 & 30 & 90 \\
\text{PgCG (more complex)} & 12 & 5 & 17 \\
\hline
\text{Total} & 72 & 35 & 107 \\
\hline
\end{array}
\]

As discussed in the Data measurement and analysis method section, in order to test the hypothesis the chi-squared test of independence is applied on variables displayed in Table 1. Applying this method (i.e. using IBM SPSS Version 22), we find that the p-value for this test is 0.752, hence at 95% level of confidence (or 0.05 significance level), we reject our null
hypothesis and conclude that the simulated project complexity level in PM games is not related to DM performance improvement.

Discussion

Key findings

There are two key findings identified in this research:

- The application of PM SGs can improve players’ DM skills;
- The complexity levels of the simulated project in the games do not affect DM performance improvement.

Our first finding is consistent with the work of Morewedge et al. (2015), which suggests that a single training intervention (e.g. by playing games or watching videos) can improve DM. Aligning with this, Wolf (1972) argues that computer games can be used to help players to explore DM abilities and behavior. As more attempts are made, players (i.e. project decision makers) gain knowledge from similar prior experiences which are gained from reflecting on their previous DM attempts and their effect on project performance (Huff & Prybutok, 2008). This helps them to make improved decisions.

The second finding suggests that both the less complex and the more complex games have the same benefit on players’ DM performance improvement. In other words, game complexity levels do not affect project DM improvement. This is consistent with two existing studies which are conducted in a general management context:

- Raia’s (1966) work, which finds that the learning benefits of a simple game are essentially the same as those provided by a relatively more complex game and the complexity degree of the simulated environment is not directly proportional to students’ learning experience.
• Wolfe’s (1978) work, which finds that although increased game complexity is identical with greater DM comprehensiveness, increased challenge and lesser monotony, they are not positively linear to learning effectiveness.

There are several possible explanations as to why different simulated project complexity levels have no effect on improved DM performance. Although the PCG is simpler, in the more complex game (i.e. the PgCG), players (project teams) are required to communicate and be transparent with each other in order to achieve the objective. Transparency in DM is a key success factor in managing a portfolio of projects (Patanakul, 2015). From another perspective, collaboration amongst project decision makers may be beneficial for their learning, as they learn not only from their experience but also from others’ experiences. Supporting this notion, Krischner et al. (2011) finds that in more high-complexity cognitive tasks (i.e. like in the PgCG), collaborative learning becomes more effective. This is because in completing these complex tasks players need to share the task’s higher “cognitive” load with other players.

Furthermore, as the more complex game (i.e. the PgCG) presents more challenges and bases the overall program group performance on the performance of its weakest project team, it is less prone to the “social loafing” effect compared to the simpler game (Kerr & Tindale, 2004). “Social loafing” is a phenomenon where people reduce their work output when they work in a group environment (Steiner, 2007). As the risk of being evaluated is reduced, players can be tempted to “free ride” on other members’ efforts. The DM process in the more complex game requires more control and leadership, and thus may reduce the risk of “social loafing.”
Additional finding: Non-linear relationship between game attempts and project decision-making improvement

In addition to the two main findings, we also identify another interesting phenomenon whereby in both the more complex and the less complex PM games the number of teams making improved decisions increases sharply on the first attempts, but the rate slows down and reaches a steady state on the last attempts (see Figures 2a and 2b in the previous section). This phenomenon is consistent with the mixtures argument theory proposed by Newell & Rosenbloom (1981). At first, the faster learners dominate the total system learning because, a fortiori, they learn faster. Nevertheless, these learners soon make fewer contributions to total learning performance and the system is then dominated by the slow learners. Hence, the rate of improvement is slower than the initial improvement rate (Newell & Rosenbloom, 1981).

Conclusions and implications

This research suggests that PM SGs can improve DM performance in both more complex and less complex project scenarios. It further investigates the effect of complexity on students’ DM performance. The results suggest that different complexity levels in a simulated project do not affect DM performance improvement.

The impact of this research can be significant for academics and practitioners. For academics, the findings offer a new perspective, as they combine three major dimensions: DM, project complexity and SGs. This complements existing studies in PM literature which only analyze two of the three dimensions. In the real-world, this research could help PM educators to acknowledge the potential benefit of SGs application in teaching, particularly in developing trainees’ DM skills to cope with project complexity. This is significant, as current PM
education struggles to aid learners in coping with the actual complexity in projects (Thomas & Mengel, 2008).

**Limitations and directions for further research**

The complexity factors used to distinguish the games are limited to the number of players’ decisions and interactions. Other complexity factors (e.g. risks, uncertainties, scope changes) are not inserted into the games. Furthermore, the criteria used in this study to measure DM performance (i.e. game objectives) are limited to time and cost, whilst project success criteria are broader (e.g. quality and sustainability). We encourage further research to incorporate these and other complexity factors in its games, as it may add insights to our findings. However, one must be careful not to overcomplicate the games, as this can reduce learning effectiveness (Al-Jibouri & Mawdesley, 2001; Baird & Flavell, 1981).

Another limitation of this research is that the respondents who participated in the experiments were master’s degree students who mainly have little or no project-related work experience. To complement this work, we are conducting separate research which examines additional feedback from experienced program managers and PM trainers and consultants on how these games can be improved and how they can be applied in PM practice. In addition, a major PM training company has invited us to apply these games in one of their training sessions, which presents us with an opportunity to replicate the experiment.
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