voice of evidence

Method: How We Selected and Analyzed the Studies

This review was done to systematically review and synthesize the literature on the subject of games for software engineering education in tertiary education. In contrast to other reviews on the effectiveness of educational games in general [Ke08] [DLR96] [Hay05] [RMW+92] [VVC+06] [Wol97], this review focuses exclusively on software engineering education. In this context, we update and amplify the review on the application of game-based learning within software engineering by Connolly et al., by including also more recent games as well as also including simulations which have been used for educational purposes.

To conduct this review we followed a defined process for conducting systematic reviews [Kit04].

Inclusion and exclusion criteria

We examined all published English-language articles on games for software engineering education that were available on the Web (via digital libraries and databases), published between January 1990 and July 2008. We limited the articles to peer reviewed work, including only papers published in journals or conference proceedings.

We included any kind of game with educational purpose, including computer and non-computer games, as well as game-like simulations which have been applied for educational purposes.

On the other hand, we excluded:

- Any kind of student project or problem/project-based exercise (sometimes referred to as a “simulation”).
- Simulations which were not used for educational purposes.
- Any research focusing on the development of games as an instructional method which did not include any kind of validation of those games.
- Any study external to tertiary software engineering education.

Data sources and search strategy

We used IEEEXplore, the ACM Digital Library, Compendex EI, the ISI (Institute for Scientific Information) Web of Science, ScienceDirect and WILEY Interscience database.

We used the following search strings:

In IEEE XPLORE:

((game <or> simulation) <and> ("software engineering" <or> "software project" <or> "software requirements" <or> "software design" <or> "software construction" <or> "software testing" <or> "software maintenance" <or> "software configuration management" <or> "software process" <or> "software measurement" <or> "software quality") <and> education)<in>metadata) <and> (pyr >= 1990 <and> pyr <= 2008)

In ACM Digital Library:

(((Title:game) or (Abstract:game) or(Keywords:game)) or ((Title:simulation) or (Abstract:simulation) or(Keywords:simulation))) and ((Title:education) or (Abstract:education) or (Keywords:education)) and ((Title:"software engineering") or (Abstract:"software engineering") or (Keywords:"software engineering") or (Title:"software project") or (Abstract:"software project") or (Keywords:"software project")((((Title:game) or (Abstract:game) or(Keywords:game) or (Title:simulation) or (Abstract:simulation) or(Keywords:simulation)) and ((Title:education) or (Abstract:education) or (Keywords:education)))and ((Title:"software engineering") or (Abstract:"software engineering") or (Keywords:"software engineering") or (Title:"software project") or (Abstract:"software project") or (Keywords:"software project") or (Title:"software requirements") or (Abstract:"software requirements") or (Keywords:"software requirements") or (Title:"software design") or (Abstract:"software design") or (Keywords:"software design") or (Title:"software construction") or (Abstract:"software construction") or (Keywords:"software construction") or (Title:"software testing") or (Abstract:"software testing") or (Keywords:"software testing") or (Title:"software maintenance") or (Abstract:"software maintenance") or (Keywords:"software maintenance") or (Title:"software configuration management") or (Abstract:"software configuration management") or (Keywords:"software configuration management") or (Title:"software process") or (Abstract:"software process") or (Keywords:"software process") or (Title:"software measurement") or (Abstract:"software measurement") or (Keywords:"software measurement") or (Title:"software quality") or (Abstract:"software quality") or (Keywords:"software quality")))
Published since January 1990

In Compendex:

((game OR simulation) AND education AND ("software engineering" OR "software project" OR "software requirements" OR "software design" OR "software construction" OR "software testing" OR "software maintenance" OR "software configuration management" OR "software process" OR "software measurement" OR "software quality")) wn KY for 1990-2008

In ISI (Institute for Scientific Information) Web of Science:

Topic=(game) AND Topic=(software) AND Topic=(education)
Timespan=All Years.
Refined by: Subject Areas=(COMPUTER SCIENCE) AND Document Type=(ARTICLE) AND [excluding] Publication Years=(1977 OR 1984 OR 1985 OR 1989)

Topic=(simulation) AND Topic=(software) AND Topic=(education)
Timespan=All Years.
Refined by: Subject Areas=(COMPUTER SCIENCE) AND Document Type=(ARTICLE) AND [excluding] Publication Years=(1987 OR 1989 OR 1984 OR 1983 OR 1981 OR 1986 OR 1970 OR 1988 OR 1975 OR 1985 OR 1976) AND Topic=("software engineering")

In ScienceDirect:

pub-date > 1989 and Title-Abstr-Key ((game OR simulation) AND education AND ("software engineering" OR "software project" OR "software requirements" OR "software design" OR "software construction" OR "software testing" OR "software maintenance" OR "software configuration management" OR "software process" OR "software measurement" OR "software quality"))

In WILEY Interscience:

"(game OR simulation) AND education AND ("software engineering" OR "software project" OR "software requirements" OR "software design" OR "software construction" OR "software testing" OR "software maintenance" OR "software configuration management" OR "software process" OR "software measurement" OR "software quality") in All Fields, in all subjects, in product type Journals" 1990-2008

Study identification and selection

The initial search returned 741 papers. In the first stage, we quickly reviewed titles and abstracts with regard to the inclusion criteria. Irrelevant and duplicate papers were removed. These steps left us with 18 publications.

In addition to our inclusion/exclusion criteria, we also superficially assessed the quality of the reported evaluations, considering only articles which described the game and presented a separate section on its evaluation. Due to the sparse literature identified, we considered any kind of evaluation ranging from non-experimental to experimental designs. Using this criterion, 2 more were excluded because they did not report enough information on the game’s evaluation [AB06] [BDV+05].

This resulted in 16 articles, which were included in the review (see Table 3).

Data extraction and checking

For each paper selected for analysis, we extracted information in a spreadsheet covering the following items:

Study. Reference of the paper as well as additional documents (e.g., dissertations), which have been used to back up the extracted information.

Game description including a brief description of the game.

Study purpose. We classified the study purpose as explanatory, descriptive or analytic research and identified the focus of the evaluation.

Evaluation level. We classified the level of evaluation of the studies in accordance to Kirkpatrick's four-level model for evaluation [KK06], a popular and widely used model for the evaluation of training and learning as presented in Table 1.

Table 1. Overview on Kirkpatrick's four-level model for evaluation [KK06]

Level	**Evaluation level**	**Evaluation description and characteristics**	**Examples of evaluation methods and instruments**
1	Reaction	Evaluates how the participants felt about the training or learning experience	Typically accomplished by using questionnaires distributed at the end of a learning experience. Feedback forms; verbal reactions; post-training surveys; …
2	Learning	Evaluates the increase in knowledge or skills (before and after)	Assessments and tests before and after the training, interviews or observation
3	Behavior	Evaluates the degree to which new learning acquired during training actually transfers to the job measuring the actual performance in the job environment.	Observation and interviews over time to assess change, relevance of change and sustainability of change, observation of job performance, and the review of administrative data
4	Results	Evaluation of the effect on the business environment by the learner	Long-term post-training surveys; observation as part of ongoing, sequenced training and coaching over a period of time; metrics, such as re-work, errors, etc. to measure whether participants achieved training objectives; interviews with trainees and their managers, or their customer groups

Study type. We classified the type of each of the studies, following common research designs used in evaluations in education contexts as presented in table 2.

Table 2. Examples of common research designs

Study type	Design	Representation (X=treatment; O=measures/evidence; R=random assignment)
Non-experimental	One-shot post-test only	X O
	One-shot pre-test – post-test	O X O
Quasi-experimental	Static group comparison group	X O O
	Static group pre-test – post-test	O X O O O
	Times Series	O O X O O
Experimental	Randomized post-test only	R X O R O
	Randomized pre-test – post-test	R O X O R O O
	Randomized pretest - posttest control group	R O X1 O R O X2 O
…		

Instrument for data collection, such as interviews, observation, questionnaires, or content analysis.

Sample size indicating the size and kind of learners involved.

Time frame and/or number or game sessions played.

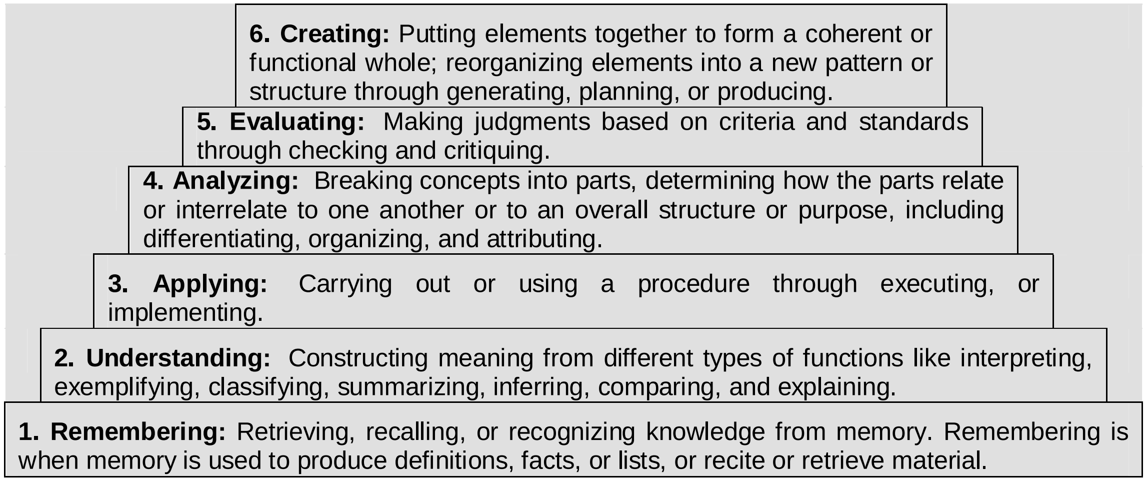
Game including a brief description of the game.

SE Knowledge Area based on SWEBOK [IEEE04] indicating the software engineering knowledge area on which the learning task is focused.

Learning task to be executed during the learning experience.

Study setting indicating in which educational context to game is supposed to be used.

Learning outcome identifying what the learner should achieve as a result of the learning experience. Here, we classified the learning outcomes into KSA (Knowledge, Skills, and Attitude) and used with regard to the learning of knowledge (cognitive domain) the revised version of Bloom's taxonomy for educational objectives [AK01] (see Figure 1) to refine the classification.



6. Creating: Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.

5. Evaluating: Making judgments based on criteria and standards through checking and critiquing.

4. Analyzing: Breaking concepts into parts, determining how the parts relate or interrelate to one another or to an overall structure or purpose, including differentiating, organizing, and attributing.

3. Applying: Carrying out or using a procedure through executing, or implementing.

2. Understanding: Constructing meaning from different types of functions like interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.

1. Remembering: Retrieving, recalling, or recognizing knowledge from memory. Remembering is when memory is used to produce definitions, facts, or lists, or recite or retrieve material.

Figure 1. Revised version of Bloom's taxonomy of educational objectives [AK01]

Learner characteristics considered in the study, such as, gender or level of experiences.

Principal findings summarizing the principal results of the study.

The articles were read thoroughly and data was extracted and cross-checked by a group of SE researchers at the LQPS – *Laboratório de Qualidade e Produtividade de Software*/UNIVALI (including professors and master students). Data extraction was hindered in several cases by the way in which the studies were reported. Most papers lack sufficient detail about the research design, execution and findings and do not report the studies in alignment with a research evaluation framework or guidelines. With few exceptions, issues of bias or validity are not addressed. On the other side, also the description of the games often is rather superficial. Thus, the values for many fields were inferred by us based on the information reported. Table 3 summarizes the information extracted.

In some cases, more than one study was reported in one paper, either on the same game or on different games. In this case, we extracted the information on each of the studies separately.

Descriptive Data

The 16 papers that were found described 21 studies on 12 different games. To summarize these studies, we present the following descriptive data.

Figure 2.a. shows the *type* of game examined by each study. As can be seen, computer-based simulations dominated the list of games being used in education. A breakdown of the studies by subject matter and learning domains reveals that the majority are developed for teaching Software Project Management knowledge (Figures 2.b and 2.c).

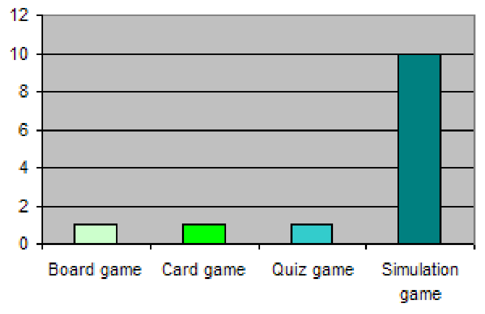


Figure 2.a Distribution per game type

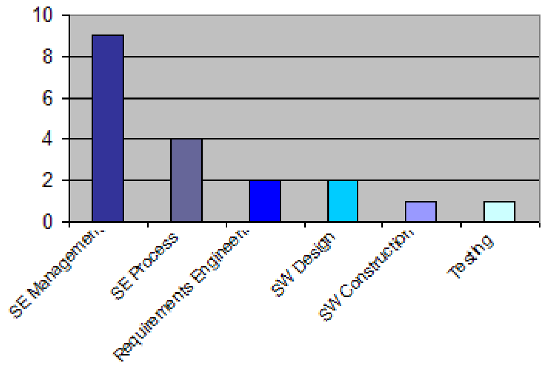


Figure 2.b Distribution per SE Knowledge area (more than one classification possible)

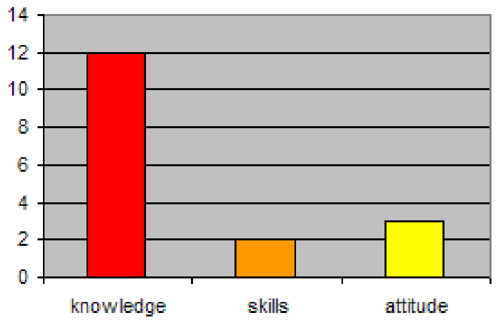


Figure 2.c Distribution per learning outcome domain (more than one classification possible)

Figures 3a and 3b summarize the studies we found according to the type of study: Whether it was non-experimental, quasi-experimental, or experimental (Figure 3b) and the level of Kirkpatrick's levels of evaluation (Figure 3b).

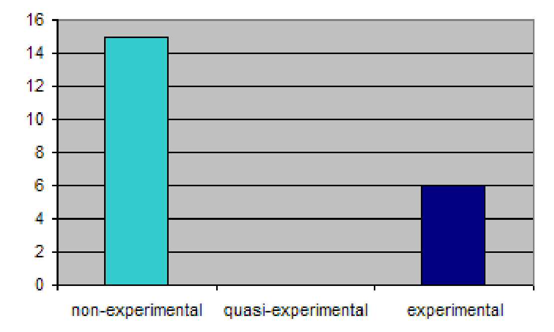


Figure 3.a Distribution per study type

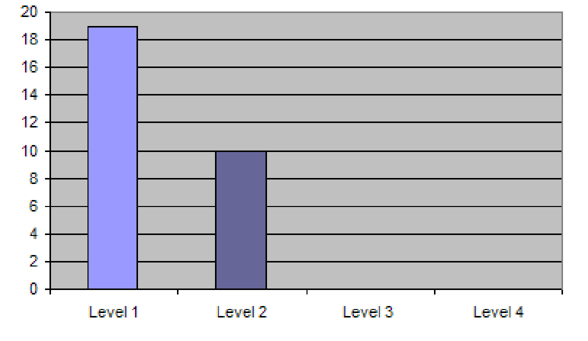


Figure 3.b Distribution of studies with respect to Kirkpatrick's model

Raw Data

Table 3, below, presents the entire set of data describing all studies found.

Table 3. Extracted data

ID	Study	Game Description	Study purpose	Evaluation level	Study type	Instrument	Sample size	Time frame	SE Knowledge Area	Learning task	Study setting	Learning outcome	Learner	Principal findings
S01	H. Sharp, P. Hall. An interactive multimedia software house simulation for postgraduate software engineers.	Open Software Solutions (OSS): a multi-player multimedia simulation of a software house, in which the learner joins software project teams to perform various technical tasks related to requirements engineering, SW design, SW testing and quality	Explorative: - Engagement - Usability - Strengths and weaknesses	1	Case study: One-shot post-test only X O	Questionnaire	Graduate students of computing for commerce and industry	appr. 100 hours of study	Requirements engineering. SW design, SW construction, SW testing	The learner 'joins' OSS as an employee and performs various technical	Game used as case study element of a SE graduate distance education course	Knowledge	--	Game is seen as easy to use and engaging. Student evaluation of the environment has been mixed and varies from very positive to very negative. - Positive aspects include its ease of use, and the inclusion of real case studies. - Negative aspects focus on the

	Proc. Int. Conference on Software Engineering, ACM: New York, 2000, pp. 688 - 691	assurance (for example, definition of state charts, entity-relationship-modeling, prototype evaluation). Each project has a mentor, who acts as project manager and offers guidance. Further feedback is also provided through sample solutions.								tasks as a member of the company's project teams.				relevance of the multimedia within the overall course and the amount of time it takes to work through the material.
S02	J. S. Collofello. University/industry collaboration in developing a simulation based software project management training course. Proc. 13th Conference on Software Engineering Education & Training, IEEE Computer Society, 2000, pp. 161 – 168.	Single-player software project simulator, which offers various exercises in which learner simulates software projects comparing life cycle models, risk management, software inspections, etc. The student's tasks are related to software project management activities, such as, planning and monitoring & control. The learner can provide input, monitor and adjust project variables via a graphical control panel.	Explorative: Added value	1	Case study: One-shot post-test only X O	Questionnaire	16 students	n/a	SE Management SE Process	Various exercises in which learner simulates software projects with respect to life cycle model comparison, risk management, planning and tracking, etc.	Simulator integrated into software project management course	Knowledge: 1-3	**--**	All participants found that the use of the simulator added significantly to the value of the course and its exercises.
S03	A. Drappa, J. Ludewig. Simulation in software engineering training. Proc. 22th Int. Conference on Software Engineering, ACM: New York, 2000, pp. 199 - 208	SESAM: a single-player computer-based simulation game for software project management in which the learner takes on the role of a project manager. S/he can hire employees, assign them to tasks or control the project's progress, etc. The simulator internally tracks various variables and provides status information to the user in form of textual messages. When the game is over, the player receives the score and can analyze his/her performance.	Analytic: Effectiveness	2	Experiment: Randomized[1] pre-test – post-test R O X O R O O	Test Project plan	19 computer science students	2 game sessions (session duration a couple of hours)	SE Management	Learner simulates project by taking the role of a software project manager	Complement to theoretical lessons in sw project manager education	Knowledge	**--**	Several students of the experimental group improved their performance. However, since the same improvement was observed in the control group, a learning effect caused by the SESAM system could not be shown.
S04			Analytic: Effectiveness	2	Case study: One-shot pre-test – post-test O X O	Test Project plan	9 computer science students	5 game sessions					**--**	Only minor changes in performance could be observed. Thus, a learning effect caused by the SESAM system could not be stated.
S05	P. Mandl-Striegnitz. How to successfully		Explorative: - Effectiveness - Strengths	1 and 2	Case study: X' O Y X'' O	Simulation scores Questionnaire	40 undergraduate students	2 sequential sessions	SE Management	Learner simulates project by taking the	Teaching concept that combines project	Knowledge	--	Comparing the performance of the students in the first and second simulation shows improvements of most of the

[1] The randomization step was not discussed in the published paper, but was confirmed via personal communication with the authors.

	use software project simulation for educating software project managers. Proc. 31st Annual Conference on Frontiers in Education, IEEE Computer Society, 2001, pp. 19-24				X': 1. simulation session Y: feedback session and seminar X'': 2. simulation session					role of a software project manager	simulations with traditional teaching components and analysis components (called feedback sessions)			students in the aspects captured by the simulation model. Yet, even in the second simulation run students still had problems to control their project and to allocate team members. Feedback sessions as part of the teaching concept are stressed to be the crucial point for achieving the educational goals. Students welcomed the chance to repeat the project to try different management strategies, immediately seeing the positive effects of applying what they have learned is very important.
S06	D. Pfahl, N. Koval, G. Ruhe. An experiment for evaluating the effectiveness of using a system dynamics simulation model in software project management education. Proc. of the 7th Int. Software Metrics Symposium , IEEE Computer Society, 2001, pp. 97 - 109	Scenario-driven interactive single-player web-based environment in which the learner has to plan and control a software project in the role of a project manager. For example, s/he can take corrective actions to complete the project considering the given resources and constraints, each action associated with project management principles and linked to model parameters. The system uses a System Dynamics (SD) simulation model, which represents three phases in a simplified, generic waterfall-model: design, implementation and test. The system presents simulation results as well as the possibility to analyze and interpret them.	Explorative: - Effectiveness - Interest	1 and 2	Experiment: Randomized pretest - posttest control group R O X1 O R O X2 O X1: SD simulation model with role-play scenario X2: COCOMO without role-play scenario	Test Questionnaire	12 computer science students	1 session (45 min)	SE Management	Learner has to plan and control a sw project in the role of a project manager	Using the process simulation model for university education in software project management	Knowledge: 1 Attitude	Personal characteristics (age, gender), university education, experience and preferred learning style.	The treatment involving the SD model had a positive impact on the change of scores from pre-test to post-test for all four dependent variables. The effect was statistically significant for Dep.1 (interest in the topic of project management), Dep.2 (knowledge of typical project behavior patterns) and Dep.3 (understanding of simple project dynamics). For Dep.4 (understanding of complex project dynamics) the power of the test seemed to be too low to be able to detect the effect at the set significance level ***a*** = 0.1. The treatment involving the SD model achieved practical significance on performance improvement and post-test performance for variable Dep. 1, and even statistical significance for variable Dep.2.
S07	D. Pfahl, O. Laitenberger, J. Dorsch, G. Ruhe. An Externally Replicated Experiment for Evaluating the Learning Effectiveness of Using Simulations in Software		Explorative: - Effectiveness - Interest - Improvement suggestions	1 and 2	External replication of 06 (meta-analysis) Experiment: Randomized pretest - posttest control group	Test Questionnaire	12 undergraduate and graduate students in computer science, information technology, information	1 session (80 min)					Personal characteristics (age, gender), university education, experience and	The results of the empirical study indicate that students using the simulation model gain a better understanding about typical behavior patterns of software development projects and increase the interest of the subject in software project management. The combination of the results from the initial experiment and the replication corroborates this finding.

	Project Management Education. Empirical Software Engineering 8(4), 2003, pp. 367-395.				R O X1 O R O X2 O X1: SD simulation model with role-play scenario X2: COCOMO without role-play scenario		engineering, microelectronic, mathematics						preferred learning style	Additional analysis shows that the observed effect can mainly be attributed to the use of the simulation model in combination with a web-based role-play scenario.
S08	D. Pfahl, O. Laitenberger, G. Ruhe, J.Dorsch, T. Krivobokova. Evaluating the learning effectiveness of using simulations in software project management education: results from a twice replicated experiment. Information and Software Technology, 46(2), Feb. 2004, pp. 127-147.		Explorative: - Effectiveness - Interest - Improvement suggestions	1 and 2	External replication of 06 and 07 (meta-analysis) Experiment: Randomized pretest - posttest control group R O X1 O R O X2 O X1: SD simulation model with role-play scenario X2: COCOMO without role-play scenario	Test Questionnaire	13 senior undergraduate students in computer science, electrical engineering and computer engineering	1 session (80 min)					Personal characteristics (age, gender, university education, experience and preferred learning style	Statistical significant evidence for the assumption that the training session involving the SD model instead of COCOMO plus performing a role-play significantly increases interest in the topic of project management, knowledge about empirical patterns in software projects, and understanding of simple project dynamics. No positive effect could be found for understanding of complex project dynamics. The results of each empirical study indicate that students using the simulation model gain a better understanding about typical behavior patterns of software development projects. The combination of the results from the initial experiment and the two replications with meta-analysis techniques corroborates this finding. Additional analysis shows that the observed effect can mainly be attributed to the use of the simulation model in combination with a web-based role-play scenario. This finding is strongly supported by information gathered from the debriefing questionnaires of subjects in the experimental group.
S09	D. Rodriguez, M. A. Sicilia, J. J.		Explorative: - Effectiveness - Interest	1 and 2	External replication of 06 (meta-	Test Questionnaire	11 undergraduate students	1 session (80 min)	SE Management	Learner has to plan and control a	Using the process simulation model for	Knowledge: 1 Attitude	Personal characteristics	Students using the e-learning system with the SD simulation model gained a better understanding about typical

	Cuadrado-Gallego, D. Pfahl. e-Learning in Project Management Using Simulation Models: A Case Study Based on the Replication of an Experiment. IEEE Transactions on Education, 49(4), Nov. 2006, pp. 451 – 463				analysis) Experiment: Randomized pretest - posttest control group R O X1 O R O X2 O X1: SD simulation model X2: COCOMO					sw project in the role of a project manager	university education in software project management		(age, gender, university education, experience and preferred learning style	behavior patterns of software development projects. The findings of the replicated experiment corroborates that using SD models increase the students' interest in software project management and also improve their knowledge about typical project behavior patterns.
S10	A. Baker, E. Oh Navarro, A. van der Hoek. An experimental card game for teaching software engineering. Proc. 16th Conference on Software Engineering Education and Training , IEEE Computer Society, 2003, pp. 216 – 223	Problems and Programmers: a multi-player card game that simulates the software process from requirements specification to product delivery based on the waterfall life cycle. Players take the role of the project leader in the same project and compete to be the first to complete the project. They pass through the phases of the software process and draw cards and take actions to continue the development as well as to react to problems. The winner of the game is the player who first achieves a sufficient number of integrated code cards without bugs.	Explorative: - Enjoyability - Effectiveness (reinforce and/or adquire new knowledge)	1	Case study: One-shot post-test only X O	Questionnaire	28 undergraduate students who had passed the introductory software engineering course	Played appr. 1½ hours, completing 1 to 2 games	SE Management SE Process	Learners take the roles of project leaders in the same company.	To be incorporated into an introductory software engineering course	Knowledge: 1-3	--	On average, students found the game quite enjoyable and relatively easy to play. Yet, they considered certain phases of the game as boring. Students felt that it was moderately successful in reinforcing SE process issues, but not very successful in teaching new SE process knowledge that was not introduced in class.
S11	K. Shaw, J. Dermoudy. Engendering an empathy for software engineering. Proc. of the 7th Australasian Conference on Computing education , Australian Computer	SimjavaSP: a single-player computer-based simulation game for project management. Learners take on the role of the project manager developing a hypothetical software product within the required time and budget, and of acceptable quality. For example, learners can hire developers, change the time allocated to V&V, assign a task, etc. Interaction occurs via graphical control panels	Explorative: - Enjoyability - Ease of play - Effectiveness	1	Case study: One-shot post-test only X O	Questionnaire participant demographics; • opinions on software development life cycles; • achievement of learning and knowledge acquired through the simulation; and	n/a	n/a	SE Management	Learners students to take the role of the project manager developing a hypothetical software product within the required	To be incorporated as a sw development process teaching tool, particularly at the introductory level	Knowledge	--	Clear qualitative indication that students enjoy learning through playing this simulation game. Students reported that playing the game was entertaining, and therefore it can be said to be providing them with intrinsic motivation. No clear indication of its learning effectiveness.

	Society, 2005, pp. 135 - 144	displaying the status of process and product attributes enabling the execution of management actions. The game ends when the project is 100% complete, or when the player runs out of either money or time.				• the usefulness of the simulator as a teaching tool				time and budget, and of acceptable quality				
S12	E. O. Navarro, A. van der Hoek. Comprehensive Evaluation of an Educational Software Engineering Simulation Environment. Proc. of the 20th Conference on Software Engineering Education & Training IEEE Computer Society, 2007, pp. 195 - 202 E. O. Navarro. SimSE: A Software Engineering Simulation Environment for Software Process Education. Doctoral Dissertation, Donald Bren School of Information and Computer Sciences, University of	SimSE: a single-player customizable, game-based simulation environment for educating students in software processes /management. The environment supports the creation and simulation of game-based software process simulation models. Currently game customizations for 6 models are available: waterfall, incremental, XP, rapid prototyping, RUP and inspections). In the game, learners take on the role of the project manager and must manage a team of developers in order to successfully complete an assigned software engineering project or task. The player drives the process by, hiring employees, assigning tasks, monitoring progress, purchasing tools, etc. At the end of the game, the player receives a performance score and a visual analysis of the game session, indicating which rules were triggered when, a trace of events, and the "health" of various attributes (e.g., correctness of the code) over time.	Explorative: - Enjoyability - Effectiveness (reinforce and new knowledge) - Strengths and Weaknesses of the game	1	Initial pilot study Case study: One-shot post-test only X O	Questionnaire	29 undergraduate students who had taken an introductory SE course	Playing for 2 hours completing 1-2 games	SE Process SE Management	Learner takes on the role of project manager and must manage a team of developers in order to successfully complete an assigned software engineering project or task.	As a complement to existing methods in a SE course	Knowledge	Gender Industrial experience Educational experience	Students found the game enjoyable and easy to play. Students felt that it helped to reinforcing SE process issues , but did not feel that the game taught them much new knowledge An explanatory tool is needed to provide students with more insight into their final score. Surprisingly, females rated nearly every question higher than males, suggesting SimSE's potential as an educational tool applicable to both genders.
S13			Explorative: - Enjoyability - Effectiveness (reinforce and new knowledge) - Strengths and Weaknesses	1 and 2	In-class evaluation Case study: One-shot post-test only X O	Questionnaire Test	2 introductory courses on software engineering	various game sessions					Gender Industrial experience Educational experience	Students found the game less enjoyable than in the initial study. Majority of students who play in parallel to a SE course were able to learn most of the concepts the models were designed to teach. Students felt that it helped to reinforcing SE process issues, but did not feel that the game taught them much new knowledge. Providing students with adequate and proper instruction in playing SimSE is critical. Students find SimSE repetitive when played for extended periods of time.
S14			Explorative: - Enjoyability - Effectiveness (reinforce and new knowledge) in comparison to other teaching	1 and 2	Comparative study Experiment: Randomized pretest -	Questionnaire Test	19 undergraduate students (12 who had taken an introducto	played three SimSE models					Gender Industrial experience Educational experie	In terms of measured gain in sw process knowledge, while all groups improved somewhat, the reading group improved the most, followed by the lecture group, followed by the SimSE group. However, data also shows that

	California, Irvine, 2006		methods - Strengths and Weaknesses		posttest control group R O X1 O R O X2 O R O X3 O X1: game X2: textbook reading X3: expositive lecture		ry software engineering course, and 7 who had not)						nce	the SimSE group in itself had significantly higher pre-test scores to begin with. Learners scored enjoyability and engagement high and the majority would choose to learn software process concepts through SimSE instead of other methods. Corrobates results from in-class study showing that: - SimSE is most effective when used as a complementary component to other teaching methods. - providing students with adequate and proper instruction in playing SimSE is critical. And, although it was clear that the longer a student plays SimSE, the more they learn, the study revealed that a longer playing time also contributes to a feeling of repetitiveness.
S15			Explorative: - Detection of learning theories involved	1	Observational study Case study: X/O O	Observation Interview	11 undergraduate students who had passed an introductory SE course	playing SimSE for 2.5 hours					--	Discovery Learning, Learning through Failure, and Constructivism are the learning theories most central to SimSE, being employed by all subjects. Learning by Doing and Situated Learning were employed by most subjects, but not all. Keller's ARCS theory was moderately evident, as some of its aspects (attention and satisfaction) were more seen more strongly than others (relevance and confidence).
S16	M. de O. Barros, A. R. Dantas, G. O. Veronese, C. M. L.Werner. Model-driven Game Development: Experience and Model Enhancements in Software Project Management Education. Software	The Incredible Manager is a single – player computer-based simulation game, where the learner acts as a project manager, being responsible for planning, executing, and controlling a software project. The goal is to complete a project, whose cost and schedule are established during a planning phase and approved by stakeholders. Project execution occurs in continuous turns, consuming the planned resources. The learner must monitor the project	Explorative: - Effectiveness - Enjoyability - Interest in project management - Strengths and improvement opportunities	1	Case study: One-shot post-test only X O	Questionnaire	Total of 11 undergraduate and 13 graduate students .	1 game session	SE Management	Learner acts as a project manager, being responsible for planning, executing, and controlling a sw project. His/her goal is to complete a project whose	n/a	Knowledge Skills Attitude	Academic degree, personal experience, and interest in software development and project management	Although the evaluation results were positive, they cannot support the effectiveness of the game-based project management education: (i) all participants approved the game-based model (ii) learners observed that they learned the lessons presented (iii) it was observed that they increased their management skills. (iv) 52.2% of participants considered the training session very pleasant. (v) majority described that the game experience raised their interest in project management.

	Process: Improvement and Practice, 11(4), Jun 2006, pp. 411 - 421	execution and take corrective actions when necessary. Visual effects and reports provide feedback, showing exhausted developers, late tasks, etc.								cost and schedule are established during a planning phase and approved by stakeholders.				Challenge, visual effects, and time pressure were viewed as important factors for the engagement and entertainment during the activity. The participants, especially novices, pointed out that graphical feedback and the possibility of practical simulation of real project situations were very stimulating. Game should be adapted to different learning situation, allowing management concepts to be presented incrementally to learners.
S17	E. Ye, C. Liu, J.A. Polack-Wahl. Enhancing software engineering education using teaching aids in 3-D online virtual worlds. Proc. 37th Annual Conference on Frontiers in Education , IEEE Computer Society, 2007, pp. T1E-8 - T1E-13	Multi-player Second Life version of the Groupthink exercise game focusing on requirements engineering. The objective of the game is to test the ability of a group of learners to reach consensus on software specifications. After discussing the specification within the group, players individually answer a set of questions on the specifications and the system evaluates the number of agreeing answers and presents performance statistics and the winner.	Explorative: - Effectiveness - Strengths and improvement opportunities	1	Case study: One-shot post-test only X O	Questionnaire	29 under-graduate and graduate computer science and computer engineering students	1 game session	Requirements engineering	The game divides the students into several groups, and tests the ability of a group to reach consensus on software specification.	As part of computer science classes to enhance SE education	Knowledge: 1 - 2 Skills: communication, team work	--	Majority of the students considered the game somewhat helpful to the Groupthink exercise. Principal strengths are scoring, team skills and interactivity and communication provided through Second Life.
S18	E. Ye, C. Liu, J.A. Polack-Wahl. Enhancing software engineering education using teaching aids in 3-D online virtual worlds. Proc. 37th Annual Conference on Frontiers in Education, IEEE Computer	MO-SEProcess is a multi-player online SE process game based on SimSE supporting the waterfall life cycle. Learners can choose one of six SE roles forming a development team together with other players. During the game, a player executes the selected role and can interact with other players. A team score is given at the end of game, if the team delivers the product before the deadline.	Explorative: - Effectiveness - Kind of knowledge learned (what did you learn) - Strengths and improvement opportunities	1	Case study: One-shot post-test only X O	Questionnaire	26 computer science and computer engineering students	At least 2 game sessions	SE Process SE Management	Learners can choose one of 6 SE roles. All the players joining the game will form a software development team. A team score will be given at the end of game,	As part of computer science classes to enhance SE education	Knowledge: 1-2 Skills: communication, team work	--	Majority of the students considered the game somewhat helpful to understand the software developing process in a team project. Principal skill learned is communication and collaboration among the team.

	Society, 2007, pp. T1E-8 - T1E-13									if the team can deliver the product before the deadline.				
S19	G. Taran. Using Games in Software Engineering Education to Teach Risk Management. Proc. of 20th Conference on Software Engineering Education & Training , IEEE Computer Society, 2007, pp. 211 - 220	Multi-player board game on software risk management, in which each player assumes the role of a project manager and competes against the others. The objective of the game is to develop a product, sell it in the market and win by having more money at the end than all the other players. In each step of the game, players can perform a project step or mitigate a risk considering the available resources and constraints. The main learning objectives are to teach risk management concepts, to enable learners to make risk-based decisions on their own and to understand the complexity of software projects.	Explorative: - Realism - Enjoyability - Simplicity - Effectiveness	1	Case study: One-shot post-test only X O	Questionnaire	150 students studying on campus and at a distance, in two separate courses taught multiple times over 4 semesters	n/a	SE Management	Each player assumes the role of a project manager and competes against the others. The objective is to develop a product, sell it in the market and win by having more money at the end than all the other players.	To be incorporated in courses dealing with software project risk management	Knowledge: 1-5	--	No synthesis of results available.
S20			Explorative: - Effectiveness - Enjoyability	1	Case study throughout the discipline: X1 O X2 O … Xn O X1: lecture X2: case study discussions Xi: game …	Questionnaire	40 students	**n/a**						Game indicated as the most enjoyable activity for that specific module – yet, students showed preferences in using multiple teaching approaches to teach risk management. Viability of games as a teaching approach to convey software risk management concepts shown. Yet, students ranked the ability to use concepts to evaluate situations and make decisions highest in the case study method (and not the game).
S21	A. I. Wang, T. Øfsdahl, O. K. Mørch-Storstein. An Evaluation of a Mobile Game Concept for Lectures Software Engineering. Proc. 21th Conference on Education and Training , IEEE Computer	Lecture Quiz is a multi-player game-show quiz, where learners have to answer multiple-choice questions. The teacher plays the role of a game show host and the questions (as well as performance results and feedback) are presented via the teacher’s PC and the players interact via their mobile phones. The learning objective of the game is to test and rehearse theory.	Explorative: - Effectiveness - Engagement - Usability	1 and 2	Case study: X’ X’’ O X’: game mode 1 X’’ : game mode 2	Questionnaire - Game scores	20 software engineering master students	1 game session (mode 1 and 2)	SW Design	Similar to a game-show, learners have to answer multiple-choice questions .	Evaluated as part of a software architecture lecture	Knowledge: 1	--	The game was easy to use. Game was perceived as entertaining, and half of the students claimed they would attend more lectures if such systems were used regularly. Indication of increased learning and preference in comparison to traditional lectures.

	Society, 2008. pp. 197 - 204													

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