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Successful implementation of user-centered game based learning in higher education: An example from civil engineering

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Abstract

Goal: The use of an online game for learning in higher education aims to make complex theoretical knowledge more approachable. Permanent repetition will lead to a more in-depth learning.

Objective: To gain insight into whether and to what extent, online games have the potential to contribute to student learning in higher education.

Experimental setting: The online game was used for the first time during a lecture on Structural Concrete at Master's level, involving 121 seventh semester students.

Methods: Pre-test/post-test experimental control group design with questionnaires and an independent online evaluation.

Results: The minimum learning result of playing the game was equal to that achieved with traditional methods. A factor called "joy" was introduced, according to [Nielsen, J. (2002): User empowerment and the fun factor. In *Jakob Nielsen's Alertbox*, July 7, 2002. Available from <http://www.useit.com/alertbox/20020707.html>], which was amazingly high.

Conclusion: The experimental findings support the efficacy of game playing. Students enjoyed this kind of e-learning.

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26 *Keywords:* Game-based learning; e-Learning; Human–computer interaction; Usability; Civil engineering; Structural
27 concrete; Theory of structures

28 “*A good game should be easy to learn, but difficult to master*”

29 Nolan Bushnell, the founder of Atari, Inc.

30 1. Introduction

31 Many projects have investigated the use of Internet and multimedia in Higher Education. Visual-
32 izations and animations are especially appropriate in engineering education (Ebner & Holzinger,
33 2003). Animations are generally more effective than comparable graphics in situations other than
34 conveying complex systems, e.g., for real time re-orientation in time and space (Tversky, Morrison, &
35 Betrancourt, 2002). For example, research supports the hypothesis that animation facilitates learning
36 when it presents fine-grained actions that static graphics do not present (Thompson & Riding, 1990).
37 However, animations are often too complex or too fast to be accurately perceived; continuous events
38 are also often conceived as sequences of individual steps. Careful use of interactivity can overcome
39 these disadvantages (Schnotz & Grzondziel, 1999). Learning is an active process on the part of the
40 learner and knowledge, as well as understanding, can only be constructed by the learners themselves
41 (Clark, 1994; Gagne, 1965; Holzinger, 2002a, 2002b; Wees, 1971). However, memorable educational
42 experiences should not only be enriching and transformational but also enjoyable (Shneiderman,
43 1998). Lastly, an important factor is the motivation of the students (Bloom, 1976; Holzinger, 1997;
44 Holzinger, Pichler, Almer, & Maurer, 2001; Logan & Gordon, 1981).

45 The project iVISiCE (interactive Visualization in Civil Engineering) was founded (Ebner &
46 Holzinger, 2002) to assist students of Civil Engineering during their learning process by using
47 visualizations and animations.

48 The students considered interactivity extremely important (Holzinger & Ebner, 2003; Ketten-
49 anurak, Ramamurthy, & Haseman, 2001; Kozma, 1991). Consequently the next phase of the pro-
50 ject was to develop Interactive Learning Objects (ILO's), which require that the students
51 independently operate this kind of visualization interactively using a didactically optimum
52 method. The didactical concept chosen accords with the instructional design of Gagne (Gagne,
53 1965; Gagne & Briggs, 1979; Holzinger, 2002a, 2002b). The interaction design has been realized in
54 close accordance to Preece, Sharp, and Rogers (2002) and Shneiderman (1998). Soon the idea of
55 building a Game Based Learning (GBL) module emerged.

56 2. Background theory

57 2.1. Game based learning

58 Despite the widespread recognition of the advantages attached to the use of games in elemen-
59 tary and secondary education, we found little evidence of their use in higher education. Game

60 Based Learning (GBL) is similar to Problem Based Learning (PBL), wherein specific problem sce-
61 narios are placed within a *play* framework (Barrows & Tamblyn, 1980). Previous experience in the
62 field of Medicine highlighted the usefulness of this approach (Baroffio, Giacobino, Vermeulen, &
63 Vu, 1997; Carlile, Barnet, Sefton, & Uther, 1998; Morrison, 2004; Schmidt, 1983). Subsequently,
64 PBL can provide a Student Centered e-Learning (SCeL) approach (Motschnig-Pitrik & Holzin-
65 ger, 2002).

66 Also, games include many characteristics of problem solving, i.e. an unknown outcome, mul-
67 tiple paths to a goal, construction of a problem context, collaboration in the case of multiple
68 players etc., and they add the elements of *competition* and *chance*. However, online games pro-
69 vide the additional possibility of building teams of players who are geographically scattered.
70 The benefits of learning through games are numerous (Mann et al., 2002), and games are often
71 closer to simulating real life experiences than more traditional educational media. This allows
72 the students to immerse themselves in a realistic simulated setting without the fear of real life
73 consequences, which – although not the necessity it is in Medicine – is also very useful in Civil
74 Engineering.

75 2.2. What makes a computer application fun to operate?

76 Fantasy can be very important in creating intrinsically motivating environments. However,
77 these must be carefully chosen to appeal to the target audience. Usually, user interfaces are
78 designed for tools and not games but much of the motivation for using a system depends on the
79 user's motivation to achieve an external goal.

80 In cases where the external goal fails to provide the necessary motivation, particularly where the
81 subject of the exercise is routine and boring, a game-like interface can be useful in making the
82 activity enjoyable. For any activity to be challenging, it needs to have a goal with an uncertain out-
83 come. The end-users need a performance feedback in order to judge how well they are achieving
84 their goals.

85 Malone (1981) summarized three essential characteristics for computer games to answer the
86 question of what makes a computer application enjoyable to operate: challenge, fantasy and curi-
87 osity. Whereas, challenge and curiosity are important aspects in the iVISiCE Internal Force Mas-
88 ter (IFM) game (see Section 2.3), fantasy is only relevant in adventure games, in Civil Engineering
89 education it could possibly be contra productive.

90 2.2.1. Challenge

91 These characteristics must encompass a clear goal and provide performance feedback regarding
92 the end-users' imminence to accomplishing their goal. The outcome of reaching the goal must be
93 uncertain (not predictable). An adjustable difficulty level is helpful in this respect and must include
94 scorekeeping.

95 2.2.2. Curiosity

96 Any activity designed to provoke the end-users curiosity must provide an optimal level of infor-
97 mational complexity (Piaget, 1951). This includes the use of randomizing to add variety without
98 making the tools unreliable. Malone (1981) emphasizes that environments should be neither too
99 complicated nor too simple with respect to the end-user's existing knowledge.

100 In any case, they must be novel and surprising while remaining comprehensible. In general, an
101 optimally complex environment will be one where the end-user knows enough to be able to antici-
102 pate what will happen but where their expectations are sometimes wrong.

103 2.3. *The concept of the online game: internal force master (IFM)*

104 The concept of the online game Internal Force Master (IFM) is to provide a motivating com-
105 puter game, wherein players need to identify the right solution in order to win. Even players not
106 willing to learn may do so indirectly; by playing and remembering the correct solution – and we
107 consider that the learning effect is much higher in an emotional and motivated situation, such as
108 when playing a game (Brehm & Self, 1989; Holzinger & Maurer, 1999; Holzinger et al., 2001; Ket-
109 tenanurak et al., 2001).

110 In order to test the efficiency of incidental learning methods and to measure the degrees of moti-
111 vation, certain demands have been placed on the learning module:

- 112 • *Background:* The target group must be able to identify with the contents of the game. The learn-
113 ers must become annoyed when they are loosing – this leads to a higher degree of motivation;
- 114 • *High score and time limits:* A lose–win situation also seems to be necessary for high motivation.
115 Difficult time limits should induce the learner to play again and again. Repeated playing leads
116 to more in-depth learning, according to (Skinner, 1954);
- 117 • *Simplicity and clarity:* Controlling the game flow without the need to read endless instructions
118 is a further step for motivating to play; this is directly connected with
- 119 • “ease of use”, which includes the possibility of adjusting the game for different levels of expertise; a
120 precondition of every successful game (Malone, 1982; Nielsen & Mack, 1994; Shneiderman, 1998).

121 2.4. *Content of the game*

122 The content of the game is based on the Theory of Structures. Before starting *any* project, each
123 Civil Engineer must calculate the internal forces of the statically determined or undetermined sys-
124 tem. Only after completing this calculation ist the design of, for example, a structural concrete
125 (wood, steel, etc.) beam possible.

126 The correct calculation of the internal forces is *the* precondition for all further measures – con-
127 sequently this is the basic and most important content of the whole study of Civil Engineering. In
128 the same way that it is necessary for every pilot of an airplane to train with a flight simulator, the
129 calculation of the internal forces is necessary for every student of Civil Engineering. This learning
130 process appears to take a long time.

131 The calculations necessary for the practical work of a Civil Engineer can be done today by
132 using computers. However, since the development of specific software it has been possible to solve
133 very complex problems within a very short time. Consequently, today the job of an engineer is to
134 make the right input and to *check and supervise* whether the output is correct. The principal task of
135 a stress analyst is to secure the exact estimation of the solution and to provide the right graphics
136 and lines of the internal forces.

137 It can be summarized that the purpose of our Internal Force Master was to help learners in the
138 field of static determinate systems by training them to distinguish carefully the correct internal

139 forces from wrong solutions *within an extremely short time*. Because of the ready availability and
 140 the encouraged use of computers, the students, of course, do not practice the calculation by them-
 141 selves and they are allowed to analyze structures on the computer, which exceeds their level of
 142 learning.

143 2.5. What is the internal force master (IFM)?

144 Internal Force Master (IFM) can best be described as educational game software specifically
 145 designed and developed for the study of Civil Engineering. The aim was to build an online com-
 146 puter game, which provides a high level of fun *and* motivation.

147 The game was programmed and designed with Macromedia Flash. As we have already shown
 148 (Holzinger & Ebner, 2003), Flash is one of the primary tools for creating content for the World
 149 Wide Web. Using the programming language Action Script it has been possible to program end-
 150 user dependent interactive tools and a specially designed online game. One of the main advantages
 151 of Flash is the very compact file size – which is a precondition for usable online distribution. Fur-
 152 thermore, only one browser plug-in is necessary – the only method which is acceptable for a heter-
 153 ogeneous environment at a university. We preferred Flash because of the possibility to quickly
 154 develop usable visualizations of the engineering models.

155 The design of the game started in January 2003 with an extensive survey and study of the mate-
 156 rial (see Fig. 1). The development team consisted of a Civil Engineer (domain expert) with experi-
 157 ence in e-learning and didactics; an expert on Human–Computer Interaction (HCI), who managed
 158 the User-Centered Development (UCD) approach (Holzinger, 2002a, 2002b; Holzinger, 2003) and
 159 the application of rapid prototyping (Holzinger, 2004); and Flash experts as well as students,
 160 whose responsibilities included drawing the examples.

161 Bearing in mind the didactical concept, the software has been separated into so-called *main*
 162 *screens*. These main screens consist of:

- 163 • *The start screen (Fig. 2)*: A description of the content and the necessary tasks are shown on this
 164 screen. Further, a definition is given of the colors used and the directions are specified. At the

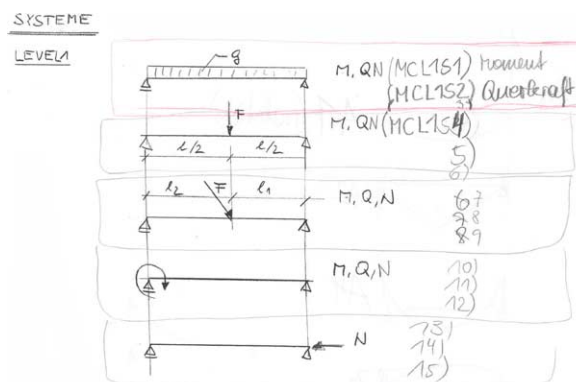


Fig. 1. One of the first sketches during the design.



Fig. 2. The start screen.

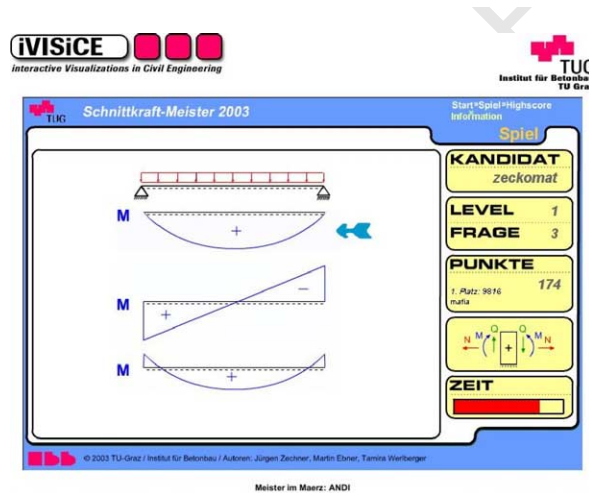


Fig. 3. The main screen.

165 end, there is the possibility for the player to choose an identifying name (nickname), which will
 166 appear in the high score lists after the game, and to choose the difficulty level.

- 167 • *The infor(mation) screen (Fig. 4)*: This screen provides an overview of the online game. The
 168 learning goals are described and also the necessary previous knowledge. The concept of this
 169 kind of meta-information is the same as we used during the development of our Interactive
 170 Learning Objects (ILO) and is a result of extensive usability studies including methods such as
 171 thinking aloud, cognitive walkthrough and video analysis (Ebner & Holzinger, 2003). The con-
 172 cept of the screens are also shown and their connection to each other.
- 173 • *The main screen (Fig. 3)*: This screen is the “game” screen, here the game takes place. On the
 174 top of the screen a static determinate system is presented and directly underneath three possible
 175 solutions. Within the available time (represented by a decreasing red bar) the learners must click

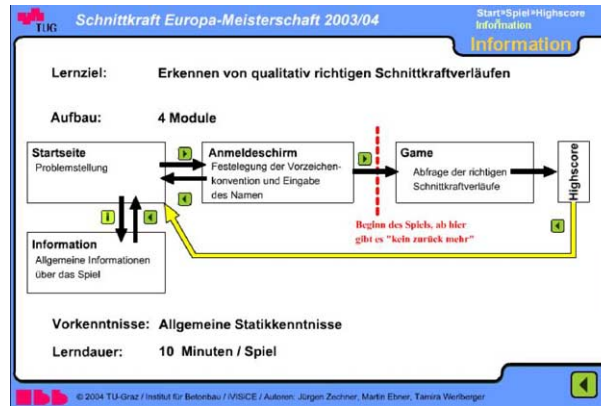


Fig. 4. The info screen.

Schnittkraft Europa-Meisterschaft 2003/04

Start*Spiel*Highscore
Highscore

| Österreich | Deutschland | Andere | Aktueller Europameister: |
|----------------------------------|------------------------------|-------------------------------|---|
| 1. Platz: 14444 havel | 1. Platz: 13999 erISD | 1. Platz: 12457 Claude TUM | Name: havel Punkte: 14444 Datum: 28.2.04 |
| 2. Platz: 14068 willi | 2. Platz: 13662 be haw hh | 2. Platz: 12429 Thimo | Meister des Monats: Monat:08/2004 Name:abcd Punkte:9565 |
| 3. Platz: 13435 Josef | 3. Platz: 13334 cbe | 3. Platz: 12372 Andi TUM | Meister der letzten Monate: Monat:07/2004 Name:be haw hh Punkte:13627 |
| 4. Platz: 12350 Hoeh | 4. Platz: 13160 chris | 4. Platz: 11896 Max | Monat:08/2004 Name:be haw hh Punkte:13627 |
| 5. Platz: 11795 ISTHM | 5. Platz: 13116 chb | 5. Platz: 7855 Berni FHA | Monat:07/2004 Name:be haw hh Punkte:13627 |
| 6. Platz: 8127 Robert u Sasha | 6. Platz: 12939 clemens | 6. Platz: 7740 Ingo | Monat:08/2004 Name:be haw hh Punkte:13682 |
| 7. Platz: 7488 hoeh | 7. Platz: 9565 abcd | 7. Platz: 7711 Hans | |

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Fig. 5. The high score list.

176 on the correct solution – to reach the next example, question or problem. This is repeated
177 throughout the game.

- 178 • The game is separated into 6 levels, which differ in the degree of difficulty of the examples and in
179 the available time for solving them. The examples change with every new game and the possible
180 solutions are randomized. This is required to counteract the decreasing motivation effect. By
181 developing a large number of examples and possible solutions, the danger of a player attuning
182 to the first level too rapidly is avoided.
- 183 • *High score list (Fig. 5)*: After each game the high score lists are presented. If the players' points
184 are high enough their nickname is registered together with their result. The lists are separated
185 into a *best of the month* and a *current high score* list.

186 The development of the game took place from January 2003 to October 2003. In accordance
187 with Nielsen (Nielsen, 1993, 1994; Nielsen & Levy, 1994; Nielsen & Mack, 1994), usability princi-
188 ples were used to help adopt the game for the target group in the best possible way.

189 One of the crucial factors during the design and development of the game was the User Cen-
190 tered Design aspect, which was extended to a User Centered Development. During the early
191 design phase, we were able to locate the end-users' problems (Holzinger, 2004). Nielsen and
192 Molich (1990) found that the optimum number of participants in such usability oriented develop-
193 ment cycles were three to five per user class and that a larger number showed diminishing returns
194 (Nielsen & Molich, 1990).

195 During our development, five students of Civil Engineering played the game for the first time at
196 the institute and participated in extensive usability tests. For example, students remarked that the
197 clicking area was too small; other students expressed that they did not know how many points
198 they had obtained for the actual level and how many levels were implemented, etc.

199 In summer 2003, an online test phase was established, including a larger number of students, to
200 check the performance and to identify any remaining bugs of the software.

201 New static systems were also implemented to enhance the variation of each level. For example,
202 one of the last feedbacks received, mentioned that there was no possibility of getting into the high
203 score list during a short online presence and that this was very frustrating for the students.

204 The findings of all these usability methods have been taken into account for the re-design of the
205 end product, which began in November 2003.

206 3. Research

207 3.1. Questions and hypotheses

208 Some of our Questions included:

209 **Q1:** Does this game lead to similar/equal learning results as the traditional methods? Are there
210 any disadvantages for the learners who used this game?

211 **Q2:** Does playing this game on a voluntary basis feel similar to incidental learning?

212 **Q3:** Is there a difference in the *enjoyability factor* between the online population and the partici-
213 pants in the lecture?

214 **Q4:** Is good usability a precondition for the acceptance of the game?

215 **Q5:** Does the game lead to increasing motivation to play again?

216 On the basis of our questions we formed hypotheses, which we carefully proved by using the
217 game Internal Force Master (IFM):

218 **H1:** Playing this game leads to at least equivalent learning results as the traditional method –
219 there is no disadvantage for the learners who used this game.

220 **H2:** Playing this game on a voluntary basis feels like incidental learning.

221 **H3:** The online participants and those attending the lecture experience a difference in the *enjoy-*
222 *ability factor*.

223 **H4:** Ease of use is a precondition for acceptance of the game.

224 **H5:** The game environment and the high score lead to increasing motivation – the learner plays
225 the game again.

226 All these hypotheses are independent of the end-user profile, this means that there is no differ-
 227 ence between an Internet expert and a novice.

228 3.2. Experimental design, setting and demographics

229 The game was tested during the Structural Concrete course at the University of Technology of
 230 Graz from November 2003 to January 2004. Parallel to the students of Civil Engineering, the
 231 game was made accessible to the public. Especially universities in Austria, Germany and Switzer-
 232 land (the German speaking countries) were invited to participate. We designated this community
 233 the *online population*.

234 In the end there were three groups:

- 235 • students who attended the lectures/courses and *played* the game on a voluntary basis (“playing
 236 students”);
- 237 • students who attend to the lectures/courses and did not play the game (“non playing students”);
- 238 • online participants who only played the game (“online population”).

239 As method, we used the pre-test/post-test experimental control group design with question-
 240 naires for the participants of the lecture. As shown in Fig. 6, the students ($N=47$) had to complete
 241 the pre-test during the first hour of the lecture.

242 They had to draw five internal forces of static determinate systems, which were also the content
 243 of the game (Fig. 7). After the first test the game was presented to the students and lecturers and it
 244 was emphasized that the tool can be used for free and on a voluntary basis via the Internet. Two
 245 months later, at the end of the lecture(s), the post-test took place (Fig. 8). The principles and tasks
 246 were the same as in the pre-test but there were some additional questions concerning the research.
 247 $N=60$ students took part in the post-test.

248 Parallel to the pre-test/post-test experimental control group, there was the possibility of playing
 249 the game and evaluating it online, independent of the participants of the lecture(s). To date, 108
 250 evaluations from the research period have been received.

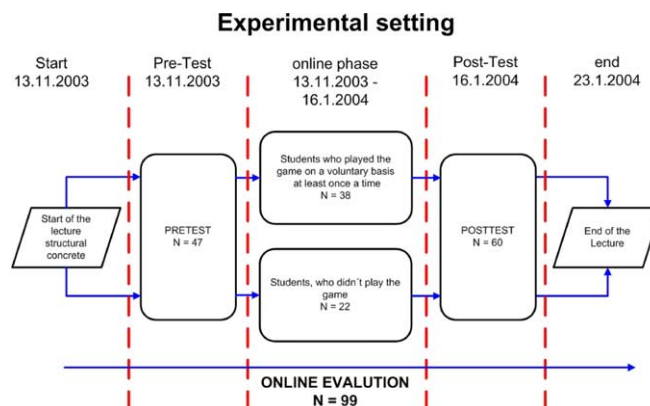


Fig. 6. The experimental setting; please notice that the students took part on a voluntary basis.

5. Zeichnen Sie die zugehörige **Normalkraftslinie**?

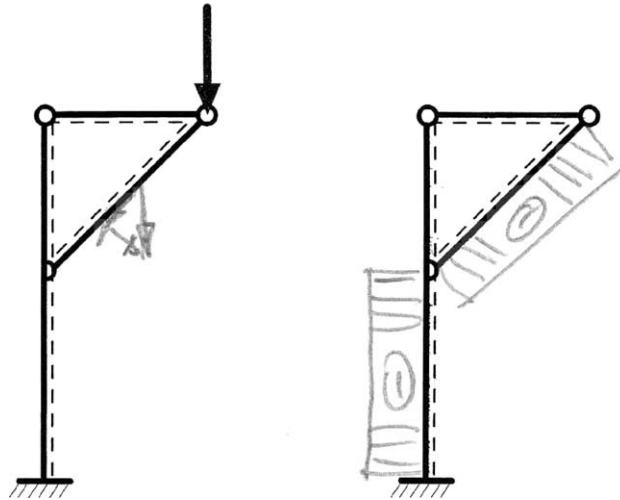


Fig. 7. Example: this problem was stated within the pre-test.

5. Zeichnen Sie die zugehörige **Normalkraftslinie**?

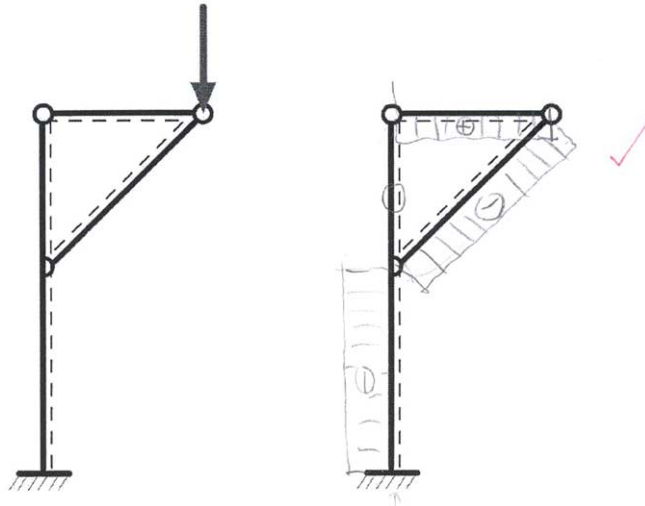


Fig. 8. Example: this problem was stated within the post-test.

251 We must point out that *all* of these investigations took place *within a real-life setting*, including
 252 all its disadvantages; subsequently we were not able to gather data similar to a laboratory setting.
 253 All participants took part in the experiment on a voluntary basis. Although this lack of control
 254 necessarily weakens our ability to generalize from the data, the chosen method has the strength of
 255 ecological validity. The difference between the number of participants in the pre- and post-test is
 256 also well founded on the real-life setting. Both populations are a randomly variety and strongly
 257 according to the whole student personnel.

258 The voluntary aspect of these experiments was one of its strengths. If the students would have
259 been forced to take part, the results would probably have been less successful.

260 4. Findings

261 4.1. Statistical methods

262 We used Mann–Whitney tests, Chi-Quadrat and Wilcoxon tests, as well as the correlation
263 coefficient according to Spearman for measuring statistical correlations (Christensen, 2001).

264 5. Results

265 **H 1.** Playing this game leads to at least equivalent learning results as with the traditional way –
266 there is no disadvantage for the learners who used this game.

267 The students of the lecture had been tested with the aid of the pre-test/post-test method. They
268 had to draw five internal forces of static determinate systems.

269 The solution to such a problem is unique and so the test result was defined by counting the cor-
270 rect solutions. 0 meant that all examples were wrong and 5 that all examples were correct (see
271 Fig. 9).

272 In Table 1, all the results of the tests have been listed.

273 The main conclusion is that there has been an obvious increase of the “correct solution” factor.
274 Before the lecture the students had drawn, on average, three correct internal forces. At the end of
275 the three months the average had increased to 4.

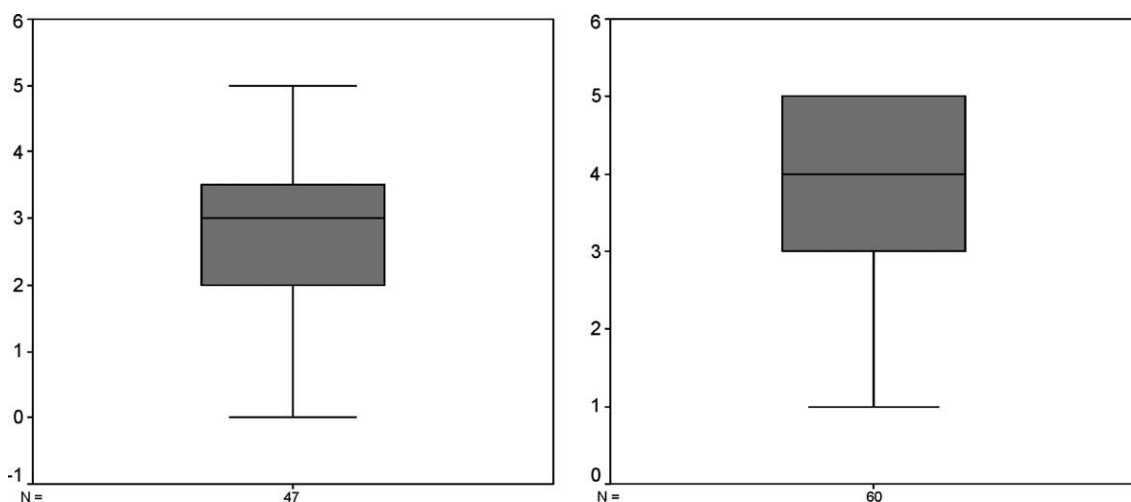


Fig. 9. Result of the pre-test and post-test.

12

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Table 1
Result of the pre-test and post-test

| Test | <i>N</i> | Mean | Standard deviation | Median |
|---------------------------------|----------|------|--------------------|--------|
| Pre-test | 47 | 2.72 | 1.425 | 3 |
| Post-test | 60 | 3.95 | 1.08 | 4 |
| Post-test, playing students | 38 | 4.03 | 1.026 | 4 |
| Post-test, non playing students | 22 | 3.82 | 1.18 | 4 |

276 Further, the group who completed the post-test was split into two groups: Those who played
 277 the game during their learning process (“playing students”) and those who never played it (“non-
 278 playing students”). The result shows that there is no difference between the two groups, which
 279 shows that the “playing students” group had the same learning result as the group who learned by
 280 the traditional method.

281 **H 2.** Playing this game on a voluntary basis feels like incidental learning.

282 This questionnaire deals with incidental learning. On a scale from 1 to 5 the players had to
 283 answer whether they feel *provoked* about their drop out and will play once more or not. The result
 284 is listed in Table 2. 1 means “yes, I fully agree” and 5 “no, I do not agree.”

285 The mean of 2.12 shows that the majority of the players cannot believe that they are losing. It
 286 should be further mentioned that nearly all (98%) played the game once more.

287 Collected comments of the evaluation showed further hints for incidental learning. Some play-
 288 ers commented: “After I chose the wrong solution, the correct answer should be shown by the
 289 game, because I want to learn it” (7 statements), “Some comments as to why this solution is the
 290 wrong one would be useful” (5 statements) and “a game mode without time limits for beginners
 291 could be helpful” (3 statements).

292 **H 3.** The online participants and those attending the lecture experience a difference in the enjoy-
 293 ability factor.

294 The next question concerned the so-called *enjoyability factor* (Knuth & Cunningham, 1993;
 295 Malone, 1980; Raskin, 2000).

296 NB: We called this factor preliminarily “fun factor”, but *enjoyability* factor seems to be more
 297 appropriate.

298 First the players had to point out whether they enjoyed playing the game (1) or not (5).

299 It is interesting that both groups (online group and the participants of the lecture) like playing,
 300 which can be seen in Table 3.

Table 2
Results of the question: “An early drop out dares me to play once more”

| Test | <i>N</i> | Mean | Standard deviation | Median |
|------------------|----------|------|--------------------|--------|
| All (evaluation) | 141 | 2.12 | 1.15 | 2 |

Table 3

Results of the question: "Playing the game is fun"

| Test | <i>N</i> | Mean | Standard deviation | Median |
|-------------------|----------|------|--------------------|--------|
| Online evaluation | 103 | 1.48 | 0.756 | 1 |
| Post-test | 38 | 2.39 | 1.264 | 2 |

Table 4

Results of the question: "I have no problem playing the game"

| Test | <i>N</i> | Mean | Standard deviation | Median |
|------------------|----------|------|--------------------|--------|
| All (evaluation) | 141 | 2.27 | 1.52 | 2 |

Table 5

Results of the question: "I think that the implementation of the high score was absolutely necessary"

| Test | <i>N</i> | Mean | Standard deviation | Median |
|------------------|----------|------|--------------------|--------|
| All (evaluation) | 141 | 1.92 | 1.19 | 1 |

301 The following Chi-Quadrat-test turned out a significant correlation ($p=0.033$) between both
 302 groups. Altogether our theory has been confirmed, that the players like to play the game.

303 **H 4.** Ease of use is a precondition for acceptance of the game.

304 The students had to answer a further question concerning the ease of use. On a scale of 1–5, 1
 305 meant the usability of the game was good and 5 meant that it was not.

306 The Mean of 2.27 (Table 4) was surprisingly good because there was no help function on how to
 307 play and no hints on how to navigate through the game.

308 This result confirms also all assumptions that good usability leads to an intuitive correct handling.

309 **H 5.** The game environment and the high score lead to increasing motivation – the learner plays
 310 the game again.

311 The last question concerned the problem of motivation. During the programming of the game it
 312 was been mentioned that a high score is absolutely necessary for a game. Now we wanted to know
 313 if the players also thought so – does the availability of such a list lead to more frequent playing?
 314 On a scale of 1–5, 1 meant that the implementation of the high score is necessary, 5 that it is not.

315 The result of Table 5 pointed out that the high score list is definitely necessary. Moreover, the
 316 tracking of the players showed that some players played the game repeatedly. This is a definite
 317 sign that this person will achieve a higher score in the lists.

318 6. Discussion

319 6.1. Learning result

320 In H 1 it has been shown that playing the game leads – at least – to an equal learning result as
 321 with the traditional method.

322 Further, H 3 pointed out that the fun factor for playing is higher than expected. The combination of
323 these two hypotheses means that there is a positive effect caused by Game Based Learning because the
324 learners enjoyed playing the game during their learning process and achieve at least an equal result.

325 6.2. Motivation

326 A high level of motivation is often a prerequisite for success. There is a high probability that
327 learning will not be successful if there is a lack of motivation. Therefore we needed some tactics to
328 motivate the students to play the game repeatedly. First the game environment and the design
329 should help to keep the students playing. Further, of course, the content of the game and also the
330 implementation of the high score lists should be motivating factors.

331 In H 5 it could be shown that almost every learner played the game again. The motivation of
332 the players was high enough for another run.

333 6.3. Incidental learning

334 In the traditional method of classroom learning, intentional learning dominates. With the aid of
335 the game incidental learning is possible because the primary intent of the players is to accomplish
336 the game rather than to learn. According to Lankard (1995, available online: <http://www.ericfacility.net/ericdigests/ed385778.html>) incidental learning occurs when it is unexpected – a byproduct
337 of other activities, such as, for example, playing a game.

338 Although the students played the game on a voluntary basis – and their primary intent was of
339 course *not* to learn – after playing the game once, a learning process occurred.

340 In H 2 it could be shown that the players discovered their mistakes and felt motivated to play
341 again. Incidental learning is also characterized by discovering something while in the process of
342 doing something else: *serendipity*.

343 Further the collected comments of the users have shown that, after the students failed, they
344 thought about the correct solution and wanted to learn why the selected answer was wrong. Their
345 statements pointed out an ongoing learning process on the part of the players.

347 6.4. Usability

348 In H 4 the usability of the game was tested. “As simple as possible” – was demanded of the end-
349 user group because things which can be used without reading complex instructions first are used
350 more enthusiastically than others. The paradigm was that *no help tools* should be necessary to
351 explain how to play the game correctly. Every student of Civil Engineering has to be able to play
352 the game intuitively.

353 According to Nielsen (1996), the ease of use must be judged a first priority, because difficult
354 technology defeats the goal. The success of games including: Tetris, Moorhuhn, Yeti (some exam-
355 ples from a long list) is in their simplicity of use. Everyone must be able to play without reading
356 any instructions – or running through preparatory installation routines.

357 Furthermore, curiosity is the learning motivation, independent of any goal seeking (Malone,
358 1980). Computer games can evoke a learner’s curiosity by providing environments that have an
359 optimal level of informational complexity (Piaget, 1951).

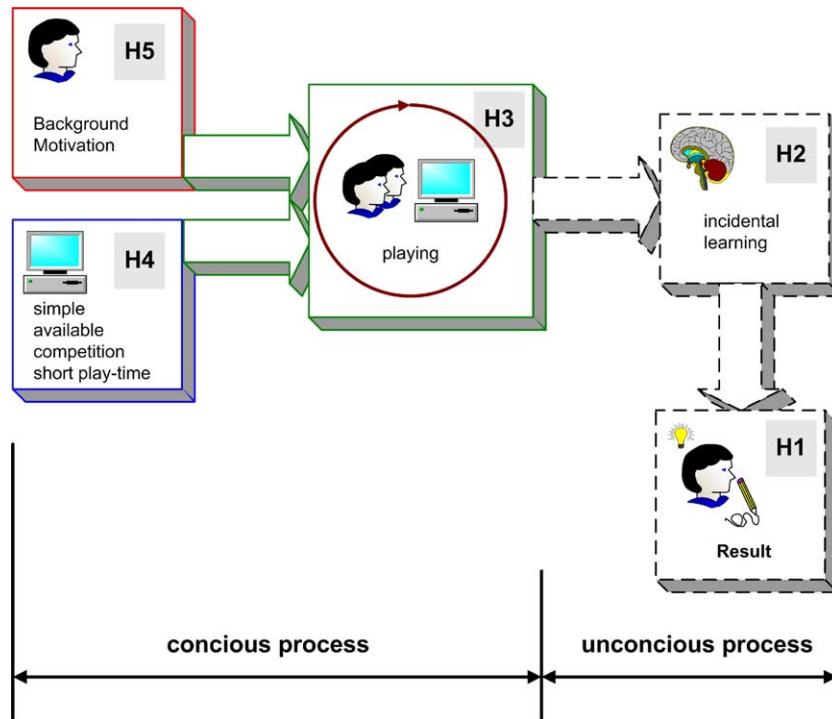


Fig. 10. Conclusion.

360 In other words, the user-centered design at the beginning of the project helped to design a game
 361 that was neither too complicated nor too simple, with respect to the learners existing knowledge.

362 7. Conclusion

363 We can definitely state that at the beginning of the lectures the students liked learning with the
 364 Interactive Learning Objects but after a short time a surprising effect was noticed: Learning,
 365 whether with or without a multimedia tool, is hard and subsequently motivation decreased.

366 It was therefore necessary to create something, which combined the following attributes: moti-
 367 vating the students and providing software, which is enjoyable and does *not* feel like learning. This
 368 idea was the incentive for the development of the Internal Force Master (IFM) which is an educa-
 369 tional game for the study of Civil Engineering at Master's level. In Fig. 10 the results of our
 370 research are summarized. Each research question aims to be a part of the whole process – the spe-
 371 cific role is displayed and explained.

372 8. Conscious–unconscious

373 First, it has been shown that the players have to be motivated to play the game. This fact
 374 includes the necessity of the game being useful to the target group (background). The results

375 confirmed these assumptions. The next box (blue) presents the necessary characteristics of the
376 game – it must be simple, availability must be independent of time and place, playable within a
377 short time and with the appearance of a competition. As a result of these facts, we showed that
378 students played the game for a considerable time – and that they like to play, as hypotheses 3
379 showed. The use of the internet-based tool led to incidental learning as hypothesis 2 expressed.
380 The important result which came out of this work is stated in hypothesis 1 – the learning result of
381 the playing group is *at least* equivalent to the group who learned using the traditional method.
382 Due to this fact, we point out, that gambling can be a new, modern and also useful method in the
383 education of Civil Engineers at masters' level of a university.

384 9. Uncited references

385 Holzinger (2005), Nielsen (2002).

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