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Game Design as a Learning Tool for the Course of Computer Networks*

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Continuous advances in technology are causing a generation gap between students and teachers to increase. There are constant breaks in communication, misunderstandings and social conflicts arising during the conduct of a course. Today students have grown up using devices like computers, mobile phones, and video consoles for almost any activity; from studies and work to entertainment or communication. Motivating them with traditional teaching methods such as lectures and written materials is proving to be more difficult daily. In order to increase the motivation of students, better understanding of the subject matter as well as improving collaboration, new form of teaching was required. That is why digital games are being considered to have a promising role in education process. We conducted a study among university students with the purpose of acquiring empirical evidence to support the claim that game design can be used as an effective form of learning. Our method consisted out of monitoring results of participants in course of Computer networks. Experimental group of participants experienced a game design as a new learning tool for teaching, while control group used network programming. Additionally, we invested an effort to measure the effects of different learning approaches with the respect of individual differences in cognitive styles. Initial results provide a good argument for use of game design as a student learning tool. In addition, we reported some influence of cognitive style on effectiveness of using game design.

Keywords: learning tool; game design; educational game; cognitive style

1. Introduction

Digital games are becoming more and more considered to have a promising role in education process. In addition, modern video games may develop higher order thinking skills such as problem solving, strategic thinking, analysis, planning and executing, resource management, multi-tasking, and adapting to changing work scenarios [1–2]. Also, achieving increased player engagement involves adding deep emotional experiences to video games [3].

Today students have grown up using devices like computers, mobile phones, and video consoles for almost any activity; from studies and work to entertainment or communication. This has probably altered the way in which they perceive and interact with the environment, both physically and socially [4]. Nevertheless, most teaching strategies ignore these social changes and remain anchored in traditional text based instructional formats, provoking problems like arising lack of students' motivation [5].

Organizing a course to respect these notions is by no means a simple task. There are usually many limitations in conducting a course by use of games, either video or standard games. These limitations include group size, adequate interaction, sharing responsibilities between students etc.

Our interest in this matter triggered when realizing the drop of motivation and interest in the subject among students at the course of *Computer Networks.* That course is conducted during third year of study at Faculty of organizational sciences, University of Belgrade, Department of informational systems. We discussed an idea of modernizing the course through the use of educational games. The need for better student involvement occurred. In order to increase the motivation of students, better understanding of the subject matter as well as improving collaboration, new form of teaching was required. Best possible way of animating new generation of 'digital natives' [4] is by approaching them in their own language, the language of video games.

Research conducted and described in this paper had a task of comparing the effect of video games integrated in to curriculum with the effects of traditional teaching. In addition, we took in to the consideration a specific cognitive style of each student and the effect this way of conducting course had on their results.

In this study we invested an effort to measure effects of different teaching approaches with the respect of individual differences in cognitive styles. In fact, we want to see whether there is some category of learners, which are more prone to one

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than to another way of acquiring specific knowledge. Due to the nature of the subject of learning, we decide not to examine the learning style differences but the cognitive style variability that is more fundamental notion.

Initially we have two presumptions. First is that the use of educational game design will increase the overall results of the students. Second is that the specific cognitive style of a student will influence the students results based on whether the student had the opportunity of designing educational games as a part of the learning process or not.

Bearing in mind that educational games can involve a student during the game-play, we encountered a question if it is enough to give them the possibility of playing an educational game or going further. Use of game designing opens the ability of better understanding the subject matter [6]. If a student had a task to adequately integrate knowledge in to an educational game, it is fair to assume that higher understanding of that subject matter is required. Also by forming groups that need to cooperate on this task, we hope to provide a good basis for development of collaborative skills. Furthermore, collaborative learning also provides opportunities for developing social and communication skills, acquiring positive attitudes towards co-members and learning material, and building social relationships and group cohesion [7].

2. Literature review

Computer games are widely accepted form of entertainment and their popularity increased over the past three decades. There were a lot of different studies concerning computer games and their influence on cognitive performance. It has been shown that computer games have great potential as a learning tool for the following reasons [8]:

- They can affect much more users than 'normal' lesson
- They can be played anytime, anywhere
- They are designed according to effective learning paradigms
- They stimulate chemical changes in the brain that promote learning
- Studies comparing video game teaching effectiveness to the classic lecture show positive improvements (for the example, *Supercharged!* [9] , the game that was used to teach students the principles of electromagnetism)

In the same time, games were associated with the concept of fun, while, with learning, it seemed that it was not always the case [4]. Games used several different techniques that kept the player motivated. Also, it has been noted that play improves ability to reason and understand the world [10]. Our opinion is that 'classic' learning can benefit from positive aspects of the computer games and, most notably, the concept of fun.

All researches stated that games had positive effect on concentration, the decision—making process, problem solving skills, logical thinking creativity, team work and, of course, computer skills [1]. Estallo claimed in his work [2] that people who play games have more developed intellectual skills than those who don't.

Dealing with teaching material in the educational games is a specific problem. One important theme that's emerged is the need for teaching material to be integrated into the framework of a game's design rather than added to it later [11]. The problem can be observed from different perspectives. From the student's point of view, embedding educational content into games dilutes the fun, and from the teacher's point of view games makes the learning process often too long and focused on the wrong objectives [12]. Educators have adopted three major approaches for integrating games into the learning process: have students build games from scratch; have educators and/or developers build educational games from scratch to teach students; and integrate commercial off-the-shelf (COTS) games into the classroom [13].

Since students are in touch with games much more than teachers, maybe material should be offered to them and the objective to create a game. Designing a game by students that contains a certain amount of educational material could be a valuable tool for learning purposes, to develop problem-solving skills, teamwork, as well as improve domain knowledge. Even though it is believed that this method will not become dominant[13] and that university education is not a good background for this method [14], we believe that by using the right setting, and using specially developed software[15] this approach can prove effective.

Educational content without proper game environment is useless when it comes to teaching. Especially if the area of teaching is engineering and computer science, since they require good practical approach. While it is the case that proper integration of game development and game content in CS classes have the potential to further engage students resulting in higher success rates, it is not the case that any game content will result in having a positive impact [16]. It is essential to combine game setting with adequately integrated knowledge to maintain good flow of the game. Hopefully, students can benefit from doing practical exercise such as game design. On the other hand different personalities might have different relation to that approach.

Individual differences in cognitive aspects are based not only on personal cognitive ability but also on the way he uses that intellectual capacities. Specific approach to problem situations is idiosyncratic and depends of many different personal aspects. Concept of cognitive style encompasses numerous personal functions recognizable in any mental activity performed by the individual; it has associations to both ability and personality traits.

Cognitive style is generally defined as 'characteristic manner in which cognitive tasks are approached or handled' [17] more specifically, it is 'a habitual and distinctive way of attending and processing perceptual and cognitive information' [18].

By applying cognitive style concept we can cover not only the situations of 'adoption of particular ways of learning' but also its 'impact upon problem solving of work place activities' [19], which is very similar to the given educational situation where students learn through simulation.

When question of learning competencies comes around, scholars use different models of explaining cognitive and learning styles: Cognitive Style Analysis (CSA) [20], Cognitive Styles Index (CSI) [21], Kirton Adaptation Index (KAI) [22, 23], Learning Styles Inventory (LSI) [24], Learning Styles Questionnaire (LSQ) [25], The Felder-Silverman Learning Style Model [26].

On the other side, when cognitive style is seen in context of human-computer interaction, other measures of intellectual functioning are used more frequently. We consulted studies that consider meaning of cognitive style aspects in computer-based education, using: Sternberg's Thinking Style Inventory [27], Kirton Adaptation-Innovation Inventory—KAI [28], Pask's holism/serialism dimension [29], Riding's Imagers/Verbalizers and Wholist/Analytic dimensions [30–32] and most often Witkin's field dependence/independence dimension [29–34].

We decided to use MBTI as an instrument for measuring cognitive style, although it is more often used as a tool for assessment of one's method of decision making.

3. Research methodology

The success of the study depends on choosing the right parameters. Creating a quality environment for the study is most essential. We decided to conduct our study among students that attend the course of Computer networks and telecommunications. That course conducts during the first semester of the third year of study at the Faculty of organizational sciences. Agenda of the course should enable students to understand basic principles of computer networks. Our course attendants major in informational systems and their profile is mainly an engineering type.

Our group of participants consisted out of 125 students. There were 66 male participants and 59 female participants. Slight supremacy in number of male participants is noticeable, but the main reason for that is the fact that the course belongs to an engineering department, which usually shows greater number in male attendants.

We divided students randomly in to two separate groups: control and experimental. Control group consisted out of 34 male and 33 female participants. Experimental group was made of 32 male and 26 female participants.

Experimental group got the assignment of designing a educational game that covers the area of computer networks while control group was involved in doing a programming assignment from the area of computer networks (protocols, distributed systems, services etc.).

Students in experimental group were divided into smaller groups (design teams) consisting of two or three members. Every two weeks, teams were given a set of questions from computer networks area. Their task was to choose some of those questions and use them in their game design. Questions were to be modeled like problems in the game. Students were free to modify the problems any way they see fit. Main problem was writing a specification/scenario for an educational game. The specification/scenario had to be very detailed: it included dialogs, scene descriptions, character descriptions, etc. Students were free to choose any type of game. Upon ending a phase in their game development they used a framework developed by research team [15] to materialize their game. Digital materials they collected or created as well as their scenarios were included in an educational video game that was the result of their work. Graphical editor was used to create the flow of the game while knowledge repository was created by the use of Knowledge manager application. All the design teams had a mentor assigned whose assignment was to overlook the progress every week and give advice.

Control group was also divided into smaller groups (programming teams) consisted of two to three person. At the beginning of the semester they were given an assignment to develop an application that uses the benefits of a computer network. That application had to posses its own network protocol. There were a variety of different application types (P2P File sharing, P2P messaging, Voice communication, Video communication, Remote control etc.). Programming teams also had a mentor assigned.

In this research we use self-report MBTI questionnaire adapted and translated on Serbian language. The MBTI F form has 95 forced-choice items that forms four bipolar scales: Extraversion-Introversion (EI), Sensing-Intuition (SN), Thinking-Feeling (TF) and Judging-Perception (JP). A combination of these dimensions builds 16 different types of cognitive functioning. Introverts, oriented primarily to the internal cues, extroverts, oriented primarily to the external events, due to the differences in focusing psychical energy, show different pattern of performing intellectual tasks.

Sensing mode of perceiving world is characterized by the respect for data obtained by one of the five senses. Contrary, intuitive type is prone to lean on inner processes, perceiving the bigger picture that enables him to concentrate and to see hidden possibilities, implications of the subject in matter.

Myers and McCaulley [35] postulate two decision-making styles when assessing the validity of perception: thinking (assessment based on logical impersonal processes) and feeling (assessment based on personal, subjective process of mental evaluation).

There are individual differences in preference of the quality of environment one exist (learn) in, explicitly the level of structure inherently given in it. So, there are two categories of subjects: judgers who structure and order that promote predictable surrounding where decisions could have been brought quickly, and perceivers who need to keep options open unconcerned for deadlines.

As MBTI is well theoretically conceptualized [36, 37] and metrically evaluated instrument [38–41], we thought that it might be useful to apply it on problem of learning by computer games.

Actually, metric characteristics of scale are mostly adequate. Carlson [38] examined great body of reliability tests for this scale and found that coefficients for split-half reliability goes from 0.66 to 0.92, and test-retest reliability shows that results are relatively stable (coefficients in different studies are ranging from 0.69 to 0.89).

3.1 Aims

Using games in education as a learning tool presents a target of much debate. There are many opposing opinions on that matter. One position is that traditional methods of teaching are most effective, while opposing opinion states strong advantages of educational games. In addition, the specific psychological profile of learner was subject of much consideration regarding educational games effect. On the other side, there is very little empirical evidence supporting any of these claims. Aim of this study is to provide some empirical evidence about effect of game design as a student learning tool on improving general knowledge and final mark. In addition, we aim to find out whether the cognitive style of the learner has any effect on the usability of game design in education. Specific cognitive style of the learner could have an effect on whether games as a learning tool are applicable and in what extent.

3.2 Hypothesis

Use of educational games in teaching is by no means a new topic. Educational games aim to pass knowledge to learners while playing. On the other hand designing an educational game requires large amount of knowledge of the matter it presents as well as creative thought. Fun during game designing process and later through playing should improve motivation and enrich learning process. This brings us to our first general hypothesis: H1 'Learning through game design is more effective and improves final mark more than learning by traditional methods.' When choosing a teaching method specific profile of the learner must be taken in to account. Every person is different, has different needs, personality, different motivational factors etc. It is reasonable to presume that some people will benefit more from learning through educational game design while others might benefit less. This raises our second general hypothesis: H2 'Effectiveness of learning through game design depends on specific cognitive style of learner.' Determining the effect of cognitive style on the benefits educational game design have on learners presents a strong challenge. Proving or even disproving our second hypothesis requires decomposition. We will decompose that hypothesis on four sub-hypothesis. By proving any of those four, we will realize that we cannot disprove our general hypothesis. The division on different dimensions of cognitive functioning mentioned earlier places persons personality in four different categories. Each person belongs to one of the two opposing categories in every group. Person can be either *extrovert* or *introvert.* One can be either *sensor* or *intuitive etc.* Since *extroverts* like variety and action, working and learning through interaction with others and they are often impatient to see the results of their activities, we presume that their final mark will benefit from learning through educational game design. In that light, we come to our first sub-hypothesis: H2a 'Extroverts, if learning through educational game design, will reach better final mark than introverts.'

Analyzing *sensers,* we realize they prefer to learn details, nurturing and establishing order, sticking to the routines and avoiding ambiguous situations. This led us to believe that designing an elaborate system such as an educational game should improve their final mark. This forms our second sub-hypothesis: H2b 'Sensers, if learning through educational game design, will reach better final mark than intuitive.'

If we compare next two decision-making styles, we can claim that *feeling* style has more to gain from learning through games than *thinking* style, since fun is involved. Fun should have less positive effect on *thinking* style since it is more prone to awards of overcoming logical hurdles and performing deductive analysis.

Next sub-hypothesis: H2c 'People that poses feeling style, if learning through educational game design, will reach better final mark than those with thinking style.' Finally, comparing *judgers* and *perceivers,* we presume that general openness to different options and ability to adapt to complex situations gives perceivers the upper edge when it comes to educational game designing. Thus, we develop our last sub-hypothesis: H2d 'Perceivers, if learning through educational game design, will reach better final mark than judgers.'

3.3 Procedures

We performed the study during three-month period that constitutes one school semester. Study was conducted during the school year 2008/2009. At the beginning of our study, we captured the cognitive style of all our participants by use of a questionnaire [35]. Earlier, we described methodology for determining cognitive styles. All participants attended traditional classes held by the professor, and they usually contained the theory in area of computer networks. In addition, our control group performed programming assignment, while experimental group had the task of designing an educational game that covers topic of computer networks. We performed evaluation of students in several steps. The final product of their project, depending if they belonged to control or experimental group, was educational game or adequate network application. At the end of the semester, they were required to take an electronic test that covered the theoretical side in the area of computer networks. By performing this test, they could earn maximum amount of 60 points. Finally, in order to measure how deep they understood the topic of computer networks, we gave them a practical test, which had a form of a case study. We introduced students to a concrete problem from the area of computer networks, and they needed to propose a solution based on their acquired knowledge.

Maximum mark for that practical test was 40 points. Final mark (maximum of 100 points) is determined as a sum of previous marks, and that mark we used in our statistical analysis.

Upon completion of the experiment we organized a discussion with participants of the experimental group in order to record some impressions and opinions on the administered learning method.

4. Results

The study means and standard deviations, as well as correlations between all factors are given in Table 1. Group1 to Group4 represent cognitive style factors that carry values 1 or 2, depending on cognitive style inside group. TotalPoints represent final score on course, and its values scale from 0 to 100. DesignGame factor defines whether student belongs to experimental or control group. Experimental group designed a game while control group performed programming assignment. Gender is a demographic factor.

For verifying correlation significance, we performed a two-tailed significance test, and presented P-values in parentheses below correlation coefficient value. Significant correlation is noticeable between Group1 and Group2 at 10% confidence level, Group2 and DesignGame at 1% confidence level and DesignGame and TotalPoints at 10% confidence level. Thus, we can anticipate significant interaction between aforementioned factors.

We did not find significant correlation among other factors, thus we can reject hypothesis H2a, H2c and H2d. Further analysis will be focused on interaction between DesignGame and Group2 regarding to TotalPoints.

Since Group1 to Group4 factors represent cognitive style group, correlation between groups one and two is not of any interest for our research and will not be further analyzed. In order to examine possible interaction between DesignGame—TotalPoints, and Group2—DesignGame, we conducted one-way ANOVA (Analysis of Variance) between given factors. An inspection of the ANOVA table (See Table 2) indicates that the interaction was significant between DesignGame and TotalPoints at 10% confidence level, as well as between DesignGame and Group2 at 0.1 % confidence level.

Hypothesis H1 suggested that Learning through game design is more effective and improves final results more than learning by traditional methods. As seen in Table 2 mean value of TotalPoints for students that did design game is 81.1638, which is greater than mean value for students that did not design game where N = 77.9104. Since F-value is 3.502, with P-value 0.064 (See Table 3), this hypothesis was not rejected.

Also, we notice significant interaction between DesignGame—Group2 at 0.1% level, which refer to H2 hypothesis. In order to analyze this phenomenon in more details, we conduct Univariate Analysis of Variance between DesignGame and Group2.

Table 1. Descriptive statistics and Correlation matrix

	Mean	S.D.	1	2	3	4	5	6	
1. Group1 (value 1) introverts (value 2) extroverts	1.54	0.500	1						
2. Group2 (value 1) sensers (value 2) intuitive	1.29	0.455	0.157 (0.081)	1					
3. Group3 (value 1) thinking (value 2) feeling	1.03	0.177	0.075 (0.405)	0.085 (0.345)	1				
4. Group4 (value 1) judgers (value 2) perceivers	1.27	0.447	–0.018 (0.843)	0.008 (0.927)	0.093 (0.301)	1			
5. TotalPoints between 0 and 100	79.4200	9.79084	–0.016 (0.862)	–0.127 (0.158)	–0.068 (0.448)	–0.018 (0.842)	1		
6. DesignGame (value 1) yes (value 2) no	1.54	0.501	0.018 (0.844)	0.308* (0.000)	–0.104 (0.247)	0.028 (0.757)	–0.166 (0.064)	1	
7. Gender (value 1) male (value 2) female	1.47	0.501	–0.003 (0.973)	–0.070 (0.435)	–0.081 (0.370)	–0.146 (0.105)	0.078 (0.385)	0.044 (0.624)	1

* Correlation is significant at the 0.01 level (2-tailed).

Table 2. Descriptives statistics for DesignGame factor. Dependent Variable: TotalPoints

					95% Confidence Interval for Mean			
	N	**Mean**	**Std. Deviation**	**Std. Error**	**Lower Bound**	**Upper Bound**	**Minimum**	**Maximum**
Yes	58	81.1638	8.61475	1.13117	78.8987	83.4289	59.50	96.00
No	67	77.9104	10.53671	1.28726	75.3403	80.4806	58.00	95.50
Total	125	79.4200	9.79084	0.87572	77.6867	81.1533	58.00	96.00

Table 3. One-Way ANOVA between correlated factors

Factors	**DesignGame TotalPoints**	**DesignGame Group2**
F	3.502 (0.064)	12.923 (0.000)

Performed analysis of variance confirmed strong interaction between factors DesignGame (1-Yes, 2-No) and Group2 (1-Sensers, 2-Intuitive) with F-value 7.059 at 1% significance level (.009). Difference between sensers and intuitive students inside experimental and control group was statistically significant, too, with F=3.667 at 10% level (0.058), thus we cannot reject hypothesis H2b which claim that sensers, if learning through educational game design, reach better results than intuitive do. This implies that we cannot reject our general H2 hypothesis too.

On the other side, we did not find any significant difference between DesignGame groups regarding to Group2 groups. Thus, we cannot claim that sensers who designed a game performed better on final score than sensers who did not design a game. Same is true for intuitive students. Finally, we provided a plot, which graphically presents estimated marginal means for Group2, depending on DesignGame factor.

4.1 Results summary

Next, we give in Table 6 summary results of testing our hypothesis.

5. Students discussion

We organized a discussion with our experimental group where project teams pointed out good and bad sides of the project, as well as some other things they noticed during the work. This way, we have gathered a lot of information about how students accepted this new way of learning. Generally, students had some problems with designing game world, scenes, locations and characters, writing story and dialogues, etc. For the majority of the groups, the hardest part of the project, as we expected, was designing problems in computer networks domain and integrating them in the game

Table 4. Descriptive Statistics for DesignGame and Group2. Dependent Variable: TotalPoints

DesignGame	Group2	Mean	Std. Deviation	N
Yes	Sensers	82.5200	7.92050	50
	Intuitive	72.6875	8.36206	8
	Total	81.1638	8.61475	58
No	Sensers	77.2436	10.17600	39
	Intuitive	78.8393	11.14056	28
	Total	77.9104	10.53671	67
Total	Sensers	80.2079	9.30475	89
	Intuitive	77.4722	10.79149	36
	Total	79.4200	9.79084	125

Table 5. Tests of Between-Subjects Effects. Dependent Variable: TotalPoints.

Source	Type III Sum of Squares	df	Mean Square	F
Corrected Model	1037.289[1]	3	345.763	3.856 (0.011)
Intercept	469586.643	1	469586.643	5237.149 (0.000)
DesignGame	3.713	1	3.713	0.041 (0.839)
Group2	328.777	1	328.777	3.667 (0.058)
DesignGame * Group2	632.907	1	632.907	7.059 (0.009)
Error	10849.411	121	89.665	
Total	800328.750	125		
Corrected Total	11886.700	124		

[1] R Squared = 0.087 (Adjusted R Squared = 0.065)

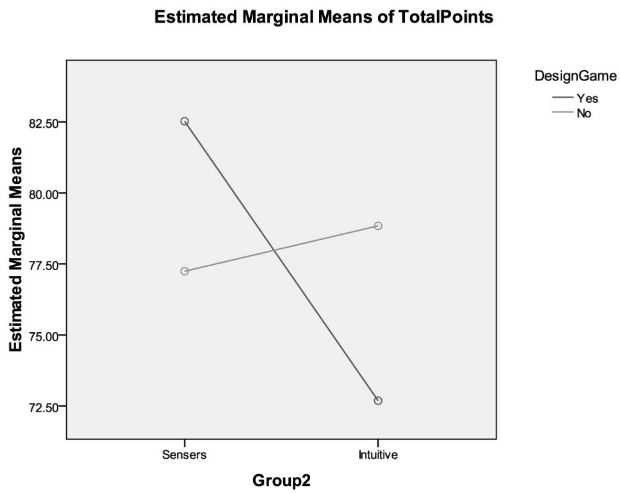

Fig. 1. Estimated marginal means of TotalPoints.

Table 6. Summary results

Hypothesis	Description	Result
H1	Learning through game design is more effective and improves final mark in comparison to learning by traditional methods	Is not rejected
H2	Effectiveness of learning through game design depends on specific cognitive style of learner	Is not rejected
H2a	Extroverts, if learning through educational game design, will reach better final mark than introverts	Rejected
H2b	Sensers, if learning through educational game design, will reach better final mark than intuitive	Is not rejected
H2c	People that poses feeling style, if learning through educational game design, will reach better final mark than those with thinking style	Rejected
H2d	Perceivers, if learning through educational game design, will reach better final mark than judgers	Rejected

world. It should be noted that students had no previous knowledge about game design. We conducted a short, quick course of game design, just to cover all the basics. We are aware that this is very complex topic that must be taken seriously— that is why we planned to include more detailed game design course in the future.

Initial problem that students brought to our attention was choosing adequate game setting. Their choice for the setting or some of its parts was preventing them to integrate the problems in appropriately. Usually, the setting students chose (or designed) was not suitable for the subject matter covered by the problems (in some cases they were heavily mismatched. For example, one of the groups wanted to create a game about vampires in medieval Europe—and it is very hard to find or make connections between such setting and computer networks).

Also, students pointed out a difficulty in integrating knowledge in a game. In this case, setting (and all other elements) was carefully chosen and described, but students were unable to come up with interesting (or even logical) problems for their game. In some cases, problems just 'showed up from nowhere' preventing the players to continue the game until solving them.

Whatever the case, the flow of the game suffered to sudden change, especially when problems pop up. Because the problems were not properly designed and integrated, their appearance was considered unnatural and they looked out of place. As we explained to the students: 'The goal is to create an interesting game, where learning, using knowledge and playing are merged in such a way, that player cannot separate one from the other.' Some of the students didn't like the idea of doing some 'extra work'. They tried to use only the most needed information and they ended up being unable to properly 'model' the problems. Those who did it the right way had significantly less difficulties. When students were asked did the project made them look for a lot more information in order to find a way to integrate problems in the game, everyone answered that it did.

It should be noted that some of the groups finished their projects with surprising results. In those cases, final game specifications were very creative, with some great ideas, developed story and sophisticated look. Problems player had to solve in those games were clever, interesting and fun. For example, one of the games was an action-adventure game with cyberpunk setting. At one point, the main character gained access to a new type of weapon. He had to go to the weapons training centre, because he had to customize weapon's targeting system. Calibration of the targeting system was conducted by playing a mini - game. The main character was positioned in front of the big screen. On the left side of the screen, there was a list of names of different applications. On the right side, there was a list of names of different protocols. In order to calibrate the targeting system, the player had to mark one application with his weapon, and then the corresponding protocol. When all applications with their protocols are connected, the sequence is over and weapon is successfully calibrated.

In spite the troubles they encountered, participants were generally satisfied with this new learning tool. Majority of them found this method interesting and fun. 'Upside of this course is a fact that we did a creative project and had the ability to search for knowledge the way we found fit.' is a comment from one of our participants. Working in teams is something they found very positive 'Team work was fun, and the casual atmosphere really contributed to the quality of our project'.

Finally, discussion gave us some perspective in what can be improved in this method 'Requirements of this project lack a bit of structure so it is quite hard to realize what is expected' and 'Lack of time presented a strong issue in realizing this project, as well as lack of personal consultations with the teaching staff'.

6. Conclusions

Idea that educational game design can be used as an effective learning tool is what inspires our work in this field. Purpose of this study was to try to find some empirical evidence to support this claim.

As seen in our results section we found that our general hypothesis H1: 'Learning through game design is more effective and improves final mark in comparison to learning by traditional methods' cannot be rejected. Analysis of gathered data also took us to a conclusion that our hypothesis H2b: 'Sensers, if learning through educational game design, will reach better final mark than intuitive' cannot be rejected. This provides a strong reason to continue our research. On the other side, since the study we conducted is novel there is a lot of room for question and improvement. That is why it is essential to take in to account subjective thoughts of our participants about this method of learning.

This project indicated that students were interested in alternative ways of learning. They accepted this project because it enabled them to learn in a different way. Also, it allowed them to put in to work their creative skills—something which was not the case with most of the other courses. Last, but maybe the most important part is fun. The concept of fun proved to be exceptionally important and students confirmed it during the discussion. This approach showed that learning can be fun and exciting.

It is important to emphasize that cognitive style is found to be in correlation with learning style [33]. So, we could comment our results showing that sensers are better performer using computer games design as a learning tool in context of Felder-Silverman's learning style model that implies that sensing learners are more prone to details and more practical than intuitive ones who prefer to learn general principles rather than to involve into concrete learning action [26]. Learning trough computer games design seems to be more 'field-dependent' activity, with computer game plot giving actual context (background) and it was proved that field-dependent learners like those sensing learners, prefer concrete material, compare to field-independent and intuitive category of learners which both prefer and are more capable to use abstract material differentiating it from the given background [42]. We could also compare our findings with the results of Graf et al. study [33] showing that so called field-dependent learners 'have difficulties in learning text-only material and benefit more from material that contains text as well as graphics'. Further, students with so called high global level cognitive styles are more effective when learning materials in less structured manner [27]. This is compatible with the intuitive holistic learning style that tolerates ambiguity and disjunction more than it is a case with those less global senser's style. So, we could conclude that sensers achieve better final mark due to the fact that they are cognitively predisposed for learning tasks on this subject and that computer games are suitable medium for learning the material in matter.

It is not peculiar that we found statistically significant differences barely on sensing/intuitive dimension, when having in mind that some scholars [20, 21] argue that there are basically two underlying cognitive processes that creates dimensions of global and analytic thinking patterns [19] that indicates preferences for global, holist perspective which creates so called intuitive cognitive style and preferences for atomistic, sequential perspective creating analytic (and sense dependent) cognitive style. Nevertheless, it has to be emphasized that cognitive style is especially important due to the fact that, unlike the expertise, it is a relatively stable quality [29] and that it creates a 'bridge' between cognition and personality [43, 44].

In spite the fact that our results are strongly speaking in favor of using game design as a learning tool in computer networks, they are actually disputable. Since the area of computer networks belongs to courses of the engineering type it is much more logical to assume that programming assignments will be a better tool for students to achieve higher results. Slight supremacy in favor of game design can be explained by the fact that we mainly measured declarative knowledge that gave the upper hand to a non practical approach. Also, another reason can be a noticeable decrease in interest for programming among new generation of students at our faculty. That is why it is essential to take in to account subjective thoughts of our subjects about this method of learning.

Another factor that compromises the results we reached is influence of mentor on a project team. It is fair to assume that some teachers have better skills in motivating the learners and inspire to work than the others. In our case the completion of the study wouldn't be possible without support for the participants. Regardless of the fact that we advised mentors to be a 'silent partner' as much as possible it is evident that had some influence on participants.

This paper provided a good basis for further research in the area. Since the results spoke in favor of some of our presumptions, all the shortcomings of the study procedure must be taken in to consideration. Good continuation of the study would be to figure out whether the results are generalizable to students of other majors or to students that are not as proficient in computer programming. Discussion with participants brought to our attention that a matter of motivation should be addressed to. Next step in our study will be to attempt to measure motivation level during the use of game design as a learning tool. This paper concentrated on using game design as a learning tool. It would be very interesting to compare game design as a learning tool with simply learning through games (learning through play).

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