Usability Testing of Educational Computer Games on the Topic "Safe Internet"

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Abstract: In the paper we present methods and techniques for usability testing and evaluation of educational computer games. We present a case of application of usability methods in process of development of four educational computer mini-games "Safe Internet". The target users groups cover students from 4th till 7th grade, teachers in school subjects Information technology and Computer modelling. Therefore we apply different methods and tools to plan and testing of the usability of the games. For the current research we use a laboratory testing with an interview with limited number of students and user opinion study with questionnaires for stakeholders – teachers and students. We apply ADDIE (Analysis, Design, Development, Implementation, Evaluation) in a combination with Agile methodologies – Scrum methodology with three sprints. The usability study and implementation are conducted in all stages of development of the games. The case study shows that conducted approach based on the agile methodology with combination of usability study with stakeholders (teachers and students) of the games give good results. The students have positive perception to the final versions of the developed educational computer games.

1 INTRODUCTION

Educational computer games have a positive impact on the acquisition of knowledge, development of skills in any school subject area, and motivation of the students in learning activities at macro and micro level.

In the same time in the process of planning and developing of educational computer games its necessary to provide usability, relevant to requirements of the stakeholders and mainly to needs and preferences of the end-users – the students.

In the paper we present methods and techniques for usability evaluation of educational computer games. We present a case of application of usability methods in process of development of educational computer mini-games "Safety Internet". The target users groups cover students from 4th till 7th grade, teachers in school subjects Information technology and Computer modelling.

The theme for safe usage of the Internet from youngsters is a key topic in the IT curricular in Bulgarian schools. In the same time, this topic is an important part of nowadays digital culture. It is completely important to develop skills for identifying and protecting from danger in the Internet. A possible approach for more effective forming of those skills is usage of educational computer games through which students get into simulation situation, solve different types of problems and situations, connected with safe usage, behavior etc . (Tuparova & Mehandzhiyska, 2018).

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2 BASIC CONCEPTS /LITERATURE REVIEW/

2.1 Serious Game

Variety of definitions about serious game analyse their characteristics and aspects (Stoyanova , Tuparova, & Samardzhiev, 2017). Zyda (Zyda, 2005) defines the serious game as a "mental contest, played with computer in accordance with specific rules that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives". Main characteristics of the serious games are: computer games, their goal is not entertainment, mostly the aim of serious games are directed to the training and education (https://www.igi-global.com/ dictionary/serious-games/26549) to "enhancing some aspect of educational, political, social, or workplace interaction" (Oravec, 2019)

Regarding the digital tools for creating and using serious games in (Terzieva, Golev, & Stavrev, 2017) the authors point out that "Serious games can be considered as part of the online education as separate and independent programs or as modules, supporting the conservative education."

2.2 Educational Computer Game (ECG)/ Didactical Computer Game

Educational computer game is type of serious computer game, applicable in educational subject-domain.

They have the technological characteristics and elements of computer games but are connected with a concrete school subject and define educational content. They are dedicated to solving various and diverse pedagogical tasks – learning knew knowledge, verification and evaluation of knowledge, development of skills, consolidation of knowledge and skills (Tuparova, 2019). They can be used in lessons for assistance the different school activities during the lesson (micro level) or for self-learning for a concrete subject (micro and macro level).

2.3 Usability

It is considered that the first introduction of the term usability is in 1971 from Miler who examines the usability of concrete system in the characteristic of "easy to use" (Shackel, 1991). Shackel defines usability in operational style and recommends

creating a plan for usability insurance of the system in the stage of specification. He defines four main attributes of usability which is needed to be achieved and in the same time measurable: Effectiveness, Learnability, Flexibility, Attitude.

Jakob Nielsen determines the term usability of computer system as quality feature which determines how easy it is to be used. He defines five main characteristics of usability: Learnability, Efficiency, Memorability, Errors, and Satisfaction. (Nielsen, 1993)

According to (Quesenbery, 2004) usability has five dimensions, called 5E: Effective, Efficient, Engaging, Error tolerant, Easy to learn.

With development of technology the models of usability regarding the characteristics and attributes are getting expanded. There are common names but some of them have different meaning. (Tuparova, 2019). International developed standards for defining the characteristics of usability of software are included. The standard ISO/IEC 9126-1:2001 Software engineering - Product quality - Part 1: Quality model sees usability as characteristic (part) of software's quality model. Revised by ISO/IEC 25010:2011 - Systems and software engineering -- Systems and software Quality Requirements and Evaluation (SQuaRE) -- System and software quality models standard. The last update is made in 2017. (ISO, 2017). This standard defines usability in the context of how much "product of system can be used from concrete users for achieving determined aims with effectiveness, efficiency and satisfaction in concrete context of usage."

In standards' definitions for usability and its characteristics there is a mandatory connection with "concrete context for usage." This suppose that for the different technologies, software and domains for software products' application, the characteristics/attributes of usability need to be refined.

2.4 Usability of Application Software and Systems for Education

It is needed to broaden the different models of usability. For example: starting from the attributes in the ISO standards, which are connected with the achievement of concrete aims in the context of concrete content, in the educational software the attributes effectiveness, efficiency and satisfaction are conditioned from the achievement of concrete points and aims, acquirement of educational content, they are also connected with the cognitive and

psychological students' characteristics, who in the same are part of the software users.

A number of researchers and scientists, dealing with developing and research the usability of educational software and systems for the technological support of the educational process, suggest expanded and advanced models for research and evaluation of usability. Apart from the classic categories of characteristics the researcher add additional categories. (Tuparova, Usabilty of educational resources, 2019).

The model MUUX-E (Harpur & de Villiers, 2015) is directed to analyze of mobile education and consists 5 categories: main interface usability (9 criteria, bases on the Nielsen's model) and the specific Educational Usability with 4 included criteria, Web based learning Usability has 6 criteria, M-learning features with 5 criteria and User Experience with 7 criteria.

The model, described in (Ssemugabi & De Villiers., 2010), for web-based education usability includes the following categories: General interface criteria, customised for e-learning; Website-specific criteria; Educational criteria for learner-centred instructional design – orientated to educational and learning goals achieving, efficiency of contemporary learning, ability of control from student side, support the individual approach in learning process, setting up and elimination of cognitive mistakes, reflection and feedback, importance of the content regarding the subject and the student, student's motivation and implementing active studying.

The model (Sobodić, Balaban, & Kermek, 2018) for usability of gamification of e-leaning is based on General usability (Nielsen's model), Educational usability and User experience.

2.5 Usability Methods and Techniques

A lot of methods exist for planning and testing of usability. For the need of current research is used a laboratory testing with an interview with limited number of students and user opinion study with questionnaires for stakeholders – teachers and students.

3 METHODOLOGY

3.1 Methodology for Development of Educational Computer Games "Safety Internet"

The topic of safe use of the internet by middle age school students is key topic in Bulgarian IT curricula. It is part of the modern digital culture. "It is necessary to reach children's perceptions and awareness of the importance of the subject. Children should be aware of the dangers they encounter by using various services on the Internet, including e-mail and social networks. It is important to develop skills to identify and prevent online hazards." (Kaseva , Tuparova, & Stoyanov, 2018).

The educational computer game "Safe in the Internet" is consisted by 4 mini games (Situations, Let's Save Polly, Who wants to be a millionaire, Let's make the puzzle) in field of Safe Internet. Main aim of the games is to check how the students will react in different type of dangerous realistic situations in the Internet, if they know the rules for safety in the internet browsing. The games are suitable to educational curricula of ICT school subject. The target group of the games is students between 5-th and 7-th grade. The levels of the different grades are separated and the games could be used and played with all the 3 grades in order to introduce the rules of safe browsing and reminding them as well. The scenario, the design and the avatars are fully pursuant with the age of the target group.

The game is developed by using Adobe Captivate 10 as SCORM package and distributed among the students through e-learning environment Moodle.

3.2 Model for Usability Study of Educational Computer Game

One of the main aims during the games development was planning and providing usability of the games.

The used model is presented in (Tuparova, 2019) which includes 3 stages.

Stage 1. Preliminary research and analysis of the requirements.

The stage includes activities as: Defining the target group of students; Research and analysis users' needs – trainers and trainees; Research and

analysis trainees' profile; Analysis and selection of educational content which needs to be added.

Stage 2. Development and current/formative usability analysis.

The activities during the stage are aimed at: Choice of methods for usability and utility research; Selection of estimators according with the chosen methods and techniques; Formation of directions for research and heuristics; Results analysis – choice of statistics methods for analysis of the quantitative data of the researches.

Stage 3. Testing the usability and utility with the end-users – trainers and trainee.

The stage is connected with: Selection of methods for usability testing; Defining the groups of testing users and the sample volume of each group; Toolkit creation for users testing; Games and toolkit provision; Collecting and data analysis from the conducted research.

The used model during the process of games is ADDIE (Analysis, Design, Development, Implementation, Evaluation) in a combination with Agile methodologies – Scrum methodology with three sprints. The usability study and implementation ware conducted in all stages of development of the games. (Fig.1.)

4 PRACTICAL EXAMPLE OF PLANNING AND IMPLEMENTATION OF USABILITY OF ECG "SAFETY INTERNET"

4.1 Stage 1

During the stage was made an analysis of students' preferences in that age group for components of educational computer games, the educational program and students characteristics was researched. It was made questionnaire research among the students for their most preferred devices for playing games, the importance of the different games' elements, types of played games and etc.

4.2 Stage 2

During the stage 2 three cycles for games development and usability testing were conduct.

During the first cycle a common game for 5-7 is developed. The first version of the design was discussed with two pre-service teachers. The characters in the game and the graphic design was chosen. The game scenario, structure and interface are discussed. (Figure 2.) Translations in English are performed in yellow boxes.

The first version of the game was presented in front of university teachers. Recommendations regarding interface improvement and structure were made: dividing the game regarding the age of student – 5, 6 and 7 grade according the school curricular and dividing the game into minigames which are SCORM compatible.
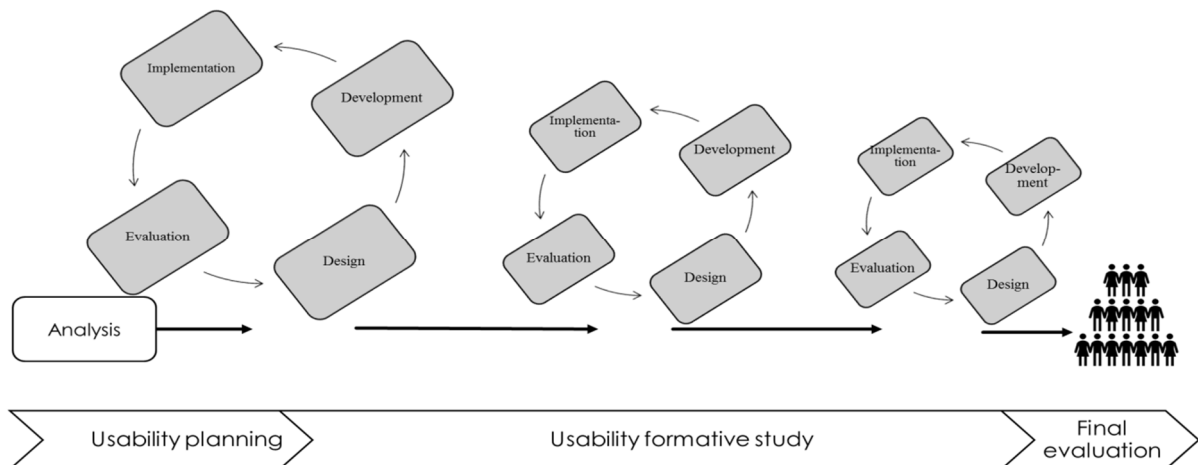

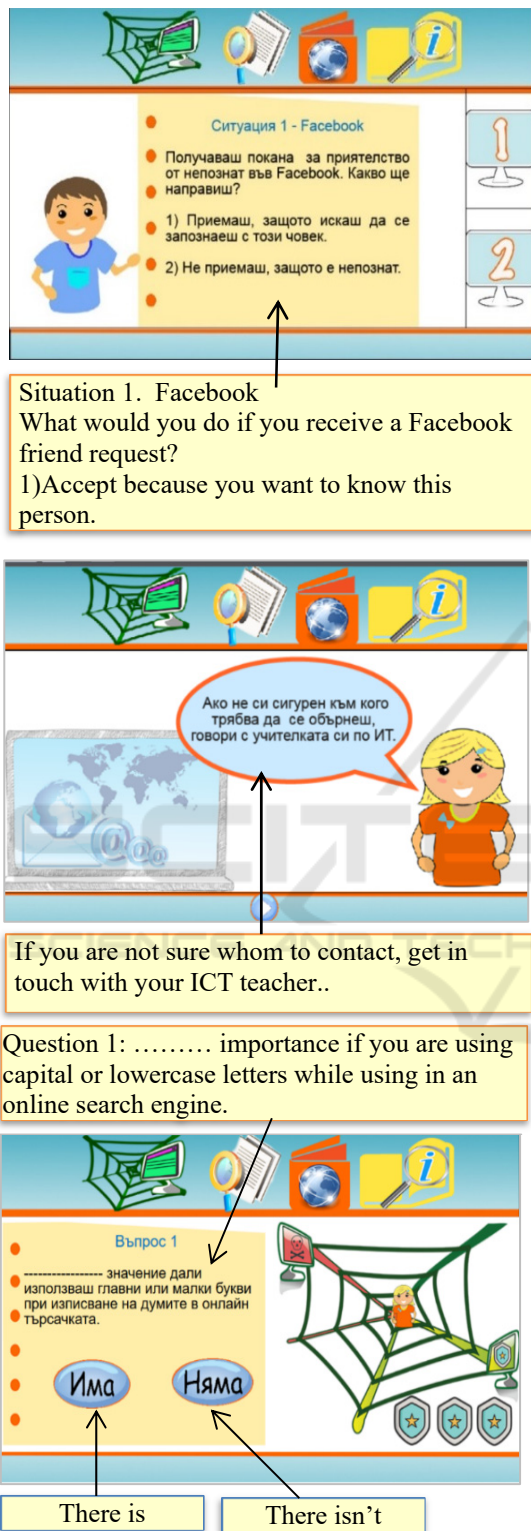Figure 1: Process of usability testing of educational computer game.

development, as well as changing the colour schemes. (Figure 3, Figure 4).

Situation 1. Facebook
What would you do if you receive a Facebook friend request?
1)Accept because you want to know this person.

If you are not sure whom to contact, get in touch with your ICT teacher..

Question 1: ……… importance if you are using capital or lowercase letters while using in an online search engine.

There is

There isn't

Figure 2: Screenshots from first version.

Characters for each grade according to students' age were chosen during the second stage of

Safe in the Internet

Hi, I am Olly

Be millionaire

Let's make the puzzle

Figure 3: Screenshots from games for 6th grade.

Safe in the internet

Hey, I am Polly!

Let's save Polly

Unfortunately, you did not make it to save Polly from the danger depth of Internet because you made tree mistakes.
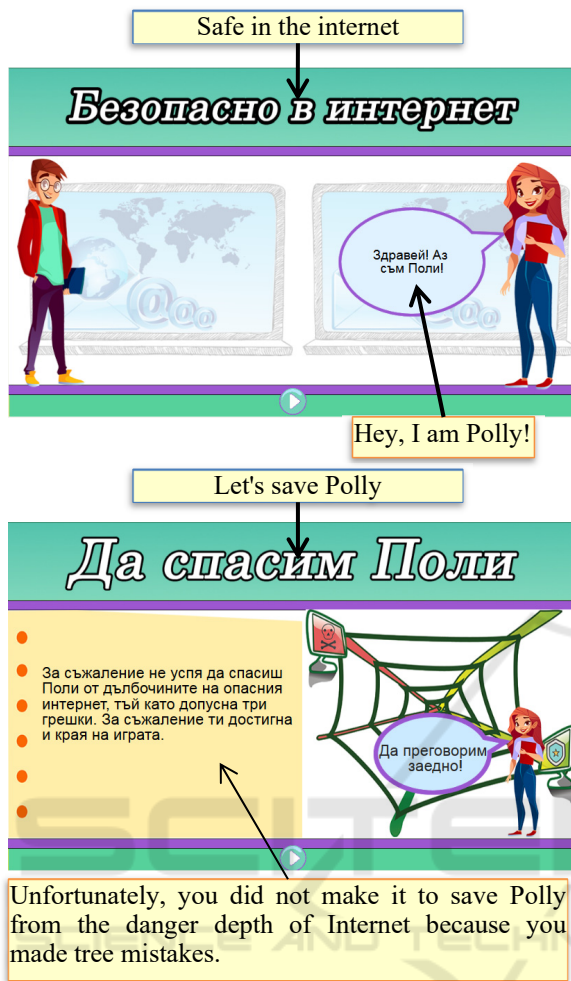
Figure 4: Interface of mini games for 7th grade.

The minigames in tat stage were presented to 11 ICT teachers and 7 students for testing. In order to evaluate the usability, we used questionnaires, for the teachers we used questionnaires which are consisted of questions referring to each of the mini games and interviews for the students.

The recommendations were mainly connected with the minigame "Let's make the Puzzles" – diversification of the puzzles and reducing their number. There was a difference in teachers and students' opinion regarding adding sound. While the teachers consider it is good to be added sound, the students have the opposite opinion and consider it is not appropriate and sound will disturb them.

In the third sprint cycle we took into consideration the recommendations for diversification of the puzzles and control of the dialog between to two characters – there was the opportunity for controlling the conversation between
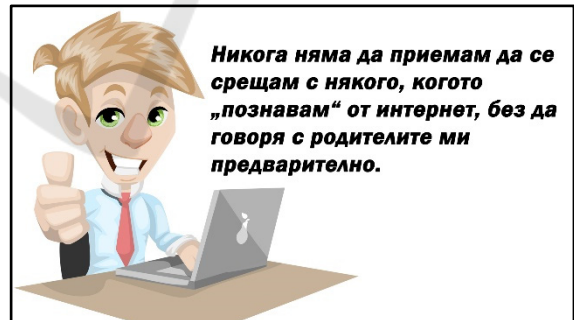
the characters with a button for moving forward, which gives the chance to the trainees to follow their own reading tempo.

I would immediately tell my parents if I find an information which I feel is impropriate for me. I can also report it here: htttps://www.safenet.bg/bg/
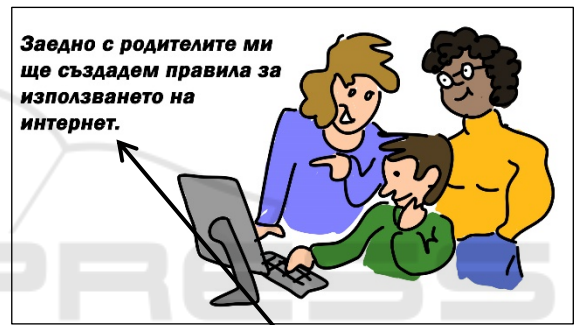
Among my parents we will make rules for safe Internet usage.

I would never agree to meet someone whom "I know" from Internet without talking with my parents in advance.

Figure 5: Pictures of the renewed puzzles.

4.3 Stage 3. Final Evaluation

During the third stage we made a final evaluation of the minigames with students from 5, 6 and 7 grade. For that, for each minigame was developed a questionnaires.

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The questionnaires for the games "Let's Safe Poly" and "Situations – What would you do if …" consist of 25 items. The items are grouped as follows: one item is related to the gender of the students; four items related to educational usefulness (utility) of the game; five items in group "easy to use"; seven items in group "design" including, colors, avatars, navigation; five items in group "general perception"; one item is open answer and related to suggestions for game improving.

The questionnaire for the minigame "Let's make the Puzzles" consists of 16 items. The items are grouped as follows: one item is related to the gender of the students; one item related to educational usefulness (utility) of the game; five items in group "easy to use"; four items in group "design satisfaction" including, colors and navigation; four items in group "general satisfaction"; one item is open answer and related to suggestions for game improving.

The questionnaires for the mini games "Who wants to be millionaire" consists of 17 Items. The items are grouped as follows: one item related to the gender of the students; two items related to educational usefulness (utility) of the game; five items in group "easy to use"; nine items in group "design satisfaction" including, colors, avatars, navigation; five items in group "general satisfaction"; one item is open answer and related to suggestions for game improving. (Appendix1.)

At the end of February 2020, we collected data of 91 students from 7th grade – 44 girls and 47 boys.

All items, except Gender, are 5 level Likert type questions - 5-Definitely Yes , 1 – Definitely No.

For all questionnaires we calculated Cronbach's alfa coefficient of reliability (Table 1.)

Table 1: Reliability of the questionnaires.

Game	Cronbach's alfa coefficient
Let's safe Poly	0,861
Situations	0,915
Who wants to be millionaire	0,775
Puzzles	0,805

Due to ordinal data we applied descriptive statistics – mode, median and percentiles. The students show positive perception of the games. (Table 2, 3, 4, 5). For all items related to the general perception/satisfaction of the games median and mode are 5 – Definitely yes and 4-Yes.

Table 2: General perception of the game "Let's safe Poly".

Game Let's safe Poly	Valid	Missing	Median	Mode	25	50	75
The game's pace is suitable for you	89	2	5,0	5	4,0	5,0	5,0
Generally you like the game	89	2	5,0	5	4,0	5,0	5,0
You will recommend the game to your friends are classmates	88	3	5,0	5	4,0	5,0	5,0
You like playing the game	88	3	4,0	5	4,0	4,0	5,0
15. You like the scenarios of the game	90	1	5,0	5	4,0	5,0	5,0

Table 3: General perception of the game Situations.

Game Situations	Valid	Missing	Median	Mode	25	50	75
22. The game's pace is suitable for you	85	9	5,00	5	5,0	5,0	5,0
23. Generally you like the game	86	8	5,00	5	4,0	5,0	5,0
24. You will recommend the game to your friends are classmates	85	9	5,00	5	4,0	5,0	5,0
16. You like playing the game	86	8	5,00	5	4,0	5,0	5,0
15. You like the scanario of the game	85	9	4,00	5	4,0	4,0	5,0

Table 4: General perception of the game "Who wants to be millionaire".

Game Who wants to be millionaire	Valid	Missing	Median	Mode	25	50	75
14. The game's pace is suitable for you	87	9	5,0	5	5,0	5,0	5,0
15. Generally you like the game	86	10	5,0	5	5,0	5,0	5,0
16. You will recommend the game to your friends are classmates	87	9	5,0	5	5,0	5,0	5,0
11. You like playing the game	86	10	5,0	5	4,0	5,0	5,0

Table 5: General perception of the game "Let's play with puzzles".

| Game Puzzles | N | | Median | Mode | Percentiles | | |
	Valid	Missing			25	50	75
13. The game's pace is suitable for you	86	5	5,0	5	4,0	5,0	5,0
14. Generally you like the game	85	6	5,0	5	4,0	5,0	5,0
15. You will recommend the game to your friends are classmates	86	5	5,0	5	4,0	5,0	5,0
10. You like playing the game	86	5	4,0	5	3,0	4,0	5,0

5 CONCLUSIONS

In the paper we presented a case study for usability planning and evaluation of educational computer games. The case study shows that conducted approach based on the agile methodology with combination of usability study with stakeholders (teachers and students) of the games give good results. The students have positive perception to the final versions of the developed educational computer games.

The next steps in our studies will be directed to data analysis regarding the gender perception of the proposed mini games and their usability characteristics – "easy to use", design, usefulness/utility, and general satisfaction.

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