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Dissertation thesis

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Information behavior and learning in the context of new media: Digital games and simulations as complex systems for information representation.

Informační chování a učení v kontextu nových médií: Digitální hry a simulace jako komplexní systémy pro reprezentaci informací.

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1 Theoretical background

This work approaches digital games and simulations as dynamic systems of information representation that are in comparison to other media able to provide some additional representational aspects. For this reason they might facilitate understanding of complex data in such information systems. The core interest of the work lies in specification of information behavior and in describing the specific aspects of knowledge acquisition as motivation, engagement and creation of mental models within the use of digital simulation.

Compared to other media, games have their unique qualities and weaknesses in information representation as well. Games are able to represent information in new forms: they can depict spatial information (through game space and spatial relation of different objects), visualize relations of different objects (dimensions, interconnections, spatial relations), distinguish objects and categories of objects by assigning specific attributes to them (audio-visual representation, interaction behavior), simulate system behavior (game rules, interaction responses, instant feedback), and control emotions (narration, immersive elements, audio-visual design and representation). Experimental studies (Whitebread, 2009) suggest that the experience of "play" is particularly effective in preparing children for effortful, problem-solving, or creative tasks which require a high level of metacognitive and self-regulatory skills. In contrast to classic teaching approaches based on knowledge transmission, in game-based learning a learner is considered to be a responsible actor in the whole process of knowledge acquisition.

Research of educational games has developed radically during the last ten years, with many universities adopting game studies as accredited study programs. Based on some studies, computer games are able to simulate tasks involving the same cognitive processes required for task performance in the real world (Tobias, Fletcher, Dai, & Wind, 2011) and can provide immediate feedback that might induce a correction of misunderstood information or mental model re-construction (Moreno & Mayer, 2005; Cameron & Dwyer, 2005). Despite all those

supportive facts, decades-long research of game-based learning still has not revealed clear answers to questions such as: which game elements support learning? (Wouters et al., 2013); and how efficient is the game-based learning in comparison with other teaching techniques? Some studies (Hays, 2005) indicate that educational computer games positively affect math and science learning outcomes, and academic achievements in general. Also, the acquired knowledge and skills have a long-lasting effect (Sitzmann, 2011, Wouters, 2011).

This dissertation brings some new insights based on experimental research, comparing game-like activities happening in a virtual environment with analogous activities executed in real live conditions and with a frontal teaching approach. The theoretical background of research presented by the dissertation is based on information science with applied cognitive and educational science. All the conclusions are based on experimental research that compares interaction with three different kinds of systems for information representation: classic frontal lecture, digital game, and non-digital game. As the research instrument is used educational game *Europe 2045 Exp.*, the other two treatments derive from its content. The research sample consists of 330 individuals, mostly Czech high school students, the typical users of the game. We studied knowledge acquisition, information behavior and motivation for information behavior through series of research methods and tools.

2 Hypotheses overview

This dissertation outlines set of four subsequent issues and explores following hypothesis:

#1 Educational games help in efficient building of complex mental models;

- Hypothesis: *"The concept maps will be more complex and retentive within the experimental group."*
- Methods of validation: content analysis of concept maps created by students (self-

reported visual representation of their knowledge); post-test and 1 month delayed post-test.

#2 Educational games foster curiosity and learning motivation, which if aroused within game-play have a stronger and longer-lasting impact on information behavior as compared to traditional lecturing;

- Hypothesis: *"The experimental group will within one month following the educational intervention show a higher engagement in information behavior."*

- Methods of validation: questionnaires, post-test and 1 month delayed post-test

#3 Educational games arouse positive emotions linked to a particular learning theme, those emotions stimulate situational cognitive engagement;

- Hypothesis: *"The experimental group will in learning situations show more positive affects which support learning and situational cognitive engagement."*

- Methods of validation: emotional graphs and PANAS test (Positive Affect and Negative Affect Scale, Watson et al., 1988); post-test.

#4 Educational games and simulations played collectively in one physical space, e.g. classroom, might stimulate creation of motivating and engaging 'learning frame';

- Hypothesis: *"Verbal and non-verbal behavior showing positive engagement and willingness to develop learning situation will be present in (inter)actions of game participants."*

- Methods of validation: class observations and conversation analysis of audio records.

a. sub-hypothesis 4.2 *"The average of all values measuring the engagement through non-verbal behavior will be higher in the game groups (the experimental digital game group and the control non-digital game group) in comparison to the control classic lecture group."*

b. sub-hypothesis 4.3 *"The graph line constructed of all values measuring the engagement through non-verbal behavior will be in the case of the experimental digital game group less descending than in both control groups (the control non-digital game group and the control classic lecture group)."*

3 Methodology

The dissertation details the results of a long-term experimental study conducted during September 2012 – May 2013 with students from high schools in the Czech Republic. The study was part of a larger study investigating the learning effects of digital games[1] using a so-called media-comparison approach (Mayer & Johnson, 2010). The main part measured knowledge outcomes by various pen-and-paper tests; the second part focused on several factors influencing knowledge acquisition (emotional experiencing, motivation for future learning, social interaction), and its results are described on the following pages. This part of the study was rather qualitative, while the main part was strictly quantitative. Within the qualitative part we have used some new research tools to closely portray aspects of knowledge acquisition; its development and applicability are discussed in the dissertation as well.

The experimental design was created in collaboration by Cyril Brom (Faculty of Mathematics and Physics, Charles University in Prague), Vít Šisler (Faculty of Arts, Charles University in Prague), Michaela Buchtová (Faculty of Arts, Charles University in Prague), Ivo Šebek (Faculty of Arts, Charles University in Prague) and Tereza Selmbacherová (Faculty of Arts, Charles University in Prague). This dissertation describes the outcomes of the qualitative part of the experiment, which focused on information behavior and processing, emotional experiencing, motivation, and behavior patterns. The quantitative part measured knowledge acquisition and emotional engagement through standardized tests and biofeedback. Qualitative design was mostly developed by Michaela Buchtová, i.e. the author of this dissertation, while quantitative was developed by Cyril Brom, who led the experiment.

[1] „Learning Effects of Educational Simulations (LEES)" project number P407/12/P152 supported by Czech Grant Science Foundation (GA ČR).

3.2 Experimental design

As the research instrument we used educational simulation *Europe 2045 Exp.* (Brom, 2010). The game attempts to teach students three kinds of knowledge; to improve their high-level skills; to increase their ability to discuss, negotiate, work in teams, and make group decisions. The second goal is to familiarize students with facts, such as geographies of European countries, EU institutions and policies, typologies of political inclinations, etc. The third goal is that students acquire mental models of large-scale processes and socio-political notions such as a model of "energy dependence" or "liberalism".

Within our present study we used three different media that were later compared to each other: (1) *Europe 2045 Exp.*, an educational digital game (experimental digital game group); (2) a classical frontal teaching approach (control classic lecture group); and (3) a non-computer game copying *Europe 2045 Exp.* played in the classroom (control non-digital game group).

After the short introduction in the beginning of the workshop day, participants were asked to fill out a pre-questionnaire assessing their knowledge of European Union affairs. Based on the scores of those questionnaires, they were divided into two or three subgroups, each getting different experimental treatment. After the knowledge pre-questionnaire, the participants received an introductory lecture about the EU that took about 20 minutes. During this time, the tests were evaluated and at the end of the lecture participants were divided into the subgroups. Teachers from our research team gathered participants into their groups and walked them into separated classrooms (till the end of a workshop day participants from different subgroups did not meet each other). From approximately 9:00 a.m. till 1:30 p.m. participants learned about the same content through different educational treatments, with a few short pauses and one 30-minute long break for lunch.

When the educational part was finished, participants got a 5-minute long pause and then the testing session started. This session took about 45-60 minutes, the tests examined students' knowledge (5 questionnaires), their mental models (concept map), emotional profile (Social

Interaction Anxiety Scale, SIAS), emotional experiencing (emotional graph), and self-evaluation in the area of knowledge of EU affairs.

One month later, the participants filled in subsequent knowledge tests and a few inventories. Students were not informed in advance. The one month-delayed testing period lasted 90 minutes.

4 General conclusions, short overview

Hypothesis no. 1 *"The concept maps will be more complex and retentive within the experimental group."* Accepted: thus, it seems that games as complex systems of information representation allow for the creation of sustainable mental models that can be qualitatively developed through time. The traditional classic lecture influences the creation and conceptual change of mental models through theoretical description, explanation, questioning and discussion. Games immerse a learner directly into the problematic and let him/her test the mental models in (inter)action. This cause-and-effect system might develop more coherent and sustainable mental models than only verbal intervention.

Hypothesis no. 2 *"The experimental group will within one month following the educational intervention show a higher engagement in information behavior."* Refuted: the long-term effects on information behavior were not affirmed by this study, but some partial outcomes indicated a possible correlation between reported self-assurance, as well as engagement in future information behavior. All the students showed similar long-term tendencies within information behavior that basically were not affected.

Hypothesis no. 3 *"The experimental group will, in learning situations, show more positive affects which support learning and situational cognitive engagement."* Accepted: the game groups reported more joviality, self-assurance and attentiveness within the educational activities. Both game group reported lower fatigue, while the control non-digital game group

started to be tired in the after-lunch period; the experimental digital game group stayed fresh throughout all the learning activities. Moreover, in their individual comments, the game groups participants more often recalled a learning agenda connected with a specific event, which may signal better retrieval cues.

Hypothesis no. 4 *"Verbal and non-verbal behavior showing positive engagement and willingness to develop learning situation will be present in (inter)actions of game participants."*

> sub-hypothesis 4.1 *"The behavior coded as 'highly engaged' will be more frequent in the game groups (the experimental digital game group and the control non-digital game group) in comparison to the control classic lecture group."* Accepted: the body postures of participants involved in game-based activities showed greater engagement in the presentations of the other participants.
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> sub-hypothesis 4.2 *"The average of all values measuring the engagement through non-verbal behavior will be higher in the game groups (the experimental digital game group and the control non-digital game group) in comparison to the control classic lecture group."* Accepted: the game particiants treatment avoided a high proportion of moments in which students were not engaged in the presentations of the other participants.
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> sub-hypothesis 4.3 *"The graph line constructed of all values measuring the engagement through non-verbal behavior will be in the case of the experimental digital game group less descenting than in both control groups (the control non-digital game group and the control classic lecture group)."* Refuted: the graph lines did not show any descending tendencies. Rather, the game groups' participants vascillated between "engaged" and "highly engaged" while the non-verbal behavior of the classic lecture group' participants maintained around "engaged".

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