The Impact of Visual Realism on the Authenticity of Educational Simulation: A Comparative Study

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Abstract: This study investigates the impact of photorealistic/cartoon-like representations of non-player characters on students' perception of an educational simulation. It is a comparative study, with within-subject design, that compares two different versions of an educational simulation, *Czechoslovakia 38-89*. Several studies of simulation design suggest that high fidelity on both physical and functional levels is required to evoke a real-world experience and maximize the transfer of learning. On the contrary, recent meta-analysis of the instructional effectiveness of educational computer games indicates that there is no argument to support opting for photorealistic visual designs, because more basic designs such as schematic/textual and cartoon-like designs are equally or more effective. However, existing studies do not relate levels of realism to specific domains of knowledge. Arguably, the appropriate level of visual fidelity depends on the learning objectives of the game/simulation. *Czechoslovakia 38-89* is a complex educational simulation for high schools that utilizes the principles of digital game-based learning (DGBL). Its educational objective is to present key events from Czechoslovakia's contemporary history and to enable students to "experience" these events from different actors' perspectives. A core element of *Czechoslovakia 38-89* is interviews with "eyewitnesses" to various events. During the development of the game, we had to make a key decision on how to visually represent these characters: either as photorealistic videos using real actors (photorealistic) or as cartoon-like animations (cartoon-like). In a laboratory study involving 48 Czech high school students (M=16, F=32) with different study backgrounds, we compared two versions of *Czechoslovakia 38-89*: photorealistic and cartoon-like versions. The simulation's content and its length were identical in all other respects. The results indicate that the vast majority of students preferred the photorealistic version; both for use at school and at home. They evaluated the photorealistic version as being more authentic and attractive. They also considered the photorealistic version to be a better source of information about Czechoslovak contemporary history.

Keywords: visual realism, authenticity, game design, educational computer games, educational simulations, Czechoslovakia 38-89

1. Introduction

It is generally agreed that the traditional process of schooling can benefit from the usage of computers as supportive tools (Tamim et al, 2011). Of the various possible approaches to using computers in education, digital game-based learning (DGBL) has emerged as a promising concept over the last decade. Digital games have been hypothesized as having the potential to provide an engaging and pedagogically-sound alternative to traditional teaching, since they support exploration, interaction and provide an immersive experience in which learners can collaborate with others to solve problems and learn from their mistakes (Whitton & Whitton, 2011).

In the last few years, a growing number of solid empirical studies investigating the effects of educational digital games on learning has been published. Recent meta-analyses on the instructional effectiveness of educational computer games (Wouters et al, 2013) and computer-based simulation games (Sitzmann, 2011) demonstrated educational games' and simulations' modest superiority over "traditional" types of instruction in terms of learning and retention.

One of the key questions in contemporary DGBL research is how to design educational games and simulations so that they effectively enhance meaningful learning. By "meaningful learning" we mean both the ability to reproduce or recognize presented material as well as the ability to use such material in novel situations (Mayer, 2009). In other words, which game design features contribute to the learning process and which do not?

There exist a number of theoretical frameworks that provide guidelines for educational games' designers (e.g. Tobias & Fletcher, 2007; Mayer, 2009; Plass, Homer & Hayward, 2009; Whitton, 2010; Brom & Sisler, 2012; Rooney, 2012). From a broader perspective, Mayer's (2009) extensive research on multimedia learning, i.e. on presentations in which people learn from both words and pictures, summarizes key evidence-based principles

of multimedia instruction and offers practical guidelines on how to design multimedia presentations. By the same token, Plass, Homer & Hayward (2009) draw on existing literature as well as original research to present additional design factors for educationally-effective simulations and animations.

Despite the growing amount of evidence-based research on DGBL, there exist many design-related questions that need further investigation. One of these open issues is the level of visual realism in educational games and simulations. First, what is the impact of visual realism on students' acceptance of games/simulations as learning tools? Second, what is the impact of visual realism on the instructional effectiveness of educational games/simulations?

During the development of the high-school educational simulation, *Czechoslovakia 38-89*, we faced a lack of evidence-based answers to these questions; particularly when related to specific content and knowledge domains. *Czechoslovakia 38-89* presents key events from Czechoslovakia's contemporary history and enables students to "experience" these events from different actors' perspectives. It deals with topics that are often subject to discussion and debate in the public space; including ethically- and emotionally-contentious issues. A core feature of *Czechoslovakia 38-89* is interviews with "eyewitnesses" to various events (e.g. the dissolution of Czechoslovakia and establishment of the Nazi Protectorate of Bohemia and Moravia; the immediate postwar era, including the reconstruction of Czechoslovakia, the expulsion of its German-speaking citizens and the rise to power of the Communist Party, etc.). During the development of the game, we had to make a critical decision on how to represent these characters visually: either as photorealistic videos using real actors or as cartoon-like animations.

While there is strong evidence that graphics do enhance learning (Mayer, 2009; Plass, Homer & Hayward, 2009), there is limited research as to whether the actual quality of those graphics makes any difference. As Whitton and Whitton (2011) note, "aesthetic design has long been a key part of the development of many mainstream commercial IT products, especially those aimed at entertainment, and may be important for meeting players' expectations for leisure gaming, but there is not enough evidence to know how important it is in terms of either acceptability of educational games or its effect on learning."

Several studies (Chalmers & Debattista, 2009; Dalgarno & Lee, 2009) on simulation design suggest that high fidelity on both physical and functional levels is required to evoke a real-world experience and maximize the transfer of learning. On the contrary, the meta-analysis of Wouters et al (2013) indicates that there is no argument to support opting for photorealistic visual designs, because more basic designs such as schematic/textual and cartoon-like designs are equally or more effective. By the same token, Rooney (2012) argues that, in the case of educational games, visuals play a minor role in sustaining student engagement and immersion.

Given that existing theoretical frameworks and research did not provide us with unambiguous answers to our design questions, we have carried out an experimental study. The study investigates the impact of photorealistic/cartoon-like representations of non-player characters on students' perception of an educational simulation and their acceptance of the simulation as a learning tool. We compared two versions of *Czechoslovakia 38-89*, i.e. photorealistic and cartoon-like versions, in a laboratory study using within-subject design involving 48 Czech high school students with different study backgrounds. The study stems from applied research, yet its results could be of interest to a broader community of DGBL researchers.

In the following sections we first introduce the educational simulation *Czechoslovakia 38-89*. Then we detail the two versions of the simulation used for the experiment and outline our hypotheses. Afterwards, we describe the experiment's setup and results. Finally, we discuss the findings, draw conclusions and outline some avenues for future research.

2. Czechoslovakia 38-89

Czechoslovakia 38-89 is a complex educational simulation for high school students. It was developed at the Faculty of Arts and the Faculty of Mathematics and Physics of Charles University in Prague and the Institute of Contemporary History of the Academy of Sciences of the Czech Republic during 2011-2013. The main target audience is students aged between 13 and 19. The simulation's general educational objective is to present students key events from Czechoslovak history during the second half of the 20th century (up to 1989) and to

enable them to "experience" these events from the perspectives of different individuals. In doing so, the simulation aims to develop a deeper understanding of the complex and multifaceted political, social and cultural aspects of this time period. The simulation contains several historical modules; each covering a different chronological period. The following paragraphs briefly introduce the simulation. For more detail see Sisler et al (2012).

The simulation utilizes gaming elements and stems from the DGBL paradigm. It features a single-player dialog-based adventure game with a strong narrative. Students assume different roles in individual modules of the simulation. They interact with the eyewitnesses in the present and "travel" back in time based on memories of the eyewitnesses yielded during conversations. The simulation consists of four types of scenes: (a) animation, (b) interactive comics, (c) interactive games and (d) interviews. Each type utilizes a different graphical style and design concept. Animations and interactive comics serve as vehicles for "pushing" the story forward and provide students with a real-world background; including multimedia and textual materials. Each module features several interactive games, which can be based on a different game genre and are intertwined with the module's learning outcomes. Finally, interactive interviews with "eyewitnesses" represent the core element of the simulations. The students follow these "eyewitness'" memories in the interactive comics and the interactive game. The simulation is enhanced by a multimedia encyclopedia, which presents students additional factual information.

Czechoslovakia 38-89 content stems from historical research on the possible manifestations of experiencing history during the 2nd half of 20th century in Czechoslovakia. It is also based on the personal testimonies of eyewitnesses to the above-mentioned periods. Nevertheless, *Czechoslovakia 38-89* does not adapt these real stories in a literal fashion; rather it uses them as a source for constructing realistic and appealing narratives. By doing so, *Czechoslovakia 38-89* enables us to produce appealing stories with a number of authentic details without "gamifying" the real-persons' – oftentimes emotionally- and ethically-charged – testimonies.

3. Study's hypotheses

During the development of the simulation, we had to make an important decision on how to represent the above-mentioned "eyewitnesses" visually in the interviews: either as photorealistic videos using real actors or as cartoon-like animations. As we have demonstrated, existing DGBL research does not agree on the level of visual realism suitable for educational games and simulations. As far as we know, there is not enough evidence to know how important visual realism is in terms of the acceptability of educational games and simulations in different contexts and knowledge domains. This holds particularly true when the games'/simulations' content deals with contentious and emotionally-charged issues from contemporary history.

For the purpose of this study, we have developed two versions of a selected interview from the simulation's first module (1938-45). This module deals with dissolution of then Czechoslovakia and the establishment of the Nazi Protectorate of Bohemia and Moravia. The interviewee used in this study is Mr. Hein, a holocaust survivor, who talks about the persecution of the Jewish population during the Nazi Protectorate and post-war retributions. A real actor plays Mr. Hein in the photorealistic version; whereas, Mr. Hein is represented by a cartoon-like animation in the cartoon-like version. The interview's content as well as its length were identical in all other respects.

Based on our pilot study (Sisler et al, 2012) we hypothesized:

1. *that the photorealistic version will be accepted by high school students as more authentic*
2. *that the cartoon-like version will be perceived by high school students as more attractive*
3. *that the cartoon-like version will be perceived by high school students as more modern*

We also investigated which version the students assessed to be more suitable for an educational simulation (both for use at school and at home) and from which versions they, in their own opinions, gained more information.

4. Method

4.1 Participants and place

During May 2013, we organized 12 experimental sessions in a computer laboratory at the Charles University in Prague. The participants consisted of 48 high school students (16 males, 32 females) aged between 16 and 20 (mean age = 17.50; *SD* = 0.72). Four to six students attended each of the 12 sessions. All students planned to enroll in university studies (diverse study programs). We recruited the students through a portal that offers short-term jobs to students. Each student received 200 CZK (approximately 7 EUR) as compensation.

4.2 Materials: Versions of the simulation

The study uses the two above-mentioned versions of the educational simulation, *Czechoslovakia 38-89*; a photorealistic (P Version) and a cartoon-like (C Version). Both versions have 8-10 minutes of gameplay on average and include the following three types of scenes:

- an interview with an eyewitness in the present (color, photorealistic video footage/black-and-white, cartoon-like animation)
- an eyewitness' memory/recollection of the past (black-and-white, interactive comics)
- accompanying materials (real, black-and-white, historical footage)

Figure 1 provides examples of all three types of scenes.

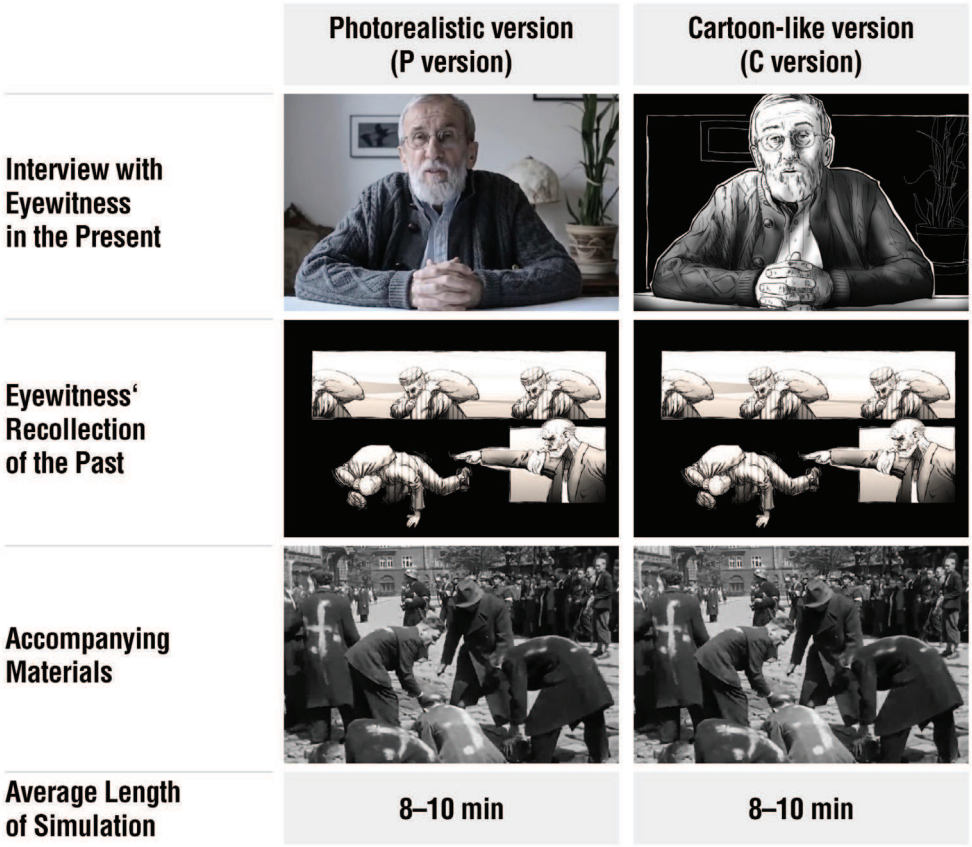

Figure 1: Examples of the three types of scenes used in the P and C versions of the simulation

For the purpose of this study, we have manipulated only the first type of scene, i.e. the interview, which included photorealistic video footage of an actor (P Version) or cartoon-like animation of the same actor (C Version). The cartoon-like animation in the C Version was accompanied by the same voiceover as used with the real footage in the P Version. Both versions had exactly the same length. We have used a limited animation technique in the C Version, which to a large extent recycles common parts between frames (e.g. the mouth of the cartoon-like actor in the C Version does not move).

The interview, i.e. the manipulated part of the simulation, constitutes approximately one half of the total length of the simulation used in the experiment. The other types of scenes were identical, in their content and length, in both versions of the simulation.

4.3 Design and procedure

We used within-subject design. The first half of the students started to play the P Version of the simulation, while the second half started to play the C Version. After completion of the task, all students switched to the version they had not played yet. Thus we have P-C and C-P treatment conditions.

Each participant was seated at one computer. We randomly (but controlling for gender balance) assigned each student to one of the two conditions after their arrival.

The agenda for each session was as follows:

- Introduction of the whole experiment
- Questionnaire I (This questionnaire elicited participants' background information, as detailed in Sec. 4.4, and it took them about 7 minutes to complete.)
- Training on how to operate the simulation (around three minutes)
- Interaction with the first version of the simulation (8-10 minutes)
- Questionnaire II (This questionnaire focused on students' first impressions of using the simulation and it took participants about three minutes to complete.)
- Interaction with the second version of the simulation (7-10 minutes)
- Questionnaire III (This questionnaire focused on comparing the two versions of the simulation, and it took participants 7-10 minutes to complete.)
- Focus group for all students taking part in the session (around 10 minutes)

We note here that after the study ended, the participants continued on with other activities irrelevant for present research purposes.

4.4 Materials: Apparatus, questionnaires and focus groups

We used PCs with at least a 21"-wide screen and with headphones. The students used a mouse to control the simulation.

We administered three, pen-and-paper questionnaires. The purpose of Questionnaire I was to obtain information about the participant's gender, age, type of high school and intended future field of study. This questionnaire also focused on self-assessed knowledge of and interest in Czech contemporary history, experience with games and students' interest in art activities. The questionnaire contained 23 questions. Self-assessed knowledge of history was investigated through six questions, e.g., *If you were to assess your knowledge of Czech 20th century history, how would you rate yourself?* using a 6-point Likert scale (1 = really good, 6 = really bad); or *How often do you watch films dealing with topics from Czech 20th century history?* (a) never or less than once a year, b) approximately one to three times a year, c) more than three times a year, but less than every month, d) at least once a month on average, e) more often – please specify _____). The following question assessed participants' frequency of computer usage: *How often do you use a computer?* (a) less than one hour a week, b) 1-5 hours a week, c) 6-10 hours a week, d) more than 10 hours a week. One question further assessed participants' frequency in playing computer games: *How often do you play computer games?* (with the same scale as the previous question).

Questionnaire II focused on the first impression of the simulation and it contained three questions. These were used for exploratory purposes only and were ultimately not included in the present analysis.

Questionnaire III focused on comparing both versions based on the following criteria: attractiveness, modernity, authenticity and better quality of the given solution as a learning tool for use either at school or at home (Table 1). Three questions focused on users' personal experience with witnesses/survivors of the holocaust; e.g., *Have you ever taken part in a lecture given by/or a discussion with a WWII witness/survivor,*

who spoke about his/her life during the war? (a) Yes – please specify how many times_____, b) No); or *Has anyone from your family ever experienced a life event similar to that described by Mr. Hein in the simulation?* (a) Yes, b) No). This questionnaire contained a total of 16 questions.

Table 1: Relevant evaluation questions: Question numbers are ordinal numbers representing their sequential order. The questions are numbered across all questionnaires (No. 1 - No. 48). The list is sorted by the type of possible answers

Type of Answer (**Bold**) / Question Asked	Question Name
Select one point on the 6-point Likert scale	
Q.31. How did you like the simulation's graphical design? a) Photorealistic version b) Cartoon-like version	Like
Q.37. Is the simulation's graphical design attractive to you? (visual aspects/appearance) a) Photorealistic version b) Cartoon-like version	Attractiveness
Q.38. Do you consider the simulation's graphical design to be modern? (visual aspects/appearance) a) Photorealistic version b) Cartoon-like version	Modernity
Distribute 10 points between the two versions of the simulation	
Q.39. Which simulation was more authentic in your opinion?	Authenticity
Q.40. Which simulation would be more suitable for classroom lessons at school in your opinion (i.e. using a data projector)?	Better for study at school
Q.41. Which simulation would be more suitable for study at home in your opinion?	Better for study at home
Q.42. Which simulation was "just better" in your opinion?	Overall preference
Choose one simulation version	
Q.36. Which of the simulations was more beneficial to you in terms of answering the above question? * * The "above question" was Q.35.: Please summarize in two or three sentences what happened during the simulation.	Information gained

The scenario for the focus group was organized around the following questions and topics:

- Opening questions: Do you like films focused on contemporary history? Do you like animated films/videos? Do you like computer games?
- Please summarize (in one minute) your experience when seeing both versions.
- Comparison of the two versions: Which version was more credible, more understandable, more attractive and simply better? Which version would you like to see again?
- Simulations as learning tools (general topic)
- Is there a big difference between both versions?
- Role of the player's gender vs. gender of the main character in the simulation

4.5 Data analysis

All quantitative data were analyzed in the statistical program R version 3.0.2. (2013-09-25, The R core Team). According to the type of answers on questions (see Table 2 and 3) we tested the differences between the two versions using Student's t-test and binomial test. For analyzed questions 31, 37, 38 we used two-sample paired t-tests. For analyzed questions 39, 40, 41, 42, we used one-sample t-tests. For question 36 we used binomial test. The effect sizes for t-test was expressed by Cohen's d, which is usually classified into negligible (Cohen's $d < 0.2$), small (Cohen's $d < 0.5$), medium (Cohen's $d < 0.8$) and large (Cohen's $d \geq 0.8$) (Cohen, 1988).

To analyze qualitative data we used the content analysis method.

5. Results

5.1 Participants characteristics

The majority of participants (43 out of 48) reported frequent use of computers (6 hours a week or more). The majority was not frequent gamers, and 35 played computer games less than 1 hour per week. Most participants (44 out of 48) reported that they watched at least one film depicting contemporary Czech history every year; 24 students watched more than three such films a year. Twenty-eight students have visited a lecture or a discussion with eyewitnesses of events connected to World War II. Ten students have a direct family experience with a narration about the Holocaust. Students evaluated their knowledge of Czech contemporary history as being average (mean = 2.94, SD = 1.17; 6-point scale).

5.2 Quantitative findings

Tables 2 and 3 show how the participants characterized the simulation's two versions. As concerns the *Like* question, they evaluated both versions of the simulation very positively; however, they liked the P Version more. The participants further evaluated the P Version as more *authentic* and more *attractive*. Regarding *modernity*, the C Version was marginally better. As concerns *Place of use* questions, the P version again outperformed the C Version. Regarding *Information gained*, the majority of students (37 out of 48) reported that they had acquired more information from the P Version (after watching both versions and no matter what the conditions). The P Version also outperformed the C Version as concerns *Overall preference*. We note here that we found no significant differences between P-C and C-P conditions.

5.3 Qualitative findings

Generally, analysis of focus group records confirmed the quantitative findings. We include several representative participant comments as concerns the comparison of the two versions (for illustrative purposes):

> *"The animation was nicely done. But when the actor was animated, it was not possible to see real emotions."*
>
> *"I liked the [P Version] because of the live actors, where I had the feeling that he was talking directly to me."*
>
> *"[The P Version] does a better job holding my attention."*

The main character interviewing people, i.e. the virtual representation of the player's self, is linguistically characterized as a young man in both versions of the simulation. We asked the participants whether they took into consideration the main character's gender and the fact that they cannot choose it? All students reported that they did not consider the linguistic gender of the interviewer to be an important factor.

Table 2: Characteristics of both versions of the simulation

		Rate							
		Photorealistic Version (PV)		Cartoon-like Version (CV)		T-test			
Type of Answer	Question	Mean	SD	Mean	SD	t	p	df	d
6 point Likert scale (1=best, 6=worst)	Like	1.81	(0.98)	2.42	(1.11)	-2.849	.006	47	-0.582
	Attractiveness	1.92	(0.92)	2.60	(1.05)	-3.738	< .001	47	-0.688
	Modernity	2.29	(1.18)	1.98	(0.98)	1.823	.075	47	0.286
Distribute 10 points*	Authenticity	6.21	(1.46)	3.79	(1.46)	5.742	< .001	47	0.830
	Better for study at school	6.26	(2.24)	3.74	(2.24)	3.826	< .001	45	0.564
	Better for study at home	6.49	(2.07)	3.51	(2.07)	4.950	< .001	46	0.710
	Overall preference	7.28	(2.34)	2.72	(2.34)	6.604	< .001	45	0.973
* Distribute a total of 10 rating points between the video and animated versions.									

Table 3: Frequency for the information gained question

		Rate			
		Photorealistic Version (PV)	Cartoon-like Version (CV)	Binom. Test	
Type of Answer	Question	Frequency	Frequency	z	p
Choose one version	Information gained	37	11	3.75	< .001

6. Discussion

The results indicate that the vast majority of students preferred the photorealistic version; both for use at school and at home (Table 2). They evaluated the photorealistic version as being more authentic and attractive (Table 2). They also considered the photorealistic version to be a better source of information on Czechoslovak contemporary history (Table 3).

Therefore, our Hypothesis 1 (P Version more authentic) was supported by the data, and our Hypothesis 2 (C Version more attractive) was refuted. The Hypothesis 3 (C Version more modern) was weakly supported; i.e. the students evaluated the C Version as marginally more modern. The P Version outperformed the C Version concerning the "overall preference" of the students.

These results are important for the further development of the educational simulation, *Czechoslovakia 38-89*. At the same time, since existing DGBL research does not agree on the level of visual realism suitable for educational games/simulations, this study has potentially interesting consequences for instructional design. The results suggest that the level of visual realism has a significant impact on the game's/simulation's acceptability as a learning tool; particularly when dealing with contentious and/or emotionally-charged historical content.

The students were asked to summarize the simulation's information content in three sentences (Table 1, Q.35). Subsequently, we asked them to indicate from which version of the simulation they gained the information needed to answer the previous question (Table 1, Q.36). The vast majority of students reported that they gained the information from the photorealistic version (Table 3). Nevertheless, their answers on the information content related mainly to the audio voiceover, which was the same in both versions. This indicates that the possibility to see a real, and not illustrated, interviewee could have important consequences for the students' paying attention to and/or perception of the simulation.

The results of this study seem to contradict the above-mentioned suggestions of Wouters et al (2013), i.e. that there is no argument to support opting for photorealistic visual designs, and Rooney (2012), i.e. that visuals play a minor role in sustaining student engagement and immersion in educational games. However, these meta-analyses/studies do not relate different levels of visual realism to specific content and knowledge domains. As Alexander et al (2005) have argued, the appropriate level of fidelity could depend on the game's/solution's learning objectives. Further research is needed in order to determine boundary conditions for photorealistic designs in educational simulations; i.e. to pin down for which kinds of knowledge domains, content, the length of exposure and learners they work, and for which they do not.

This study, like any other study, is not without its limitations. We compared two versions using only one interviewee. The C Version used a limited animation technique, and the P Version used color footage; whereas, the C Version used a black-and-white cartoon. It is also important to note that we have not tested the learning effect of the two versions of *Czechoslovakia 38-89*. We have only examined how high school students perceive them, how they accept them as a learning tool, and students' self-reported evaluations of the simulation as a source of information. Yet as Whitton and Whitton (2011) suggest, the perceived acceptability of the learning materials, and the initial motivation to use them, constitute important aspects of the successful implementation of DGBL.

7. Conclusion

This study investigated the impact of photorealistic/cartoon-like representation of non-player characters on students' perception of an educational simulation. In a laboratory study using within-subject design and involving 48 Czech high school students, we compared photorealistic and cartoon-like versions of an educational simulation *Czechoslovakia 38-89*. The results indicate that the vast majority of students preferred

the photorealistic version; both for use at school and at home. They evaluated the photorealistic version as being more authentic and attractive. They also considered, which is very important, the photorealistic version to be a better source of information on Czechoslovak contemporary history.

Acknowledgements

This study was supported by the grant project DF11P01OVV030 "Příběhy z dějin československého státu: výzkum a experimentální vývoj softwarových simulací pro výuku historie českých zemí ve 20. století" financed by the Czech Ministry of Culture in 2011-2014.

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