A Mixed-Method Approach on Digital Educational Games for K12: Gender, Attitudes and Performance

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Abstract. Research on the influence of gender on attitudes towards and performance in digital educational games (DEG's) have quite a long history. Generally, males tend to play such games more engagingly than females, consequently attitude and performance of males using DEGs should be presumably higher than that of females. This paper reports on a investigation of a DEG, which was developed to enhance the acquisition of geographical knowledge, carried out on N=281 British, German and Austrian K12 students aged between 11 and 14. Methods include a survey on initial design concepts, user tests on the system and two single-gender focus groups. Gender and cultural differences in gameplay habit, game type preferences and game character perceptions were observed. The results showed that both genders similarly improved their geographical knowledge, although boys tended to have a higher level of positive user experience than the girls. The qualitative data from the focus groups illustrated some interesting gender differences in perceiving various aspects of the game.

Keywords: User experience, UX, gender differences, digital educational game, DEG, performance

1. Introduction

Digital games are omnipresent within the life of the current generation of K12 students. According to a 2008 survey by the Pew Research Center (Washington, DC), 97% of children between the ages of 12 and 17 regularly play computer, Web, portable, or console games [1]. Obviously, Digital Educational Games (DEGs) can offer exciting and dynamic environments with which to engage players in meaningful and motivating learning activities and to inspire them to explore a variety of topics and tasks [2], [3], [4], [5], [6].
Play is definitely one of the most important concepts, consequently games, used in an appropriate setting, can be used as splendid educational tools.

Nonetheless, some previous research suggests that children in general tend to find such educational games quite uninteresting, and that huge gender differences do exist, implying that boys have a more negative attitude towards so-called edutainment games than girls [7]. Whilst some recent research has indicated that the gender gap is beginning to close (cf. gender similarities hypothesis [8]), whether such a gap-narrowing can be generalized to the domain of computer games remains completely unclear. In fact, the number of girls playing computer games has been increasing tremendously, however, they still tend to be perceived as a masculine activity, that more boys than girls prefer and are willing to spend time on. The questions remains on How much of this is pressure from outside? How many **non-academic** families see it as acceptable for boys to spend 3 hours in front of a computer, while girls are expected "not to waste their time?"
Such a disparity is attributable to the stereotypical presentation within games, a general lack of female characters in games, high competitiveness, and limited social interaction [9], [10], [11], [12]. Even children in elementary schools perceive that software is gendered by design. The implication is more than just the attitude towards games; more serious impacts are girls' low confidence in working with computers and avoidance from technology-related fields [13], adversely affecting their employability. Specifically, Kinzie & Joseph (2008) [7] identified some interesting gender issues in game character preferences, for instance, the children in their study preferred characters to be of their same gender and ethnicity. Presumably, culture with its values, beliefs and norms plays an important role in shaping children's perceptions of game characters.

We are motivated to study gender differences in the context of a DEG under development. The prototype topic is based on geography. In the first phase, an initial game design concept was developed prior to any implementation. In brevity, the game story was about an alien kidnapping a boy and their flying round the world to collect relevant geographical information. A survey was designed to evaluate the acceptance of the target groups towards the game design, to verify if there are any gender and cultural differences in perceiving the game characters, and to elicit feedback on improving the game concept - a practical means to gather user requirements. In the second phase, an executable prototype was produced. User tests primarily in the form of observations and questionnaires were implemented to gauge the learning efficacy of the game, user acceptance towards it and different aspects of user experience. To further explore the issue of gender differences, two focus groups with representative

school children were additionally conducted. Results from these three empirical studies (designated as Study 1, 2 and 3, respectively) relevant to gender issues are presented subsequently.

2. Related Work

Research questions addressing the influence of gender on attitudes towards computer games in general and on performance resulting from playing DEGs in particular are not new (e.g. [14]). However, answers to these questions keep on changing, given the highly dynamic landscape of gaming technologies. Besides, the computer game industry tactically lures more females to become frequent players. Broadly speaking, there exist two major types of factors – personal and technical - contributing to gender differences in computer gameplay patterns. On the personal level, traits [15], motivation [12], [16], (Hartmann & Klimmt, 2006), [6], [17] and self-concept pertinent to IT competence [18] are salient variables that interact intricately with game design features. Specifically, two genders are observed to differ in achievement needs, with males generally demonstrating a higher level of desire to compete and beat their opponents than females [12], who seem disadvantaged and less effective in competitive settings such as computer games. An apparently weaker competition orientation of females undermines their engagement in computer gameplay. Apparently – because it has not yet been established (to our satisfaction) that this is not inherent in the upbringing, i.e. environmental rather than genetic. We know a number of people – both genders – where this tendency is reversed.
Similarly, males are found to be keener sensation seekers than females as they tend to take risks (e.g. extreme sports) in pursuit of intense feelings and emotional arousal. The notion of sensation seeking has been widely adopted by Zuckerman (1979), [19] and other scholars to explicate a range of social phenomena including various types of addictive behaviors. For example, arousal is an interesting, but not fully researched, psychological construct underlying sensation seeking as well as gameplay [20], [21] [22]. Interestingly, arousal is said to be normally at a higher level in males than females [23]. These observations partly explain gender differences in gametype preferences and their different motivations to play. Males prefer games with confrontational and violent contents entailing fast responses and yearn to gain high scores, sense of control and other personal esteems. In contrast, females appreciate storylines and personalities of game characters to be explored at a relaxing pace and value building relationships with game characters or co-players [10]. Intertwining with competition and sensation seeking orientation is the issue of self concept. Despite insignificant gender difference in online abilities as indicated by some objective measures, females subjectively perceived such abilities to be much inferior to males [18]. Evidence on the trainability of cognitive-perceptual skills, which have traditionally been assumed to be innately stronger in males, seems not yet able to dispel the misconception in females.

In summing up the aforementioned arguments, presumably males tend to play games more engagingly than females; the former are then expected to show significantly

higher learning gain from DEGs than the latter. However, recent empirical evidence indicates that no such gender difference can be detected [2]. Indeed, with the increasing awareness of gender differences and their underpinning factors, today's DEGs are so designed as to eliminate potential biases against any gender by incorporating a range of features and activities [24]. Our project 80Days adopts a gender-sensitive approach by adapting the game to gender-based differences to optimize the learning process. Note, however, the elaboration of the adaptivity mechanism concerned falls outside the scope of this paper.

3. Method and Procedure

3.1 Study 1- A Survey on Initial Design Concepts

Design of the Questionnaire. The questionnaire consists of two major parts. Part A contains five close-end questions on the respondent's gender, age, gameplay habit, gametype preference, and affinity for geography. Specifically, four gametypes – learning, action, strategic and sport – are provided as options to reduce the possible confusion in children; the other taxonomies are deemed rather complex (e.g. [25]). Part B addresses different aspects of the game. First a synopsis of the game story is presented. Then two close-end questions on the perceived interestingness of stories about aliens/UFO in general and of the game story in particular. An open-end question on describing improvement suggestions is presented. A set of four questions on understanding how respondents identify themselves with the story's main play characters are given. Another set of three questions on the preference of non-play character is posed. The last question is to assess the respondent's intention to play the game in the future.

Participants. Two samples from Germany and England were involved in the survey. They were school children aged between 11 and 14, the target group of the game. In Germany, the survey was conducted in the context of computer games fair. In England, the survey was administered in the classrooms of the five participating schools. Due to organizational constraints, the survey could only be conducted by the school teachers, who were asked to read aloud a script with similar wordings used in the German event. This step was taken to maximize the comparability of the data collected from the two settings.

Table 1. Demographic data of the survey respondents in the two countries

Country	Number/Age	Girls	Boys	Sub-total
German	Number	78	61	139
	Mean Age (SD)	12.6 (1.1)	12.8 (1.1)	12.7 (1.1)
British	Number	59	83	142
	Mean Age (SD)	12.5 (0.9)	12.7(0.9)	12.6 (0.9)
	Sub-total	137	144	281

3.2 Study 2 - User Tests of the Executable Prototype

Design of the User Test Session: It was conducted in groups of various sizes, ranging from 4 to 14, in the rooms within the respective school premises. Each participant was allocated to one computer where the game was installed and played it on an individual basis. One or two researchers were present in the rooms all the time to provide help and observe the participants' performance and behaviours. The arrangement of the test session is summarized in Table 2. The instruments listed therein have been developed by the project's research team.

***Participants*:** Two and four secondary schools in England and Austria were involved. Due to some technical problems, some of the participants could not complete the four missions. To compare validly the scores earned in Pre-test AoL and those in Post-test AoL, which were based on the contents of the four missions, our data analysis focused on the cases that successfully attempted all the missions. Besides, considering the differences in the test setting (e.g. larger group size in Austria) and curricular design, data of the British and Austrian samples are not merged whereas data from different schools in the same country are collapsed into one sample. In this paper, considering the length limit, we just report the findings on the British sample. Thirty-six children from the two British schools, of which the academic performances and infrastructure were comparable, could play through the four missions; the average age was 13 years old; 16 of girls and 20 are boys.

Table 2. Overview of the arrangement of a user test session

Activity	Objective and Instrument
Introduction	Describe the aim of the evaluation tests and instruct how to operate the laptops and headsets
Fill in the Background Questionnaire	Items: Identifier (ID), gender, age, gameplay frequencies, gametype preference, affinity for geography, subject grades, early involvement, and expectation
Fill in Pre-test Assessment of Learning (AoL)	16 domain-specific questions, open and close-ended, are based on the content of the game.
View Tutorial	6 open- and close-ended questions about the usefulness and usability of the tutorial material and presentation
Total Pre-Gameplay time: ~ 30 minutes	
Play each of the four micro-missions and fill in "After Mission Questionnaire" (AMQ) right away	Questions of AMQ are adapted to the content of the respective micro-mission. Research on user experience evaluation [X] suggests that data be collected as close to the interactive event as possible. Otherwise, the validity of the data may be compromised.
Total Gameplay time: ~52 minutes	
Fill in the Post-test Assessment of Learning (AoL)	The same questionnaire used for Pre-test. The rationale is to assess whether the children's knowledge of the geographical concepts covered in the game can be enhanced after playing it.

Usability and User Experience Evaluation of the Game Features	It consists of six sections with each of them focusing on different aspects of the game. The first section "General Game Experience" was adapted from [X].
Debriefing	Summarize the activities of the test session and thank the participants
Total Post-Gameplay time: ~33 minutes	

3.3 Study 3 - Focus Groups

Procedure: Prior to taking part in focus groups, participants were asked to play through the whole game without being required to fill in any questionnaire except the one for background data. Subsequently, focus groups were conducted as follows:

- Introduction: Participants were explained the purpose of the focus group
- Game recall exercise: Each participant was given a stack of Post-it notes and asked to write down whatever they could remember about the game.
- Sharing game recollections: Participants were presented three A3 sized sheets, one for each: "Positive" (green), "Neutral" (yellow) and "Negative" (red). They were asked to stick their notes to the respective sheets based on their own judgment how to categorise their notes.
- Guided discussions on different aspects:
  - Gameplay, e.g. "*In the whole game, which game character do you think you are supposed to be and which one would you like to be?*" (NB: the rationale is to understand if there is any mental gap in role adoption)
  - Game characters and game story, e.g. "*How would you change the alien so that you will like him better*?"
  - Learning part, e.g. "*How would you compare learning geography through the game with through normal classroom teaching?"*
  - Geographical content, e.g. "*If you could add any aspect of Geography to the 80Days game, what would it be and how would you do it*?"
- Debriefing

Participants: Two single-gender groups, five boys and five girls, from a British secondary school (different from that in Study 2) were involved. Their participations were voluntary. The average age was 13.4 for the female group and 14.0 for the male one. All the participants, except one girl who had never played computer games before, were frequent gamers.

4. Results and Discussion

4.1 Study 1 - Survey

Results show that half of the British boys (52%) play games everyday and half of the German boys (51%) play games more than twice per week. Interestingly, 14% and 12% of the British and German girls report that they have never played games, whereas all of the British boys have played games. 45% of the German girls play games less than once per week whilst 44% of their British girls play more than twice per week. These figures seem to suggest that (i) Boys tend to play games more frequently than girls, irrespective of the country of residence; (ii) the British children tend to play games more frequently than their German counterparts. To investigate whether these observations are statistically significant, we performed the linear categorical regression analysis. The value of R^2 = .25 indicates that the two predictor variables *gender* and *country* can explain only 25% of the variations of the gameplay frequencies. Results show the significant effect of the predictor *gender* (beta = .49, t = 9.32, p<.001)) and the non-significant effect of the covariate *country* (beta = -.017, t =-.136, p>0.05). Boys tend to play games more frequently than girls, and the country of residence does not have a strong effect on the children's gameplay frequency.

Cramer's V was used to evaluate whether *gender* was associated with *gametype preferen*ces. The most preferable gametype for both the British girls (51.7%) and boys (49.5%) are Action, followed by Strategic and Sport. The least preferable gametype is Learning with only 3.2% and 2.2% for the girls and boys, respectively. The value of the Pearson chi-square equals 0.581 (p =. 901), indicating that *gender* and *gametype preference* for the British sample are **not** significantly related. In contrast, the German sample demonstrates a slightly different pattern from their British counterparts. The most preferable gametype for the German girls is Strategic (40.7%), followed by Action and then Sport; the most preferable gametype for the German boys is Action (54.3%), followed by Strategic and then Sport. The least preferable gametype is Learning with 13.2% and 3.2% for the girls and boys, respectively. The value of the Pearson chi-square equals 13.972 (p = .003), indicating that *gender* and *gametype preference* for the German sample are significantly related.

With the aim of evaluating to what extent the respondents tended to associate the Boy's (the main play character) attributes with their own, they were asked to rate first the Boy and then themselves, using a 7-point scale, with respect to six pairs of contrasting adjectives adapted from the instrument Speech Evaluation Instrument [4] consisting of three subscales – superiority, attractiveness and dynamism, against which the entity of interest is evaluated:

- *Superiority*: Intelligent vs. Unintelligent; Uneducated vs. Educated;
- *Attractiveness*: Friendly vs. Unfriendly; Cold vs. Warm;
- *Dynamism*: Peaceable vs. Aggressive; Talkative vs. Shy

The exercises resulted in a set of so-called "Boy-based ratings" and another set of "Me-based ratings". We computed the correlations among them independently for the

German and British samples. A number of statistically significant correlations are found. Nonetheless, based on our research interest, we explore whether there are gender differences in perceiving the relationships between the Boy's attributes, between the Me attributes, and between these two sets. Interestingly, results consistently show that the German female respondents tended to perceive the attribute interrelations, be they applied to the Boy or themselves, in a more complicated manner than did their male counterparts. Presumably, the German male respondents may associate their own attributes with the Boy's (same gender) more strongly than the female respondents (opposite gender) do; however, the empirical results indicate otherwise. In contrast, the British respondents' perceptions, irrespective of gender, are less complicated than those of their German counterparts. Interestingly, the British male respondents tend to perceive the associations in a more complex way than their female ones – a reverse of the trend demonstrated by the German sample. Fig. 1 and Fig. 2 illustrate the results of how the respondents perceive the associations between the game main play character ("Boy") and themselves ("Me"). Contrasts are observed across gender and culture. We also aim to find out whether those who perceived a stronger "Boy-Me" association might have a higher tendency to play the game in the future (i.e. the last question of the survey) by summing the absolute differences in ratings over the six pairs of adjectives. While there is a moderately significant correlation for the British sample (r =-.24, N = 199, p<.05), it is not significant for the German sample.

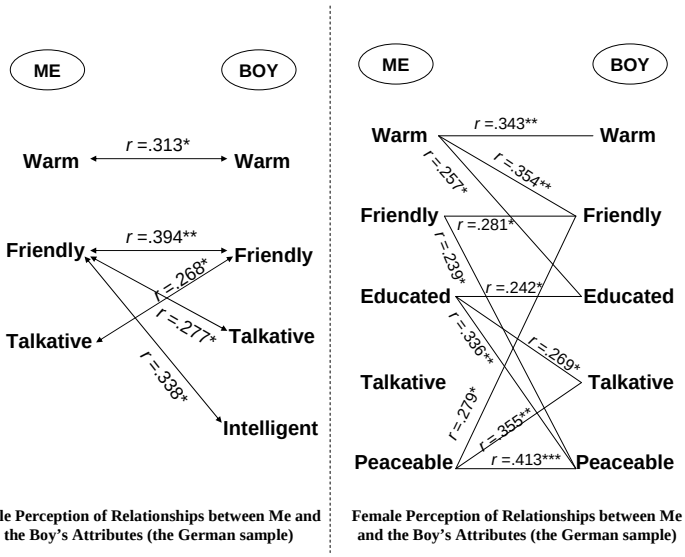

Fig. 1. Gender-specific perceptions of the play character and oneself (German sample)

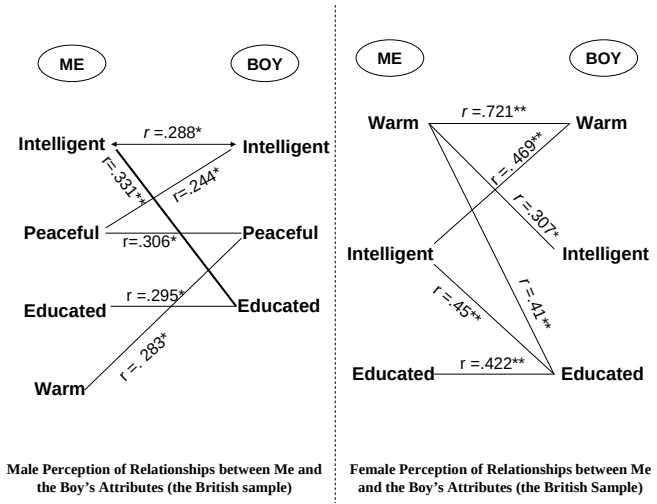

Fig. 2. Gender-specific perceptions of the play character and oneself (British sample)

4.2 Study 2: User Tests of the Executable Game Prototype

Our basic assumption is that by completing the four Missions of the game the participating children can gain better understanding of the geographical contents addressed therein. The improvement can be measured in terms of the significant difference in their performance between the Pre-Assessment and Post-Assessment of Learning Questionnaire (Pre-ALQ vs. Post-ALQ). The British participants demonstrated statistically significant learning gains (Pre-ALQ: mean = 20.8; Post-ALQ: 27.4; $t = 5.25$, $df = 35$, $p<.001$).

When breaking down the data by gender, some interesting observations are obtained. In both Pre-ALQ and Post-ALQ, the boys performed significantly better than the girls ($p <.05$). The girls gained on average 5.1 points with the range of difference being -6 to 14 whereas the boys gained on average 7.8 points with the range of difference being -9 to 23 (Note that some children lost rather than gained points after the gameplay; we speculate that either they made guesses in Pre-ALQ or got confused about certain concepts during the gameplay). But the boys did *not* improve to a significantly larger extent than did the girls. In other words, both genders benefited from the gameplay in terms of knowledge gain, but it did not privilege the boys or frequent gamers (i.e. gameplay frequency is a non-significant covariate).

Existing literature suggests that evaluation of children's game experience should address seven dimensions, including *challenge, competence, flow, immersion, negative affect, positive affect and tension* ([26]). Accordingly, 14 statements are adapted for evaluating our game, two for each dimension (Table 3). The participants are asked to rate each of them with a 5-point Likert scale with the rightmost and leftmost anchors being 'not true at all' and 'very true', respectively.

Table 3. Seven dimensions of general game experience

S1.	Playing this game was useful for me to learn geography	(Challenge)
S2.	This game was interesting for me	(Positive Affect)
S3.	I put a lot of effort in playing the game	(Challenge)
S4.	Playing this game was a waste of my time	(Negative Affect)
S5.	I felt frustrated when playing the game	(Negative Affect)
S6.	I felt proud when I finished the game	(Competence)
S7.	The game was too difficult for me	(Competence)
S8.	I could concentrate easily on the game activities	(Flow)
S9.	I had the feeling of controlling the game	(Positive Affect)
S10.	I was completely absorbed by the game	(Immersion)
S11.	I felt exhausted after playing the game	(Tension)
S12.	I had the feeling that I had returned from a journey	(Immersion)
S13.	I felt time pressure	(Tension)
S14.	I was fast at reaching the target of the goal	(Flow)

Results indicate that significant gender differences can only be found in two dimensions, namely *Competence* (S7) and *Flow* (S8, S14). The girls rated themselves lower in Competence than did the boys . This seems to be a much investigated and frequently documented phenomenon – particularly in human resources, one is taught to add 10% to a female assessment of herself and to deduct 10% from a male assessment. (M*g* = 2.3, M*b*=1.4; *t* = 2.4, p<.05; NB: the higher the rating in S7, the lower the perceived competence is). In contrast, the boys rated significantly higher than did the girls in S8 (M*g* = 3.1, M*b*=4.0, *t* = 2.4, *p*<.05) and S14 (M*g* = 3.1, Mb= 4.0, *t* = 2.5, *p*<.05). As the feeling of flow [x] is imperative for engaging in gameplay, it can be inferred that the boys had stronger positive experience through playing the game than did the girls.

4.3 Study 3 – Focus Groups

The focus groups were audio-taped and transcribed in verbatim. Some interesting gender-specific findings are obtained. In game recollections, only two boys named a negative feature: the character Aunt (i.e. a static 3D female figure presenting geographical information via a text window) and controls of the Spaceship. In contrast, all the five girls named at least two negative features, including the Aunt and the Spaceship. This observed differences suggest that the boys had a higher acceptance towards the game than did the girls. In guided discussions, all the five boys and only one girl considered flying UFO the most positive aspect. Three girls appreciated the graphics the most and criticized that there was too much talking in the game. With regard to the role adoption, it seemed that both genders had difficulty in recognizing that they were supposed to play the role of the abducted Boy. One girl, who was able to do so, uttered: “You were the boy. You were looking through his eyes” whereas another stated surprisingly: “I never even knew we were playing with him. I didn’t even know we were that person.”

Concerning the learning part, both groups mentioned the importance of getting an explanation. Some girls remarked: “The teacher gives you more of an explanation”, “… you can ask them (the teacher) if you’re stuck. Similarly, a boy mentioned “In the classroom you’ve got an explanation… but in the game it just tells you you’ve got to go here and name the countries, like it doesn’t give you an explanation.” Interestingly, some boys suggested lengthening the missions but some girls suggested shortening them. Quite unexpectedly, none of the girls proposed including a female game character (cf. the Boy) whereas one boy recommended providing a choice of a male or female play character.

5. Concluding Remarks

Previous research suggests that children, especially boys, tend to find learning games boring. It is corroborated by our findings of Study 1 that, among the four gametypes, the learning game is least preferable and that girls are more positive towards it than boys. Existing research also suggests that children tend to prefer game characters that are in some way “like me”. Cultural preferences for normative personal qualities may influence children’s preferences for the characters they play. While there are some very interesting gender and cultural differences in interpreting the main play character’s qualities and in associating those qualities to theirs, such associations do not affect their intention to play the game. The setting, where the survey was conducted, could have impact on the children’s perception and acceptance of the game: the relaxing atmosphere in the game fair with the exhibitors as opposed to the more structured classroom environment with the teacher. Results of Study 2 suggest that both genders could benefit to a similar extent from playing the game in terms of domain-specific knowledge gain. Interestingly, the female participants found the game more difficult to play than did the boys. In other words, the girls’ perceived competence in gameplay was significantly lower than the boys’. This observation is consistent with the earlier research. In the same vein, the boys had experienced a significantly higher level of flow feelings, which are important for engaging in and enjoying a game. Findings of the two single-sex focus groups also suggest gender-specific likes and dislikes towards different aspects of the game. Surprisingly, the girls tended to be more critical. Currently, we are exploring psychosocial theories to explicate the phenomena observed and their implications on future work.

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