The influence of a game making project on male and female learners' attitudes to computing

Judy Robertson

To appear in Computer Science Education 13(1). March 2013

Computer Science, Heriot-Watt University, Edinburgh, UK

Earl Mountbatten Building

Heriot-Watt University

Edinburgh

EH14 4AS

UK

Judy.Robertson@hw.ac.uk

The influence of a game making project on male and female learners' attitudes to computing

There is a pressing need for gender inclusive approaches to engage young people in computer science. A recent popular approach has been to harness learners' enthusiasm for computer games to motivate them to learn computer science concepts through game authoring. This paper describes a study in which 992 learners across 13 schools took part in a game making project. It provides evidence from 225 pre-test post-test questionnaires on how learners' attitudes to computing changed during the project, as well as qualitative reflections from the class teachers on how the project affected their learners. Results indicate that girls did not enjoy the experience as much as boys, and that in fact the project may make pupils less inclined to study computing in the future. This has important implications for future efforts to engage young people in computing.

Keywords: gender; game authoring; teacher education

Introduction

Increasing young people's enthusiasm and interest in computing is a high priority at a time when the demand for suitably qualified IT graduates is growing (Klawe, Whitney, & Simard, 2009; e-skills UK, 2011) and when recruitment to undergraduate computing degrees is waning in many countries. In the UK, in which the present study takes place, the number of applicants to computing and IT courses has fallen by 44% since 2001, while applications to higher education in general increased by 41% in the same period (e-skills UK, 2011). A related problem is that computing careers do not tend to attract females – in 2010 only 15% of applicants to IT related degree courses in the UK were female, and only 18% of IT and Telecoms professionals were female (e-skills UK, 2011). In a significant report that criticised the state of computing education in UK schools, the Royal Society identified that the standard of teaching was low, with confused definitions of the topics which should be considered as "computing", an out of date curriculum, and poorly trained teachers (Furber, 2012). It is clear that there is a need for motivating, up to date, gender inclusive computing activities in UK schools, delivered by adequately trained teachers.

One approach to solving these problems has been to introduce young people to engaging, creative and highly visual environments such as Scratch, Alice or Greenfoot (Utting et al., 2010) to support the learning of computing concepts. Educators have also been drawing on the perceived motivational power of computer games to encourage children to learn through designing their own games (Carbonaro, Szafron, Cutumisu, & Schaeffer, 2010; Robertson & Good, 2005; Robertson & Howells, 2008; Robertson, 2012). Indeed some researchers have considered how the principles of game design might apply to the design of effective learning environments in general (Gee, 2003; Salen et al., 2011). Creative, visual tasks, particularly around storytelling have been used to encourage girls to become interested in programming (Kelleher, Pausch, & Kiesler, 2007; Denner, Werner & Oritz; 2011). Kelleher's work is of particular interest, because of the lack of diversity in the field of computing (Klawe et al., 2009; Singh, Allen, Scheckler, & Darlington, 2007).

This paper considers the impact of the game making project (called Making Games in Schools) on pupils' self-reported attitudes to computing, and whether there are differences in attitudes by gender. It also reports the teachers' perceptions of their game making projects in terms of pupil engagement and learning. The paper begins with a review of the literature relating to two main themes: studies of girls' attitudes to computing and the educational benefits of making games. A description of the Making Games in Schools project follows to establish the context for the reporting of the quantitative attitude survey administered to pupils and the qualitative interviews and focus groups with teachers. The paper ends with a discussion of the findings in the light of recent studies.

Background

There are two main strands of previous findings which are relevant to this project: 1) studies which explain the issues which prevent women from studying computer science and 2) research results relating to the educational benefits of making computer games in the classroom, including gender differences where relevant.

Gender issues in computer science education

Previous studies have found gender differences in students' attitudes to computer science. There is evidence it is not lack of ability which prevents women from entering the profession, but rather it is a lack of confidence in their technical abilities which puts them off (Singh et al., 2007). Interestingly, there is a paradoxical tendency for women to believe that while women in general have equal ability and opportunity to pursue computing careers, they personally don't happen to be good at it.

Beyer, Rynes, Perrault, Hay & Haller (2003) conducted a multivariate analysis of the differences in attitudes between 56 male and female Computer Science (CS) majors and non-CS majors. They found no gender differences in ability, motivation, or attitudes towards computer science. There was, however, a significant difference in self-reported confidence in computing abilities with women lacking confidence in comparison to men. Indeed, female CS majors reported less confidence in their CS abilities than men who were not studying CS. The authors point out that low self confidence has a negative effect on performance, and is also likely to deter women from choosing CS careers, and make them vulnerable to dropping out of CS courses. They urge that "it is of the utmost importance to increase female CS students' computer confidence." p52. Similarly, Margolis and Fisher's work found that female students are more likely to give up on computing than male students, even when more competent (Margolis and Fisher, 2003).

However, women also actively reject computing careers because they perceive a poor fit between their aspirations and computing professions. In fact, computing professions do not appear to be attractive career choices for either gender. A recent study by Lang found that only the most technically inclined men, considered careers in computing (Lang, 2010). Less than a third of female computer science undergraduates interviewed reported choosing computing as a career by middle school - instead they often decided to study it later in their school careers as a result of happenstance rather than a long interest in the subject. While approximately two thirds of the men interviewed became familiar with technology through playing computer games, the women did not expect to proceed from playing games to studying computer science at university (Lang, 2010). Taken together, these findings could suggest that an interesting course in game design in early high school could encourage both boys and girls to pursue computing as a career, assuming that the teachers discussed how game making related to the discipline. More boys could perhaps be persuaded to follow up on their hobby as a career choice and more girls could be influenced into considering computing at an earlier stage.

Educational benefits of game making

From a constructionist perspective, there are theoretical reasons for believing that making games can be educationally beneficial: Kafai has argued that when making games, learners also construct knowledge and their relationship to it (Kafai, 1995; Kafai, 2006). She writes: "The learner is involved in all the design decisions and begins to develop technological fluency. Just as fluency in language means much more than knowing facts about the language, technological fluency involves not only knowing how to use new technological tools but also knowing how to make things of significance with those tools and most important, develop new ways of thinking based on use of those tools" (Kafai, 1995; p39). Technological fluency, and an ability to think using computational tools are required while studying computer science, and so it is reasonable to investigate games creation as a motivating way to encourage young people to begin studying the subject.

A particularly popular example of a game making environment, Scratch, was developed at MIT based on constructionist principles. This visual programming environment is currently popular in secondary schools to teach game design as part of the technology objectives within a new interdisciplinary curriculum[1] in Scotland (where this study took place). Scratch has been found to be successful in teaching

[1] http://www.ltscotland.org.uk/learningteachingandassessment/curriculumareas/technologies/eandos/index.asp

computer science concepts to middle school children (Meerbaum-salant & Ben-ari, 2010). It is based on the premise that children should be digitally fluent in designing, making, sharing and editing interactive media. It was designed on Papert's principals for instructional programming languages: "low floor, high ceiling and wide walls". That is, the environment is intended to enable beginners to get started easily, supports students who wish to work on complex projects, and makes it possible to work on a wide range of project topics depending on students' preferences (Resnick et al., 2009).The environment, which is freely available online, has a very large user community of 81,000 children who have created 700,000 projects (Hill & Monroy-Hernández, 2010).

In a study of the computer science education potential of another popular games programming environment for children, Denner, Werner & Oritz (2011) analysed 108 games created by 59 middle school girls using the software Stagecast Creator. They found that the girls' games exhibited moderate levels of programming complexity and were moderately usable. They concluded that "game construction involving both design and programming activities can support the learning of computer science concepts". (Denner, Werner & Oritz, 2011;p240).

However, the benefits of making games need not only be in developing computer science related skills; this activity can develop a range of transferrable successful learner skills such as enthusiasm and motivation for learning, determination to reach high standards of achievement, independent and group learning, and linking and applying learning in new situations (Robertson & Howells, 2008). Learning-by-making can be applied in other subject domains. Vos, van der Meijden and Denessen (2011) conducted a study in which 235 elementary school students (10-12 years old) either played or constructed their own drag and drop memory games in the Dutch language. There was a significant difference in self reports of intrinsic motivation and deep learning strategy use; children who made their own games enjoyed it more and reported using deeper learning strategies than those who played existing games. There were no significant gender differences for perceived competence, interest or use of deep learning strategies. In a study of the effects of game construction on 9-10 year old children's literacy, Owston, Wideman, Ronda & Brown (2009) asked the children to create educational quiz questions which would be incorporated into an electronic version of a board game. They report significantly better performance on a logical sentence construction item on a battery of standardised tests. Interview data from teachers also suggested that the game development task helped the students with content retention as well as a variety of research skills required to prepare the questions for their game. There were no gender differences reported on literacy scores or by teachers.

Both these studies explored learning and motivation in quiz style 2D online games rather than the story-based 3D role-play games which the children in this study made. However, previous work has established that children in the target age range of 12-14 years old also find making narrative focussed games of this sort highly motivating (Robertson & Good, 2005). With respect to the skills gained by game-making, analysis of games created by a class of twenty-five 11 year old learners (using the same Adventure Author and Neverwinter Nights software which was used in the present study) showed that the children mastered the basics of game making and developed a range of new media storytelling, visual design and audience awareness skills (Robertson, 2012). In spite of concerns published in the literature that girls could be disadvantaged by their lack of prior knowledge of computer games during classroom based gaming activities (Jenkins & Cassells, 2008; Carr & Pelletier, 2008; Steiner, Kickmeier-rust, & Albert, 2009; Kelleher, 2008), this study found that girls performed considerably higher in the educational game making activity overall. The girls outperformed boys on aspects of game making related to storytelling (such as writing dialogue), suggesting that their prior skills from classroom writing activities were outweighing their relative lack of experience in gaming. Another potential reason for girls' better performance was their greater willingness to change their games according to peer feedback.

While the previous study on Adventure Author with Neverwinter Nights considered the development of new media literacy skills, Carbonaro et al. (2010) report on a study which focussed on using Neverwinter Nights for the development of computer science skills. In this study, 24 female and 26 male high school students (aged 15-16 years) made computer games using the Neverwinter Nights Aurora toolset with the ScriptEase plug-in. The Aurora toolset is the precursor to the toolset used in Making Games in Schools, although the graphics are not so sophisticated. ScriptEase is a graphical interface for specifying patterns of interaction between game characters and objects which does not require specialist programming knowledge. The researchers measured the higher order thinking skills used by the young people in creating their games, computer science abstraction skills demonstrated in the ScriptEase patterns which the students successfully used in their games, and the students' enjoyment of the game making activity. They found evidence to indicate that the game authoring activity stimulated higher order thinking skills and that female students scored significantly higher than boys on this measure. Analysis of the students' use of ScriptEase patterns "indicate that students attained a reasonable level of Computing Science skills" (Carbonaro et al., 2010; p1108). No major gender effects were found.

Students preferred to write interactive stories over traditional stories, with boys more inclined to agree with this than girls. This finding is interesting, given the context of previous research on boys' literacy which indicates that although boys do not respond well to fictional writing tasks, they can be more willing to engage in them when using ICT (Daly, 2003). The authors claim that their approach is "a viable gender-neutral approach to teaching Computer Science in particular and Science in general that may increase female participation in the discipline" (Carbonaro et al., 2010; p1098). This claim is examined further in the light of the results reported here in the Discussion section.

In summary, there are pedagogical and empirical reasons for exploring the benefits of computer game making in the service of encouraging children to study computer science in a gender inclusive way. Previous results in the domain of computer science (and more generally) indicate either no gender effects, or even that girls score higher on some measures of learning.

The Making Games in Schools Project

The purpose of Making Games in Schools is to disseminate research software and pedagogical theory developed during the EPSRC Adventure Author project (Robertson & Howells, 2008) to local schools in a sustainable fashion. Adventure Author is an educational game making tool which is built as a plug-in on top of the Neverwinter Nights 2 Aurora Toolset (Robertson, 2012). The software enables non-expert users to make their own 3D role-play games and provides support for stages of the creative process including ideas generation and peer review. The educational aims of Adventure Author are to give children the opportunity to develop skills in new media literacy, learn how to manage the creative process and to become familiar with basic concepts in computer science. The new media literacy skills include techniques for telling a story in a multimodal, spatial medium and anticipating the needs of the game player by creating an environment with well-structured navigational cues and ensuring that the challenge level of the game is suited to the player's skill (Howells & Robertson, 2012). Learning to manage the creative process requires the learner to iterate between creativity stages productively, for example from problem finding to problem solving, or from testing solutions privately to sharing them with peers. In terms of computer science, the software introduces the concepts of conditions and variables through a user friendly interface to interactive conversation writing in which different outcomes occur depending on which conditions are fulfilled. For example, a character might only agree to give the player a reward if the player has collected a series of items, or the world is in a particular state, or a variable has a particular value. The game designer can also specify actions which should happen after lines of dialogue have been chosen by the player, including setting and updating variable flags. The interactive conversations are represented in a dialogue tree in which choices are branches and the depth of the tree corresponds to the number of conversational turns taken between the player and the non-player character.

Adventure Author also encourages systematic testing strategies, requiring the designer to think about what tests must be performed to check that a sequence of events will work correctly depending on the state of the game world (e.g. what would happen if the character who informs the player of a crucial quest is killed in combat by a non-player character before the player meets him?).

A screenshot of the Neverwinter Nights toolset for building game areas is shown in Figure 1 and an example view of a game world from the player's point of view is shown in Figure 2. The components of Adventure Author are as follows: *Fridge*

Magnets, which is designed to assist in recording and storing creative ideas; *Conversation Writer*, which enables children to write interactive dialogues with conditions and consequences (such as the one shown in Figure 3); and *Comment Cards* which supports structured peer and self review of games. Over the course of a typical project, pupils might spend a session (1-2 hours) exploring the toolset, sculpting terrain, adding blueprints for buildings and props and experimenting with the behaviour of non-player characters. Another session might be spent planning ideas for the game using the Fridge Magnets software. Learning how to use the Conversation writer to create interactive conversations, augmenting the conversation with actions and mastering conditional lines of conversation can take three or more sessions depending on the age of the learner. It is then beneficial for the learner to have several "free" sessions to concentrate on building and testing their game as they wish before introducing Comment Cards for peer and self evaluation towards the end of the project.

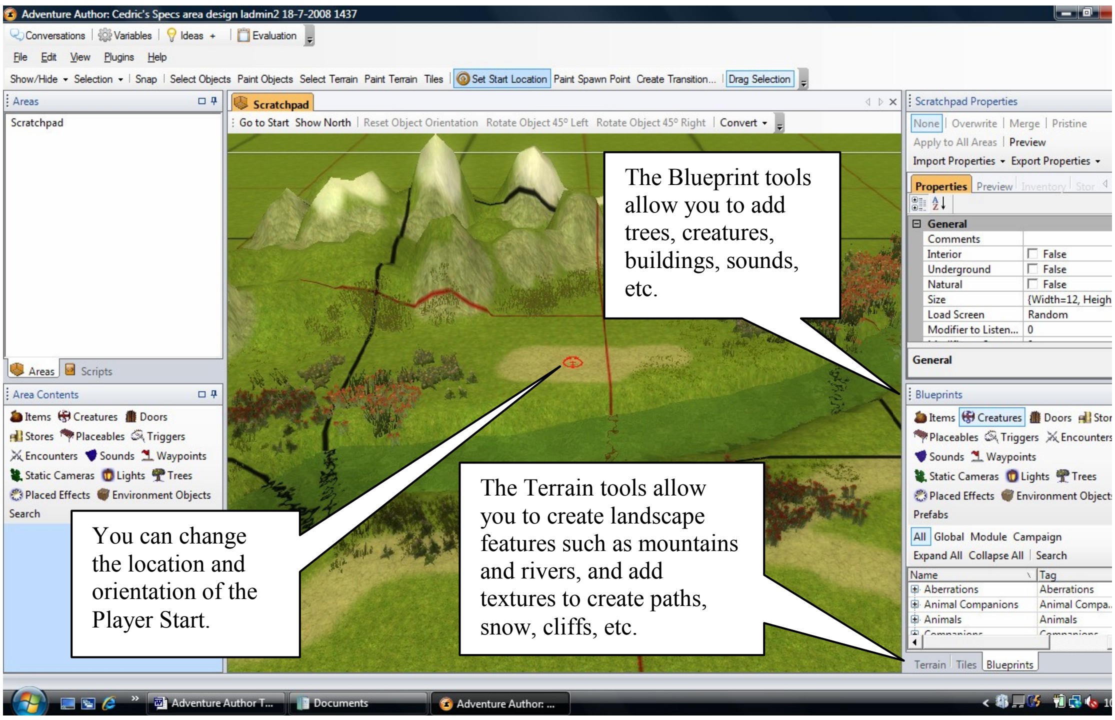

Figure 1. Area design in the toolset

Figure 2. The player's view of a game world

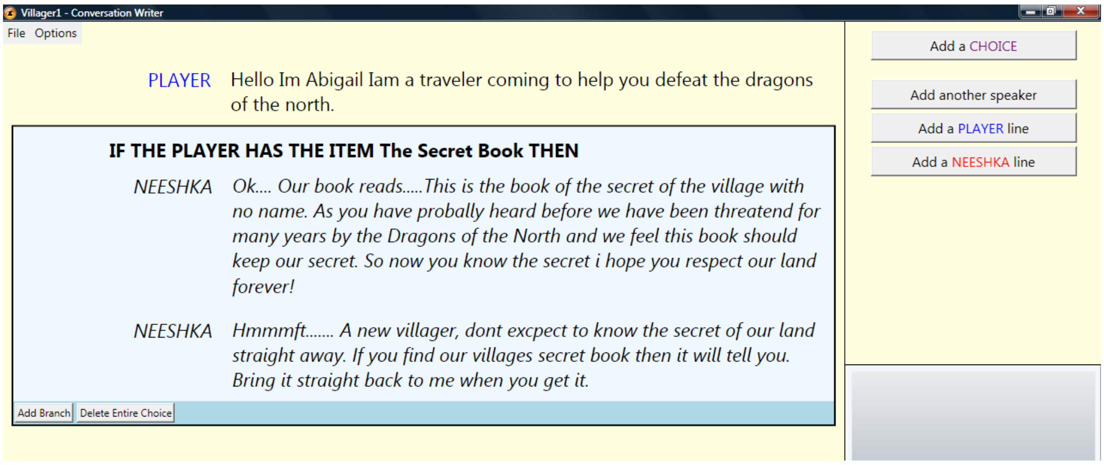

Figure 3. An example conditional quest in the Conversation Writer created by a pupil.

Adventure Author was designed and evaluated using the CARSS learner centred design framework (Good & Robertson, 2006; Robertson & Nicholson, 2007). This framework guides designers as they consider the context, activities, roles, stakeholders and skills required of the design team. The development process included two, week long field studies with young people in informal educational settings, a six week requirements gathering study in a state funded primary school (Robertson & Howells, 2008), extensive consultation with a literacy expert, a four week project with a child design team in a state funded primary school and a six week evaluation study in a different state funded primary school (Robertson, 2012). Having invested effort in developing the research software, the team recognised the need to make it accessible to teachers and their classes as part of everyday classroom activities. We intended that it should be used in schools over a period of years without intervention of researchers, and therefore sought funding to provide high quality training to enable teachers to run game making projects using Adventure Author. With funding from EPSRC, the Making Games in Schools project offered continuing professional development training to thirty one in-service teachers using the Train the Teacher model for disseminating educational technology (Robertson, Macvean & Howland, 2012). Offering training to teachers so that they could deliver the project in schools had several advantages including naturalistic data gathering from real classroom settings; sustainability in the sense that an initial investment in training would result in hundreds of children using the software over the course of many years; and the updating of teachers' skills as recommended in the Royal Society report (Furber, 2012). The author and a colleague who is an experienced teacher trainer, trained 31 teachers from 19 organisations in a series of four 2.5 day residential workshops. Five of the organisations were primary schools working with 11 year old learners, one was a secure facility for educating young people with special behavior needs, one was a support unit working to support young people with special education needs, and the rest were secondary schools working with 12-14 year old learners. One primary school and the secure facility dropped out after training but before starting a project. Two teachers from the same school but in complementary departments often decided to take part in the training together so they could team teach afterwards. For example, computer science teachers paired with drama, English, and geography teachers. In one case, a primary school teacher teamed up with a secondary school computing teacher on a project designed to ease the transition of students from primary to secondary school.

The teachers were split into four cohorts who received training and support at the same time. On-going classroom support was offered in the form of a classroom visit from the teacher trainer and technical help from a computer science graduate student. The teachers were also encouraged to share best practice with their cohort using a blog. Training, support and software was provided for free, on the understanding that the teachers would commit to training their colleagues at school or in the wider educational authority and that they would provide access to data about learners' attitudes to the researchers.

The workshops were run using an active, experiential model of learning; teachers spent much time exploring the Adventure Author software for themselves after watching introductory demos. They also learned about suitable pedagogical (constructionist) approaches for teaching game design and reflected on how they could incorporate these in their classroom practice. The workshop participants were given access to training videos and a handbook on technical topics to remind them of their learning when they returned to the classroom[2].

It is important to note that we deliberately did not issue formal lesson plans, or worksheets for learners. We provided general learning outcomes mapped to Scottish

[2] All teacher resources can be downloaded from www.adventureauthor.org

curriculum objectives[3], suggestions and ideas during discussions but we wanted the teachers to take ownership of their projects and devise their own learning activities around the software. In this way we hoped that the projects would become more sustainable because of the teachers' personal involvement. As the teachers were specialists in different subjects, the learners encountered Making Games in Schools activities across a range of classes, most commonly computing. In one school, for example, the computing department lead the project, offering one lesson per week in which the pupils could use the software, but this was complemented by a weekly English lesson in which the English teacher assisted them in developing the story aspects of their games. In other schools, Making Games in Schools was used as a cross-disciplinary project for first year pupils, which although lead from the computing department, was intended to develop a spectrum of skills in the areas of literacy, team building, communication as well as computing.

The variation in the way the projects were run reflects changing attitude to the professional role of the teacher in Scotland which results from a recent major curriculum reform: teachers are expected to be flexible and competent practitioners who can creatively design opportunities for cross curricular learning. Because of this, the game making project was different in each school although the teachers all used the same software.

[3] See "Part 2: Teaching and Learning" at http://judyrobertson.typepad.com/adventure_author/teaching-materials.html

The Making Games in Schools Intervention

Research Questions

An aim of the project was to capture a snapshot of young peoples' attitudes to computer science in Scottish schools (including gender differences), and to measure how those attitudes would change after taking part in a game making project in a naturalistic classroom setting. This would test the assumptions that the constructionist approach of making games could be a motivating way to interest learners in computer science, and that it would not be gender biased. In addition, professional opinions from teachers involved in the project were gathered to get experienced insight into learners' behaviours which would not emerge from self-report questionnaires. The research questions were as follows:

1. *Attitude benchmarking*: What are pupils' opinions of computing, working with computing in the future, and what are the perceived attitudes of friends and family?
2. *Impact of the game making project*: Did the pupils enjoy taking part in the project, and did it change their attitude to computing?
3. *Gender differences*: Are there gender differences in the pupils' attitudes to computing and towards the project? Are there gender differences in the pupils' change in attitude after taking part in the project?
4. *Teachers' perceptions*: What is the educational impact of the project as perceived by the teachers who took part?

Qualitative data gathering from teachers

After running a project in their school, the teachers were asked to complete an online exit survey to record basic data about how many pupils took part as well as their opinions about the learning which took place, and reflections on the success of the pedagogical approaches used in the project. The open ended questions were: “What was the impact of the project on the learners?”; “What impact did the project have on your teaching practice?”; “Was there anything you found surprising during the project?”; “How did the project compare to your initial expectations?”; “What has been the impact of the project on your school?”; “If you were to run the project again, what would you do differently?”.

In January 2011, we conducted a workshop open to all teachers involved in Making Games in Schools to share their experiences with each other and the research team, as well as learn about new features of the software. Ten of the teachers from eight of the schools accepted this invitation. This enabled us to run a focus group discussion to understand in more depth some issues which were emerging from the quantitative analysis, and to gain valuable insights from experienced professionals about how the impact of the project on their pupils. The focus group session began with each teacher in turn summarising the impact of the project on her pupils in her own words, with interjections and questions from the other teachers. The researchers then followed up on emergent topics of interest, with a focus on gender issues.

Quantitative data gathering from pupils

Participants

By the start of November 2010, when the project officially finished, 13 of the schools completed exit surveys which indicated how many pupils had taken part in the project and how long each project ran. A total of 992 pupils took part, for a total of 15772 hours of learning with the software. The patterns of activity in the project varied between schools. The mean number of pupils taking part in each school was 70, for a mean of 2 hours per week for a mean of 9 weeks. To illustrate the range of projects arrangements: one school adopted Adventure Author as an interdisciplinary project across 8 academic departments and used the software with all of the first and second year cohorts (308 pupils) for 3 x 1 hour slots for 6 weeks. In contrast, a team of literacy advisors working with pupils with special educational needs worked with 15 pupils for 2 hours a week for 8 weeks.

744 children completed the pre-test survey and 225 completed the post-test survey (from only 7 of the original 13 schools)[4]. This represents a 75% return rate on the pre-test and a 23% return rate on the post-test when considered by learner (or 53% return rate when considered by school). In November 2010, four of the projects had not yet started due to technical and scheduling problems although three of these completed pre-tests[5]. Table 1 gives a breakdown of the participants by age and gender.

Age	**Male**	**Female**	**Total**
10	4	3	7
11	79	76	155
12	179	156	335
13	74	72	146
14	20	19	39
15	3	0	3
16	8	0	8

[4] Despite the low return of post-test data, the power of the study is still good at 0.91 for the questions relating to the project itself, and 0.81 for the attitude questions. Power was calculated using the pwr package documented at http://www.statmethods.net/stats/power.html.

[5] The pre-test data was retained as it was relevant to the benchmarking research question

17	1	0	1
18	1	0	1
Total	369	326	695[6]

Table 1. Breakdown of participants by age and gender

Materials and procedure

All pupils were asked to complete an attitude questionnaire during the first lesson of the game making project before they had seen the software, and during the last lesson of the project. The questionnaire was available on Survey Monkey and was completed in the school computer labs with the teacher on hand to answer queries. The questions, which were adapted from a questionnaire developed at Georgia Institute of Technology (Ericson & Mcklin, 2005) and piloted with 56 different children are shown in Table 2. The items "Programming is hard" and "Computer jobs are boring" are reverse scored. Taken together, they are intended to measure the latent variable of learners' self reported attitudes towards computing (including enjoyment, perceived difficulty and future involvement).

Item	*Response format*	*Questionnaire*
Computers are fun	5 point Likert scale	Pre-test and post-test
Programming is hard	5 point Likert scale	Pre-test and post-test
Computer jobs are boring	5 point Likert scale	Pre-test and post-test
I am good at computing	5 point Likert scale	Pre-test and post-test
I like computing	5 point Likert scale	Pre-test and post-test
I know more than my friends about	5 point Likert scale	Pre-test and post-test

[6] There is a disparity between the total number of pupils completing the questionnaire and the gender and age counts because some children chose not to disclose this information.

computing		
My family encourages me to use computers	5 point Likert scale	Pre-test
My friends like using computers	5 point Likert scale	Pre-test
I like the challenge of computing	5 point Likert scale	Pre-test and post-test
I can become good at computing	5 point Likert scale	Post-test
I want to find out more about computing	5 point Likert scale	Pre-test and post-test
This project was fun	5 point Likert scale	Post-test
This project made me more interested in computers	5 point Likert scale	Post-test
I would recommend this project to a friend	5 point Likert scale	Post-test
The best thing about this project was…	Free text entry	Post-test
Can you suggest any improvements to this project?	Free text entry	Post-test
Is there anything else you would like to tell us?	Free text entry	Post-test

Table 2. Attitude survey questions.

Scale reliability

An exploratory factor analysis was carried out to examine the reliability of the scale. Cronbach's alpha for the full scale was 0.8, which is considered as "good" reliability according to de Villis (2012). Field (2009) recommends that items which have a low correlation (< 0.3) with the overall score from the scale should be dropped. This was true for the items "Programming is hard" and "My friends like using computers". Once these items were dropped, Cronbach's alpha increased to 0.817. It is worth noting that a teacher reported that her pupils had difficulty in understanding what the word "programming" referred to when completing the pre-test questionnaire, as at the start of the project they had never encountered this term.

There was a generally low variance in the scale, which possibly suggests that the items did not discriminate between opinions sufficiently.

Checking for school-level effects

The data in this study was gathered across multiple schools, thus introducing the possibility that the responses of learners who attended the same school were correlated. This would violate the assumptions of standard analysis of variance models (Bliese & Hanges, 2004). For this reason, it was necessary to carry out a series of tests to check the between and within group variance[7]. These were computed on an overall questionnaire score which was the mean of all the questionnaire items. Using a linear mixed effects model, the estimate of between schools variance was 0.007, and within schools variance was 0.277. In fact, there was more variance in the scores within schools than between schools, indicating that answers from learners at the same school were not similar to each other. The intra-class correlation (ICC1) was 0.02. That is, only 2% of the total variance is accounted for by the school learners attended. Similarly, random group resampling models (Bliese & Hanges, 2004) indicated that the responses by school were not distinguishable from those of randomly generated groupings from the same dataset (Z = -0.81, n.s.). These results indicate that is reasonable to proceed with an analysis of variance without using multi-level modelling.

---

[7] Using the R code documented in http://cran.r-project.org/doc/contrib/Bliese_Multilevel.pdf.

Quantitative Results: Pupils' attitudes

Opinions of the game making project

As a whole, the pupils regarded the project positively, as shown in Figure 4[8].67% of respondents agreed or strongly agreed that the project was fun (75% and 59% for boys and girls respectively). However, the other measures were more ambiguous: only 45% agreed or strongly agreed that the project made them more interested in computers (57% of boys, 41% of girls) while 54% agreed or strongly agreed that they would recommend the project to a friend (68% of boys, 49% of girls).

After normality tests confirmed that the distribution of none of these attitude variables was normal, the Mann-Whitney U test was performed to check whether the data from boys and girls had the same distribution. Effect sizes for gender were also computed using the Probability of Superiority metric (Grissom, 1994). This should be interpreted as the probability that a randomly sampled boy from the sample will answer more positively than a randomly sampled girl. A Probability of Superiority value of 50% means that there is no effect (i.e. that a randomly picked element from either group is equally likely to outperform a randomly picked element from the other group.) In this data set, for example, for the "Computers are fun" measure, there is a 61% chance that a boy would make a higher point on the answer scale than a girl. The alpha value was set to 0.05, but as 3 post-hoc comparisons were made, this was corrected to 0.02 (rounded to two decimal places) using the Bonferroni correction.

[8] Complete descriptive and inferential statistical results can be found at http://www.macs.hw.ac.uk/~judy/AdventureAuthor/mgisdata/FurtherDetailsOfStatisticalTests.pdf

There was a significant difference by gender for “This project was fun” (U = 4699, Z = -3.088, p = .002, effect size = 0.61). There were no significant differences for “This project made me want to find out more about computing” (U = 4848, Z = -2.613, n.s., effect size = 0.6) or “I would recommend this project to a friend (U = 5005 , Z = -2.073, n.s., effect size = 0.58). According to Grissom’s conversion of the Cohen’s interpretation of effect sizes, the effects are small (Grissom, 1994). Another way to put this is that the proportion of boys who agreed or strongly agreed that the project was fun was 75%, compared to 59% of the girls, a raw difference of only 16%.

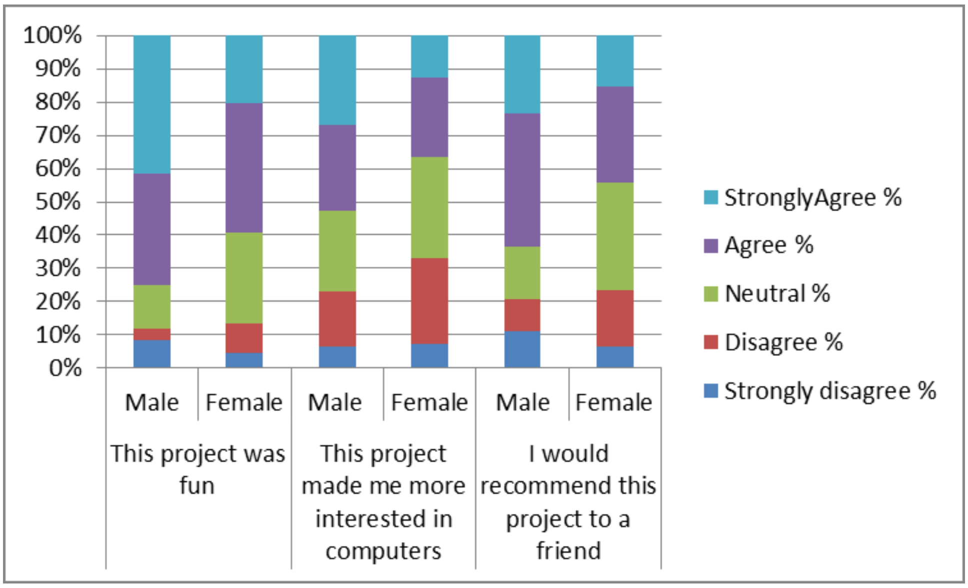

Figure 4. Frequencies of responses to post-test questions about attitude to the project.

Attitudes to Computing

The pupils had a positive attitude to computing before taking part in the project (see Figure 5). 91.8% of the pupils agreed or strongly agreed that computers are fun, 82.4% agreed or strongly agreed that they liked computing, and 67% perceived themselves to be good at computing.

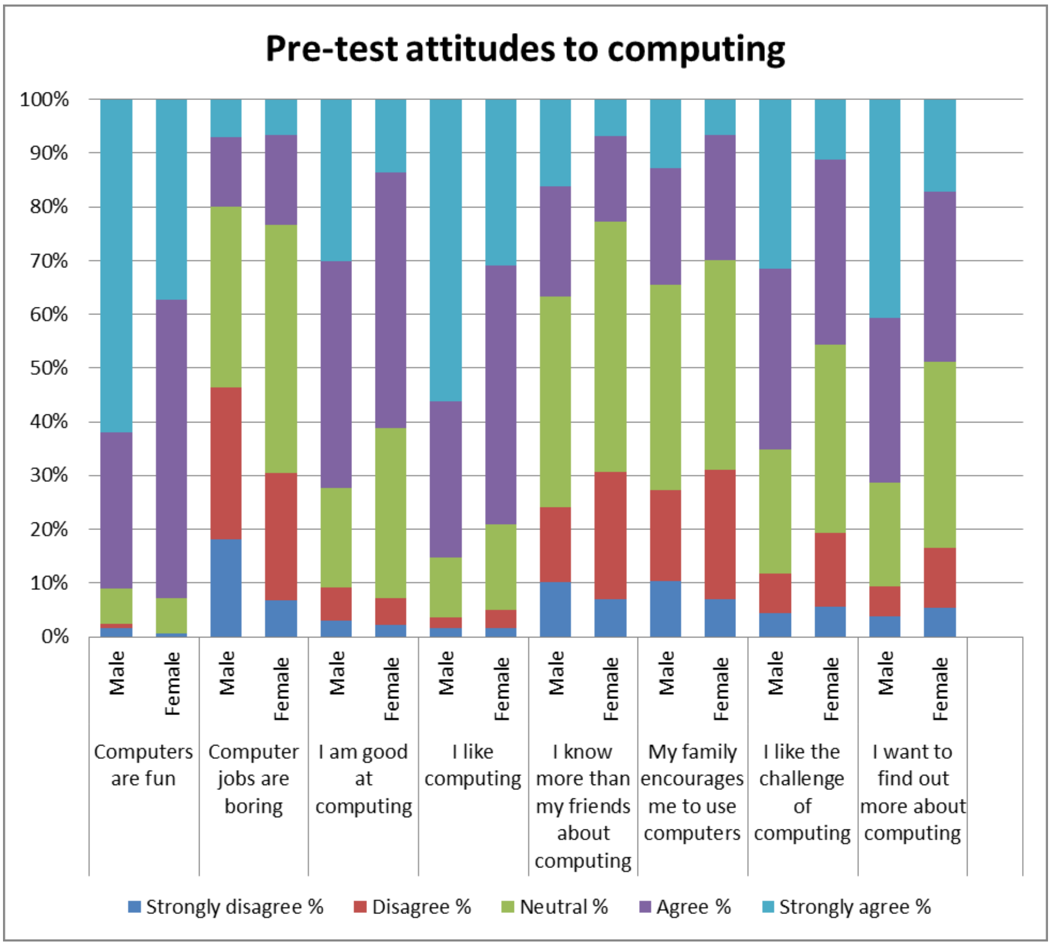

Figure 5. Descriptive statistics of pre-test attitudes to computing.

The descriptive statistics illustrate that girls *are* positive about computing, but the inferential statistics reveal, boys are more likely to be *more* positive on some measures.

For each scale item, an analysis of the two by two mixed subject design was conducted using the ANOVA-type statistic (ATS) suitable for factorial designs with ordinal data reported in (Kaptein, Nass, & Markopoulos, 2010; Shah & Madden, 2004). The alpha value was initially set to 0.05, but a Bonferoni correction was applied for 8 comparisons, making this more stringent at 0.006. There is a significant difference by gender for "*I like computing*" (ATS = 18.17, p = 0.00) and "*I want to find out more about computing*" (ATS = 16.06, p < 0.0001). Regarding to attitude changes pre- and post-test, there is a significant difference for "*I like computing*"

(ATS = 13.65, p < 0.0002) and "*I want to find out more about computing*" (ATS =24.3, p = 0.000). There are no significant interaction effects, which means that changes in attitude for girls did not differ from changes in attitudes for boys.

It is also important to consider the magnitude of these differences[9]. In the pre-test 82.4% of the learners agreed or strongly agreed to the statement "I like computing" whereas in the post-test this was reduced by 6.8 percentage points to 75.6% (. For the statement "I want to find out more about computing", 60.7% of the learners in the pre-test agreed or strongly agreed, but in the post-test only 40.7% did, a drop of 20 percentage points.

In terms of gender, in the post-test, 81% of males agreed or strongly agreed to the statement "I like computing" in comparison to 70% of females – a difference of 11 percentage points. For the statement "I want to find out more about computing", in the post-test 52% of males agreed or strongly agreed in comparison to 23% of the females – a difference of 29 percentage points.

Qualitative results: pupils' comments about improvements to the project

As part of the online questionnaire, the pupils were asked "Can you think of any improvements to the project?" In order to better understand the reasons behind the pupils' quantitative answers to the survey questions, a brief informal qualitative analysis of the 200 responses offered by survey respondents was carried out by a single researcher. Using NVivo, the answers were coded into the following main emergent categories: *no improvements* (53), *teaching/learning related* (50), *technical*

---

[9] These are considered in the text as raw differences in percentage points because it is easier to reason about the real world impact this way. For estimated relative treatment effect size statistics, see http://www.macs.hw.ac.uk/~judy/AdventureAuthor/mgisdata/

limitations (43), *content related* (35), and *fun related* (10).There were also three comments which requested that the project should be made more suitable for girls. The *teaching/learning* related category contains comments about making the project easier (which may also refer to usability problems in the interface), including more help and spending more time on the project. A minority of comments mentioned the teaching approach, for example suggesting more exploration would have been useful. The *technical limitations* category referred to hardware and software glitches which arose mainly from the inadequacies of the hardware (particularly lack of disc space) available in the schools. The quality of the graphics seemed to be an important issue for 14 of the respondents. The *content related* category includes comments made by the learners about their genre preferences (e.g. preferring sports games to the fantasy RPG genre of Neverwinter Nights 2), requests for more realistic modern day content, and requests for additional material for the libraries of buildings and creatures which can be added to the game. The *fun related* category was used for comments which indicated that the project should be more exciting or engaging. None of these comments suggested how this could be done, or mentioned specific elements which were not fun.

Qualitative Results: Teachers' insights

Exit survey findings

Each teacher who completed the exit survey noted that the impact on staff and pupils was positive and enthusiastic e.g. "The project has created a buzz in the school and the classes are at full capacity." Some of the teachers noted that it had caused them to change their teaching practice, for example by allowing the children more time for exploratory learning. Others acknowledged that they too had been learners during the project e.g. “I was challenged on a daily basis to think outside the box in an area where I was sometimes out of my depth of knowledge. But I loved this! The children enjoyed seeing me as a learner too!” When asked to comment on any surprises they had encountered during the project, teachers remarked on how the children’s achievements, enthusiasm, pride in their work and willingness to teach their peers had exceeded their initial expectations. Two noted unexpected but positive gender effects which will be further discussed below: “In the current session girls are equally as excited as the boys about the software” and “High level of pupil engagement across the gender and ability lines as I had expected some issues”.

Focus group findings

During the focus group, the teachers reported that their projects were extremely successful and that they were enjoying teaching them. They came to the consensus that pupils across the ability spectrum were highly engaged, and several cited examples of pupils with behavioural or motivational difficulties, or special educational needs such as autism, who particularly benefited. The teachers who ran daily lunchtime clubs described how they were oversubscribed. Teachers from schools in which computing is an elective subject which competes with other subjects in the timetable were pleased to report that the game making topic had encouraged more pupils to sign up than in previous years. They believed that offering courses in game making encouraged pupils to study computing, which was a good result for them in the context of falling enrolments in computing courses over a period of several years.

After summarising the findings relating to gender from the pupils’ attitude survey, we asked the teachers to comment on how boys and girls had reacted to the project in their experience. This provoked some discussion because some teachers said that all of their pupils had been engaged while others felt that some of the girls had not been so enthusiastic. One teacher noted that he observed that the girls were interested in the project but their enthusiasm did not last as long as the boys'. He thought that girls were ready to end the project after a shorter time period "I think after five or six weeks the girls have had enough", an insight with which the other teachers agreed on reflection. An experienced teacher elaborated that she thought this was not confined to games projects as she had noticed it in other computing topics. Another teacher described how when given the choice of finishing writing a fantasy story set in the game world or spending more time working on their game, all the girls in the class chose the story writing task while all the boys chose to work on their games. This is consistent with previous findings from Carbonaro, Szafron, Cutumisu, & Schaeffer (2010) that males favour making games with Neverwinter Nights over writing traditional stories, although that study found no difference in girls' preferences for the two tasks.

In summary, the teachers who took part in the project believed it had a positive effect on the pupils in terms of engagement and attitude to learning. There is evidence that it encouraged pupils to engage with computing as a subject by electing to study it instead of other curricular options and by spending their free time on it during lunchtime or after school clubs.

Results Summary

	Research Questions	Findings
Attitude benchmarking	What are pupils' opinions of computing?	Positive: they agree that computing is fun, they like it and think they are

		good at it.
	What are pupils' opinions of working with computing in the future?	Positive: they would like to find out more about computing, but are neutral about whether computer jobs are boring.
	What are the perceived attitudes of friends and family?	Pupils believe that friends like computing and are neutral about whether family encourage them.
Impact of the game making project	Did the pupils enjoy taking part in the project?	Yes, they thought it was fun. Just over half of the learners would recommend it to a friend.
	Did it make them more interested in computers?	Mixed results: just under half of the pupils thought the project would make them more interested in computers.
	Did it change their attitudes to computing?	Yes. Pupils are *less* likely to like computing or to want to find out more about computing.
Gender differences	Are there gender differences in the pupils' attitudes to computing?	Yes. Girls are positive towards computing but less positive than boys.
	Is there a difference by gender in changes to computing attitudes after	No.

	taking part in the project?	
	Are there gender differences in the learners' attitudes to the project?	Yes, boys enjoyed it more than girls.
Teachers' perceptions	What is the educational impact of the project as perceived by the teachers took part?	Highly positive. Pupils highly engaged across ability spectrum. Pupils with special needs benefited. Girls were interested but perhaps their interest was of shorter duration.

Discussion and implications

The findings relating to the pupils' baseline attitudes to computing are interesting, because they indicate that young people's attitudes to computing are broadly positive at the start of high school, and although girls are not quite so positive as boys, they do not have negative attitudes. This is in contrast to the findings from a recent study by Varma in which she found that early socialisation was a factor in women's under-representation in computer science. Although the author writes "Both boys and girls need to be taught that computers are for them" (Varma, 2010; p 314), the results in the present study would suggest that the children in this study did initially believe that computers are for them.

Although previous authors have reported low self confidence in computing skills among female students (Beyer et al., 2003), this was not the case here: only 7% of the girls disagreed or strongly disagreed with the statement "I am good at computing" in the pre-test and this remained unchanged in the post-test.

It is interesting to contrast the findings relating to gender differences in enjoyment during this study to our findings from a recent study in which the quality of games produced by boys and girls was compared (Robertson, 2012). In the present study it was found that girls enjoyed the project less than boys, whereas previously we found that girls made better games than boys. These facts are not necessarily contradictory, of course. It is possible to be competent at an activity for which you have a mild enthusiasm, or indeed to greatly enjoy a task even although you have some weaknesses in that area. In the previous study, girls' games scored more highly largely because of their more sophisticated storytelling skills. It is a well known problem in literacy education that boys tend to lag behind girls in narrative skills, and that they are not motivated by narrative tasks (see for example Beard & Burrell, 2010). Taken together with the present findings this suggests that the task of making a game is sufficiently motivating for boys that it overcomes their reluctance towards storytelling. However, girls' enjoyment of narrative may not be sufficiently motivating to cause them to enjoy making role-play games to the same extent as boys. This may be because girls have many other opportunities to tell stories in other media, whereas boys do not often have the opportunity to pursue their interest in games in the classroom. It is also possible that gender differences in the quality of games were not present in the present study, as most of these learners were around a year older and attended secondary rather than primary school.

Contrary to a previous preliminary study (Carbonaro et al., 2010) which concluded that game making projects are gender neutral and may encourage girls to participate in computer science, this study found significant differences in attitude to the project by gender. Boys found the Making Games in Schools project more fun than girls (76% of boys agreed or strongly agreed that they enjoyed it in comparison to 59% of girls). In the previous study, there was no significant difference between boys' and girls' enjoyment of using ScriptEase, with 74% and 72% respectively enjoying it at least "some". The more optimistic results from the previous study may stem from differences in the software used (ScriptEase rather than Adventure Author with Neverwinter Nights), from the questions asked (relating to interactive stories rather than game making) or from the smaller scale of the study. The findings of the present study are more likely to be generalizable than the previous study on the grounds that it involves a larger number of pupils, a naturalistic classroom setting and direct questions about future interest in computing.

There is a disparity between the pupils' attitudes to the project and the teachers' perceptions of the success of the project. Pupils and teachers agree that the project was fun. However, some of the teachers described a more positive attitude to studying computing in general, and gave evidence in the form of how many children had signed up for their courses. A potential explanation for the discrepancy could have been that teachers took different approaches to teaching game making and some may have been more successful than others. Furthermore, some schools had technical problems which could potentially have had a negative impact on the pupils' attitudes. Indeed, issues related to teaching approach and technical limitations were both raised in the suggestions for improvements to the project offered by the learners in the online survey. These potential explanations relating to differences between schools can be ruled out by the checks for school level effects described in the analysis section: only 2% of the variance in attitudes can be explained by the school the pupils attended.

Given that school level effects have been ruled out, another possible explanation might be that the enthusiasm of the teachers who completed the exit survey and attended a follow up workshop is not representative of all the teachers' experiences. It is also worth noting that some of the teachers were comparing the success of the game making project to previous computing topics. It is possible that even although the games project did not cause pupils overall to become more interested in computing, it still created *more* interest than previous topics which the teachers regarded as extremely dull. The teachers might also be commenting based on a halo effect: the interest sparked in particular pupils with an interest and aptitude for games might be colouring their view of how the whole class perceived it.

Threats to validity

There are some limitations in the current study which should be corrected in future work. A threat to internal validity is that we do not have a baseline measurement of how learners' attitudes to computing would naturally change over this period of time without the game-making intervention. As many of the learners had never had formal instruction in computing, their pre-test scores may well have changed considerably as a result of *any* computing topic, as a result of their sudden leap in knowledge about the topic.

It is desirable to address the low return rate on post-test attitude surveys. Such low return rates are not uncommon for online surveys, particularly in educational research (Robertson, Macvean & Howland, 2012). The teachers told us that while they had time before the project started to administer the pre-test surveys, they became time pressured as the project drew to a close and wanted their pupils to spend time finishing the games rather than completing the post-test survey. This is a difficult problem to tackle as it relies on the teacher finding time, and this is not under the control of the researchers.

There are also some adjustments which should be made to the attitude questions, to improve construct validity. The statement “I like the challenge of computing” assumes that the respondent does indeed find computing challenging and this bias should be corrected. In addition, the statements are inconsistent in use of the term “computing” and “computers” (e.g. “Computers are fun” but “I like “computing”) and this may make a difference to the way participants respond. Clarification of what pupils understand by these terms would also be beneficial. Given the low variance in item responses which suggest the Likert options did not discriminate between learners’ opinions finely enough, an adaptation of the questionnaire in which the respondent is asked to give a numerical rating of their attitude between 1 and 10 would be an improvement (de Villis, 2012).

Future work

There are three main avenues for follow on research. We need to better understand why the pupils enjoyed the project but did not become more interested in computing. This could be ascertained by qualitative analysis of interview data gathered at a representative school. Interview questions could be prepared according to the categories identified in the informal qualitative analysis of the learners’ suggestions for improvements to the project. In addition, this study did not address whether the pupils learned about computing concepts as a result of taking part in the project. This could be done by analysing the games created by the children using the rating scale devised by Carbonaro and colleagues (Carbano et al., 2010). Thirdly, the current data only reveals a snapshot of the pupils’ thinking about their future computing interests. As the post-test was administered immediately after the project, we do not know how their attitudes will stabilise over time. A further administration of the questionnaire would give some insight into this issue. Follow-up data on the proportions of pupils who choose to pursue computing careers (in terms of school subject choice or university entry) would also be very valuable, although difficult to obtain.

A final point on methodology for consideration: the Making Games in Schools project, which was funded through a research dissemination scheme, aimed to establish new educational technology in real classroom settings in a sustainable way. We intended that Adventure Author should be embedded as part of classroom practice by teachers in the way which they considered to be most suitable. As the curriculum in Scotland has recently changed to become flexible and cross-disciplinary, this approach was appropriate to the local educational context. An obvious drawback of this from a research design point of view is that each project was unique. The learners did not follow the same prescribed series of steps in each lesson. A randomised strictly controlled design was not possible. However, a benefit of the approach is ecological validity: the results give a picture of pupils' attitudes in the complex, messy setting of an everyday classroom managed by an autonomous professional which in the long run is how the software would be used in this country. In fact, the results of the linear mixed effects modelling indicate that the pupils' attitudes were remarkably consistent between schools. It would appear that variation in teachers' delivery was not in fact such a problem for the experimental design as one might have predicted.

Conclusion

The results of this study indicate that both boys and girls in the early years of high school have positive attitudes to computing and want to find out more about it. Boys are more likely to be more strongly positive than girls. The pupils thought that the game making project was fun and around half of them would recommend it to a friend. Their teachers believed that the project was a highly positive experience for their pupils in terms of motivation, and that it benefited pupils right across the ability spectrum. However, the attitude survey did *not* show that the project makes pupils more interested in computers, possibly because they were well disposed towards computers in the first place. Furthermore, changes in pre- and post-test attitudes indicate that the pupils are less likely to like computing, or want to find out more about the subject after taking part in the project. It may be that learners initially had very little knowledge of what computing might involve, and that once they found out more they realised it was not for them, as happens in other specialist subjects which are new to learners. However, these findings suggest that researchers and educators should be realistic when embarking on computer game making projects with the hope of encouraging young people to study computing, particularly because it does not address the gender gap which has been a problem in computer science recruitment for many years.

Acknowledgements

The author is grateful to Cathrin Howells and Andrew Macvean for their help in data gathering, to Maurits Kaptein for his assistance with the R scripts used for statistical analysis, to Katy Howland for her comments on a draft and to the pupils and teachers who took part in this project. Thanks also to the anonymous reviewers who suggested very valuable improvements.

References

Beard, R., & Burrell, A. (2010). Writing attainment in 9- to 11-year-olds: some differences between girls and boys in two genres. *Language and Education*, *24*(6), 495 - 515.

Bliese, P. D., & Hanges, P. . (2004). Being Both Too Liberal and Too Conservative: The Perils of Treating Grouped Data as though They Were Independent. *Organizational Research Methods*, *7*(4), 400-417. doi:10.1177/1094428104268542

Beyer, S., Rynes, K., Perrault, J., Hay, K., & Haller, S. (2003). Gender differences in computer science students. *Proceedings of the 34th SIGCSE technical symposium on Computer science education - SIGCSE '03*, 49. New York, New York, USA: ACM Press. doi:10.1145/611892.611930

Carbonaro, M., Szafron, D., Cutumisu, M., & Schaeffer, J. (2010). Computer-game construction: A gender-neutral attractor to Computing Science. *Computers & Education*, *55*(3), 1098-1111. Elsevier Ltd. doi:10.1016/j.compedu.2010.05.007

Carr, D., & Pelletier, C. (2008). Gamers , Gender , and Representation. In R. Ferdig (Ed.), *Handbook of research on effective electronic gaming in education* (pp. 911-921). Hershey, PA: Information Science Reference.

Daly, C. (2003). *Literature search on improving boys' writing*. Office for Standards in Education. Retrieved from http://www.ofsted.gov.uk/resources/literature-search-improving-boys-writing

Denner, J., Werner, L., & Ortiz, E. (2012). Computer games created by middle school girls: Can they be used to measure understanding of computer science concepts? Computers & Education, 58(1), 240–249. doi:10.1016/j.compedu.2011.08.006

DeVellis, R. (2012). *Scale development: Theory and App*

e-skills UK. (2011). *Summary Technology Insights 2011*. *Technology*. London.

lications (3rd ed., p. 203). Thousand Oaks, California: Sage Publications.

Ericson, B., & Mcklin, T. (2005). Girl Scouts Compute! *Special Interest Group in Computer Science Education*. Retrieved from http://gacomputes.cc.gatech.edu/Members/jpdimond/girlScouts2009-sigcse-barb.pdf

Field, A. (2009). *Discovering Statistics Using SPSS* (2nd ed.). London: Sage Publications.

Furber, S. (2012). *Shut down or restart? The way forward for computing in UK schools*. *Technology*. London. Retrieved from http://royalsociety.org/education/policy/computing-in-schools/report/

Gee, J. P. (2003). What video games have to teach us about learning and literacy. New York ; Basingstoke: Palgrave Macmillan.

Good, J., & Robertson, J. (2006). CARSS: A Framework for Learner-Centred Design with Children . *Internation Journal of Artificial Intelligence in Education*, *16*(4), 381–413.

Grissom, R. J. (1994). Probability of the superior outcome of one treatment over another. *Journal of Applied Psychology*, *79*(2), 314-316. doi:10.1037/0021-9010.79.2.314

Hill, B. M., & Monroy-Hernández, A. (2010). Cooperation and Attribution in an Online Community of Young Creators. *CSCW 2010* (pp. 2-3). Savannah, Georgia.

Howells, C., & Robertson, J. (2012) Children as game designers – new literacy opportunities. In G. Merchant, J. Gillen, J. Marsh, & J. Davies (Eds.), Virtual literacies: Interactive spaces for children and young people. London: Informa UK Limited, in press.

Kafai, Y. (1995). *Minds in Play*. , Mahwah, NJ: Lawrence Erlbaum.

Kafai, Y. B. (2006). Playing and Making Games Perspectives for Game Studies. *Games and Culture*, (October 2001), 36-40.

Kaptein, M. C., Nass, C., & Markopoulos, P. (2010). Powerful and consistent analysis of likert-type ratingscales. *Proceedings of the 28th international conference on Human factors in computing systems - CHI '10* (p. 2391). New York, New York, USA: ACM Press. doi:10.1145/1753326.1753686

Kelleher, C. (2008). Using Storytelling to Introduce Girls to Computer Programming. In Y. Kafai, C. Heeter, J. Denner, & J. Sun (Eds.), *Beyond Barbie and Mortal Kombat: New Persepctives on Gender and Gaming* (pp. 247-264). Cambridge, Mass.: MIT Press.

Kelleher, C., Pausch, R., & Kiesler, S. (2007). Storytelling alice motivates middle school girls to learn computer programming. *Proceedings of the SIGCHI conference on Human factors in computing systems - CHI '07* (p. 1455). New York, New York, USA: ACM Press. doi:10.1145/1240624.1240844

Klawe, M., Whitney, T., & Simard, C. (2009). Women in Computing - Take 2. *Communications of the ACM*, *52*, 68-76. doi:10.1007/s00415-011-5991-3

Jenkins, H., & Cassell, J. (2008). From Quake Grrrls to Desperate Housewives. In Y. Kafai, C. Heeter, J. Denner, & J. Sun (Eds.), *Beyond Barbie and Mortal Kombat:*

New Persepctives on Gender and Gaming (pp. 5-20). Cambridge, Mass.: MIT Press.

Lang, C. (2010). Happenstance and compromise: a gendered analysis of students' computing degree course selection. *Computer Science Education*, *20*(4), 317-345. doi:10.1080/08993408.2010.527699

Margolis, J., & Fisher, A. (2003). *Unlocking the club house: women in computing*. Cambridge, Mass.: MIT Press.

Meerbaum-salant, O., & Ben-ari, M. M. (2010). Learning Computer Science Concepts with Scratch. *ICER 10 Proceedings of the Sixth international workshop on Computing education research* (pp. 69-76). New York: ACM.

Owston, R., Wideman, H., Ronda, N. S., & Brown, C. (2009). Computer game development as a literacy activity. *Computers & Education*, *53*(3), 977-989. Elsevier Ltd. doi:10.1016/j.compedu.2009.05.015

Resnick, M., Maloney, J., Monroy-Hernández, A., Rusk, N., Eastmond, E., Brennan, K., Millner, A., et al. (2009). Scratch: programming for all. *Communications of the ACM*, *52*(11), 60-67. ACM. doi:10.1145/1592761.1592779

Robertson, J. (2012). Making games in the classroom: Benefits and gender concerns. *Computers & Education*, *59*(2), 385-398. Elsevier Ltd. doi:10.1016/j.compedu.2011.12.020

Robertson, J., & Good, J. (2005). Story creation in virtual game worlds. *Communications of the ACM*, *48*(1), 61-65.

Robertson, J., & Howells, C. (2008). Computer game design: Opportunities for successful learning. *Computers & Education*, *50*(2), 559-578. doi:http://dx.doi.org/10.1016/j.compedu.2007.09.020

Robertson, J., Macvean, A., & Howland, K. (2012). Embedding Technology in the Classroom: the Train the Teacher Model. *Interaction Design and Children 2012*. Bremen: ACM Press.

Robertson, J., & Nicholson, K. (2007). Adventure Author: a learning environment to support creative design. *Interaction Design and Children 2007*. Aalborg, Denmark: ACM. doi:http://doi.acm.org/10.1145/1297277.1297285

Salen, K., Torres, R., Wolozin, L., Rufo-Tepper, R., & Shapiro, A. (2011). *Quest to Learn: Developing the School for Digital Kids*. *Digital Media*. The John D. and Catherine T. MacArthur Foundation Reports on Digital Media and Learning.

Shah, D. A., & Madden, L. V. (2004). Nonparametric Analysis of Ordinal Data. *Phytopathology*, *94*(1), 33-43.

Singh, K., Allen, K. R., Scheckler, R., & Darlington, L. (2007). Women in Computer-Related Majors: A Critical Synthesis of Research and Theory From 1994 to 2005. *Review of Educational Research*, *77*(4), 500-533. doi:10.3102/0034654307309919

Steiner, C. M., Kickmeier-rust, M. D., & Albert, D. (2009). Little Big Difference: Gender Aspects and Gender - based Adaptation in Educational Games. *Lecture Notes on Computer Science Vol 5670: Learning by Playing. Game-based Education System Design and Development* (pp. 150-161).

Utting, I., Cooper, S., K¨olling, M., Maloney, J., and Resnick, M. 2010. Alice, greenfoot and scratch –A discussion. ACM Trans. Comput. Educ. 10, 4, Article 17 (November 2010), 11 pages.

Varma, R. (2010). Why so few women enroll in computing? Gender and ethnic differences in students' perception. *Computer Science Education*, *20*(4), 301-316. doi:10.1080/08993408.2010.527697

Vos, N., van der Meijden, H., & Denessen, E. (2011). Effects of constructing versus playing an educational game on student motivation and deep learning strategy use. *Computers & Education*, *56*(1), 127-137. Elsevier Ltd. doi:10.1016/j.compedu.2010.08.013