International Journal of Gender, Science and Technology
http://genderandset.open.ac.uk

# Can a Serious Game Attract Girls to Technology Professions?

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**ABSTRACT**

In many European countries, women are still underrepresented in technology careers. For example, in Germany women represent less than 10% of those in technical vocational training with many factors influencing their occupational pathways. Among the reasons why young women may choose to avoid technology careers are (a) their low confidence in their own technical abilities; (b) the absence of female role models; and (c) a lack of interest in technology professions in general. In order to address these issues in a way that has the potential to counteract such deficits, we developed a serious game in the form of a point-and-click adventure in which pupils between the ages of 12 and 16 can work on technical tasks embedded within the story of a game. These tasks were taken from the vocational curricula in the field of renewable energies in Germany. The digital game, developed for computer and touch-screen devices, introduces female role models and teaches technical knowledge and competencies in a gender-sensitive way. The tasks (or game quests) include special feedback strategies that allow players to experience success and mastery. Furthermore, the adventure underlines the social relevance of renewable energies, as "social relevance" is a factor that young women in particular tend to take into account when making decisions about their future occupational directions. This article describes the game-design process, introduces the digital game *Serena Supergreen and the Broken Blade*, and reports on the initial findings from the evaluation of the effects of the game on its young participants.

**KEYWORDS**

vocational education; technology; self-concept; serious game; career path; gender

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## INTRODUCTION

As well as free entry to higher education for the suitably qualified, Germany's educational system also offers the dual vocational training system. For a period of up to three years, young people can combine attendance at a vocational school with practical in-company experience. Despite an increase in the number of women studying engineering subjects at German universities (Federal Statistical Office Germany, 2018), according to the Federal Institute of Vocational Education and Training [Germany] (2014) the number of young women in technical vocational training remains very low. This has not changed significantly since 1993. For instance, women represented less than 2% of electronics technicians or information electronics technicians in 2015 (Federal Institute for Vocational Education and Training [Germany], 2017). Among young women, none of the 20 most sought-after vocational training courses in 2015 was within the field of technology. Instead, young women tend to limit their choices to a small number of the 329 dual vocational training options on offer, such as office management assistant or sales assistant (Federal Institute for Vocational Education and Training [Germany], 2017). While there are several initiatives in Germany that focus on arousing young women's interest in university subjects from the Science, Technology, Engineering, and Mathematics (STEM) fields, there are very few projects that specifically address technical vocational training.

In the following case study, we describe a project intended to arouse the interest of schoolgirls in technical vocational training by means of a digital game for computer and touch-screen devices, such as smart phones and tablets. Serious games have been shown to have positive effects on motivation and learning (Wouters, van Nimwegen, van Oostendorp & van der Spek, 2013), and therefore seem to offer a promising mechanism by which to introduce the topic of occupational choice to the classroom. Even though until now no serious games have been developed to address gender-sensitive career orientation for technical vocational training, Gee and Hayes (2010) assert that games are a popular topic in schools and can be used for career orientation. The authors successfully increased the interest of young women in computer science by working with them when designing the game.

The quests in the point-and-click adventure *Serena Supergreen and the Broken Blade* are based on relevant technical knowledge from the field of renewable energies. The digital game can be used as a tool by teachers, parents, and other individuals or organizations focused on promoting schoolgirls' interest in technical vocational training. In the first section, we describe the conceptual framework involved in designing the serious game *Serena Supergreen and the Broken Blade*. As a result of the transdisciplinary cooperation of digital game designers, psychologists, vocational educators, and experts in gender studies, various perspectives were taken into account. In the second section, we refer to the features of the game itself. Finally, we present the first evaluation data from a pilot study with the target group.

## CONCEPTUAL FRAMEWORK

Computer games are extremely popular among girls (Entertainment Software Association, 2016). Serious games in particular can motivate girls and boys equally to learn (Papastergiou, 2009; Wouters et al., 2013). In Germany, young people usually make their choice for a vocational training course after the tenth grade between the ages of 15 and 16. Against this background, it was our aim to develop a serious game for 12-to-16-year-olds that contained information about technical vocations and could thus be used to promote schoolgirls' interest in such career choices. A person's vocational inclinations express their personality, self-beliefs, motivations, emotions, values, and individual characteristics (Gottfredson, 1999; Holland, 1997). Thus, the appropriateness and possibility of a socially relevant identification with technical vocational training must be emphasized in order to increase interest in these professions (see also Gottfredson, 1981).

We identified three different dimensions relevant to the development of a gender-sensitive game for career orientation: (a) the instructional *content* addressed in the game; (b) *career orientation* features (gender stereotypes, self-efficacy, knowledge about vocational training); and (c) the *features of the game itself* (such as genre, context and story). In an interdisciplinary approach, and together with schoolgirls between the ages of 12 and 16, we developed our game by carefully designing the three dimensions according to the preferences of the target group.

### Content

Previous research has shown that one of the main motivators driving the interest of female adolescents in engineering professions is how such professions can make a meaningful contribution to society (Seron, Silbey, Cech & Rubineau, 2016). Girls in particular tend to care about the environment (Sjoberg & Schreiner, 2010), and "young engineers are increasingly likely to consider the promotion of environmental sustainability a core part of their identities as engineers" (Cech, 2015, p. 71; see also Spangenberger, 2016). Against this background, professions in the field of renewable energy were chosen as the focus of the game.

To identify relevant content, we conducted an analysis of the current demands of the job market and the core competencies required for professions in the field of renewable energy. In 2014 and 2015, we surveyed over 20,000 job advertisements, of which 1,686 were evaluated according to a predefined system of categories. During those periods, job advertisements—both in selected print and online media—were screened weekly and examined with regard to the selection criteria. Using the data obtained, we identified technical training professions in demand in the renewable energy sector. For instance, we established that electricians are particularly sought after in the fields of wind energy, grid technology, photovoltaics, biogas, combined heat and power, and building technology. The evaluation of the advertisements also showed that most of the jobs were to be found in the wind energy industry (42.9%), followed by building technology (16.4%) and photovoltaics (15.1%).

Certain crucial competencies and qualifications are necessary in order to pursue a successful career in the field of renewable energies. We identified these—as well as

the social competencies and key tasks—by analyzing the training regulations and curricular framework in the relevant technical vocational training schemes. Among the required professional competencies, for example, was the ability to connect a wind turbine to a power grid as part of a team of service technicians, and among the competencies required to install a solar panel on the roof of a family house was the ability to consult the owners.

**Career Orientation**

Career orientation, as another important dimension of the game, is based on two approaches: Firstly, in order to derive design tips we conducted a secondary analysis of literature devoted to women's career choices. Secondly, we were able to identify women's own assessment of their personal abilities as a decisive variable when it comes to career choices in the field of technology (Eccles, 1989; Eccles, 1994; Eccles & Wigfield, 2002).

As part of the literature analysis, the general factors that influence women's choice of pathway were analyzed in over 150 relevant national and international publications on the subject. In the resulting gender review, we formulated general recommendations that should be considered in the game design, as well as in the pedagogical material for a career orientation session employing the game:

(a) The game should offer identification possibilities, a constructive analysis of mistakes, room for failure and alternative solutions, a relaxed and creative handling of mathematical skills, and also engage with the physical, psychological and emotional needs of the target group (Powell, Andrew & Bagihole, 2012).
(b) Technical vocational skills should be transmitted via content-related arguments, such as the daily life experiences of young women or the meaning of technology to society. Sustainability, in particular, has a stronger subjective significance for the career choices of women than for men (Seron et al., 2016; Sjoberg & Schreiner, 2010; Spangenberger, 2016).
(c) Caution is advised in the explicit addressing of girls about their gender role. Female adolescents do not want to be addressed in relation to a perceived deficit (Funk & Wentzel, 2014). Instead, game design should correspond to girls' tastes and arouse interest through appropriate content.
(d) Fun in technology should be a major element in the game (Faulstich-Wieland & Scholand, 2016). However, after playing the game, supplementary pedagogical material regarding career orientation should deliver possibilities for reflection as well as information about technical vocational training.

As already mentioned, we considered the possibility that female adolescents do not pursue occupations in the field of technology if their own assessments of their personal technical abilities suggest that they are not going to master the upcoming challenges. Based on value-expectancy models of motivation, the experience of mastery when solving technical tasks can strengthen this sense of self. According to Eccles and Wigfield (2002), and in line with Mustapha, Azami, Long, and Mohd (2009), the importance of addressing female adolescents' self-concepts of their own technical abilities is of great importance in influencing their occupational pathways in the field of technology. Therefore, we designed tasks (game quests) with special

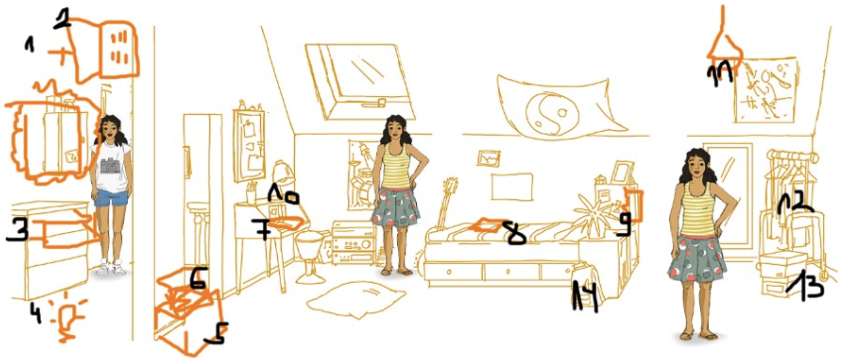
accompanying feedback strategies that allow players to experience success and mastery.

Development of the formative and summative feedback strategies was based on the Interactive Tutoring Feedback-model (Narciss, 2008, 2013). Informative tutoring feedback strategies provide learners with feedback in order to help them manage the tasks by themselves despite any difficulties faced. The feedback strategy guides the player through the necessary cognitive processes without providing immediate knowledge of the result.

**Game Features**

At the beginning of our project, we organized two Serena-workshops. 50 girls between the ages of 12 and 16 participated. We assessed their knowledge of renewable energy and the job possibilities in this area. Additionally, we evaluated their gaming experiences and preferences, and discussed possibilities for what the game could look like. The characteristics of the domain and the preferences of the target group resulted in the decision to make the Serena-game a "point-and-click adventure"—a game genre that allows the incorporation of relevant content and is perceived as attractive by pupils between the ages of 12 and 16.

Each problem scenario takes place in a specific room. The player needs to find, collect, and use certain objects or obtain information to solve the (technical) problem. Each object and its accompanying interaction were mapped in an overall dependency chart. Every quest is accompanied by dialogues and chats that advance the story and explain the quests. For all the technical quests, the player can source help from non-player characters. All scenarios were sketched with the objects and interaction spots marked (see Figure 1). The main character, Serena, is shown in her room. The first quest is to collect the necessary documents for the application for a job in the mall, followed by the changing of a broken light bulb and the fixing of a power outage.



1 frame (to hang in front of the fuse box)
2 open fuse box (in two positions)
3 open drawer
4 light bulb (for drawer)
5 box with a printer
6 paper inside printer with lines on it
7 sheet of paper on desk
8 smart phone
9 CV inside a folder
10 laptop
11 light bulb (one glowing / one damaged)
12 two cloths (separated)
13 cloth item (separated at top of box)
14 window (openable)

*Figure 1: Definition of items in Serena's bedroom. Quests 1–3. First draft.*

Within this process, we adapted tasks, interactions, and necessary feedback. In doing so, we considered the research findings about gender-sensitive approaches, as well as the points of view of girls between the ages of 12 and 16. Partnering with different schools provided us with the cornerstone of our approach—to ascertain and integrate feedback from the girls on complexity, feedback strategy, fun, style, and usability. For instance, we visited schools in order to investigate their preferences regarding the design features of their avatar. We interviewed 116 girls and boys between the ages of 12 and 16. Based on the data obtained, we then developed four different female avatars from which the player can choose. Furthermore, we asked the sample group how the non-player characters within the game should look in order to be perceived as a competent person. Both girls and boys were presented with drawn characters and asked to decide which one they would approach for help with a technical or social problem, and why. Based on the resulting data, we developed female non-player characters that can be accepted simultaneously as competent feedback providers and female role models.

The whole game design process was accompanied by formative evaluation sessions with experts and the girls from the sample group. Once the content and the levels had been developed, the sample group decided on a title via an online survey. As a result, the serious game was named *Serena Supergreen and the Broken Blade* (in German: *Serena Supergreen und der abgebrochene Flügel*).

## THE GAME *SERENA SUPERGREEN AND THE BROKEN BLADE*

In accordance with literature on women's career choices in the field of technology, the game introduces non-stereotypical role models, such as a female shop owner, female scientists, and a father who is responsible for housework. The final game, *Serena Supergreen and the Broken Blade,* is based on the conceptual framework

presented in the previous section. The game integrates all three dimensions: instructional content, career orientation, and game design. Within the game, we tell a story that appeals to girls between the ages of 12 and 16 and integrates their daily life experiences while offering them a variety of identification possibilities. The player takes on the role of the avatar Serena Supergreen—a girl who lives the life of a typical teenager.

Throughout her daily life, Serena is confronted with technological problems she has to solve together with her friends. In the introductory tutorial, the player learns the character's basic controls and her interaction possibilities, as well as how to collect and combine items within the point-and-click adventure. At the end of this introduction, and before starting the game, the player can choose one of four different Serena-avatars. In part one, Serena wakes up in her room and has to collect documents for a job application. She then talks with her father and chats with her two best friends via her smartphone. After solving the first technical quest (changing a broken light bulb), Serena learns about the adventure she is about to embark on: she wants to go on holiday with her friends Kiki and Myra, and therefore has to earn money to cover the travel expenses.

Part two takes place at the mall and consists of several different rooms, where Serena has to solve quests in order to earn money for the journey. After being hired to work in a pet shop, Serena is asked to help change various light sources in the fish tanks (see Figure 2). Figure 2 also shows the non-player character of Alice Falke (the pet shop owner) giving feedback to Serena in order to allow her to solve the quest on her own. The instructional content—the basic elements of light sources: watts, lumens, and the characteristics of different light sources—is associated with the professional career of electricians. The pet shop owner does not only give technical advice; she also serves as a role model by guiding Serena through the quests in order to help her experience mastery. This specific setting in the pet shop was derived from the workshops with the target group, in which girls expressed great interest in animals and listed "going to the mall" as one of their favorite leisure activities.

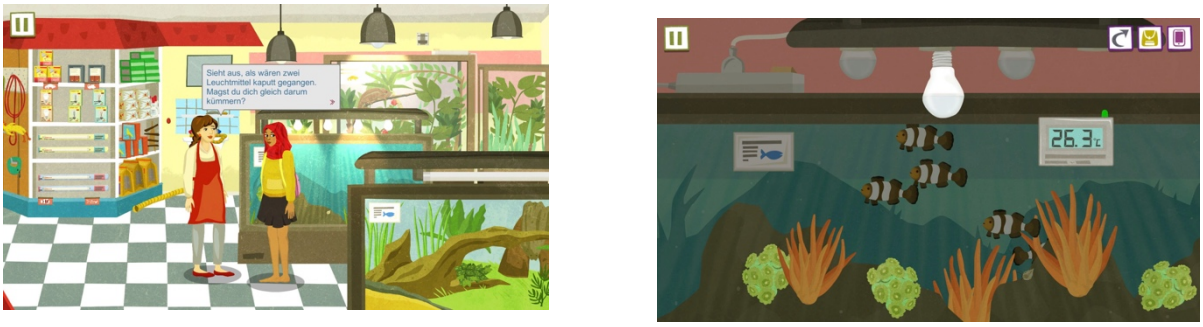



*Figure 2: Serena and the pet shop owner, Alicia Falke (left); and a close-up of the fish tank (right).*

The third and final part takes place on an exotic island, illustrating the travel experiences of the three girls. They end up on a deserted island and have to solve various quests in order to escape. Repairing a wind turbine generator station and solar collectors in order to save a friend are among those quests (see Figure 3).


*Figure 3: Serena standing on top of the wind turbine in order to repair it.*

**EVALUATION**

In a first pilot study, 49 young adolescents between the ages of 13 and 15 (24 of whom were girls) participated. Due to time restrictions, they played only the level in the pet shop and had 20 minutes to solve up to four quests. Before playing the game, we used a questionnaire to establish their motivation for dealing with technical quests, as well as sociodemographic variables and their computer game experience. After playing the game, all participants were asked to fill out another questionnaire. This time they were again asked about their motivation for dealing with technical tasks, with the addition of open questions with respect to the game's general challenges, positive or unexpected characteristics, and complexity.

Additionally, the players were asked to describe the game to another person. Finally, by using three closed questions, we wanted to discover if they would play the game through to its conclusion, as well as the device on which they would play it, and whether they would recommend it to others.

## RESULTS

Prior to playing the game, girls ($M$ = 2.82, $SD$ = 1.05) and boys ($M$ = 3.91, $SD$ = 1.08) differed significantly in their reported interest in technical quests ("I find technical tasks very exciting": 1 - totally disagree, 5 - totally agree; $F$ (1.44) = 13.00, $p < .01$; Cohen's $d$ = 1.01). After playing the game, we asked them again. Whereas the ratings of the boys had become slightly more negative ($M$ = 3.33, $SD$ = 1.17), the girls' motivation with regard to the tasks had improved ($M$ = 3.25, $SD$ = 1.03). There were no significant differences between boys and girls anymore ($F$ = .07). Due to differences in the ways boys and girls view themselves—with advantages for boys in technology domains (Jansen & Stanat, 2016)—the results could indicate that boys initially overestimated their interest and then modified their thinking after working through the tasks in the game. Conversely, girls initially rated their interest lower, yet reported an increased interest after playing the game.

One unexpected result of the open questions in the pilot study showed that only the girls referred to the gender of the main character. While the boys mainly described the game as one in which you have to master technical tasks in a pet shop (only one boy mentioned "that the game might be more for girls"), the girls stressed the presence of the female player. Almost half of the girls explicitly named the female avatar in their description of the game. Given the fact that the information about the game as one especially for girls was not available, the gender of the main character seemed to stand out only for the girls, who focused either on the female character in general ("It is a game where a girl has to solve tasks and do a job"), or mentioned the presence of a female character who has to earn money ("It is an adventure game in which you play a girl who has to earn money to go on vacation"). 45 of the 49 participants wanted to play the game to its conclusion (91.8%). We further identified the context in which they would do this—55.1% said they would finish it in their spare time, while 36.7% would finish it during school lessons.

## IMPLICATIONS AND FUTURE RESEARCH

The initial evaluation data suggests that the game *Serena Supergreen and the Broken Blade* is perceived by girls as both interesting and an experience that can foster their interest in technical tasks. However, further evaluation studies are necessary in order to investigate empirically the effects of the game on (a) knowledge acquisition regarding technical vocations; (b) long-term interest in technical vocations; and (c) the players' self-assessment of their own technical acuity. To this end we are currently planning an empirical investigation of the effects of the game on pupils who play the entire game (around six hours)—either in class, or at home—in comparison to pupils who participate in other career orientation programs.

The upcoming study will also investigate another important aspect: We assume that the use of additional pedagogical material employing didactical concepts for use in schools is one promising method of using the game as a serious, appropriate, and promising way to attract girls between the ages of 12 and 16 to professions with a technological bias. In this way the game not only positively impacts the self-assessment of personal technical acuity for girls by introducing them to relevant technical activities, but also provides opportunities for the preparation of future learning activities within the classroom. Educators can use experiences acquired via the game to identify aspects relevant for specific career choices. They can elaborate further on different technologies, on students' self-concepts (based on their perceived success within the game), or on different role models (incorporated as non-player characters within the game). By taking into account the three relevant dimensions — (1) game design aspects matching the target group's interests; (2) the most relevant career choice aspects; and (3) carefully chosen instructional content from the field of renewable energy — this game has the potential to act as an innovative means by which to promote gender-sensitive career orientation.

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