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Development of a game-design workshop to promote young girls' interest towards computing through identity exploration

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ABSTRACT

Despite recent improvements, women remain underrepresented in Computer Science (CS) in both industry and higher education. Self-perception and identity play an important role in young women's opinions of careers in CS. We believe that by presenting software programming in a way that facilitates identity exploration early on, young girls will be more likely to consider careers in CS later in life. In partnership with an organization that focuses on technology education for middle school girls we developed a game design workshop in an effort to change young girls' perception of CS by increasing their knowledge of programming and empowering them to develop their own identities as computer scientists. This paper presents the results of a case study with 21 participants that was carried out to evaluate the workshop's short-term influence on young girls' attitudes towards CS. The study employed a mixed methods design, including a pre and post application of a validated survey instrument, focus-group interviews, and content analysis of games developed by the students. The pre and post surveys focused on how students' attitudes towards computing may have been influenced by their participation in the workshop; the focus-group interviews aimed to gain further insight into their workshop experience; and the content analysis of games focused on the learning outcomes of our workshop. The findings suggest that the workshop resulted in improvements in both young girls' attitudes towards CS as well as in their self-reported confidence and competence with computers. These results highlight the importance of providing positive identity exploration opportunities in shaping female students' attitudes towards CS.

1. Introduction

While gender parity can be found in some areas of technology, game design is faced with great gender disparity; though roughly half of the gamers in the US market are women, only 11% of game designers are women, and of that percentage, only 3% are developers (Burrows, 2013). Women utilize Internet and computer technologies nearly as much as men do; however, they usually act as technology consumers, rather than designers, creators, or producers of computer technologies (Margolis &

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Fisher, 2003). Although the overall percentage of women employed by video-game companies has increased over the past ten years, nearly all of that growth has occurred in non-technical fields like public relations (Burrows, 2013).

The gender disparity in computing practice has been identified as a key issue in computer science (CS) education and the computing community. Existing efforts to address this gap includes the promotion of women's participation in CS research and practice through scholarships and grants, such as the Anita Borg scholarship and the Women Techmakers program initiated by Google (Welle & Smith, 2014). In particular, the Techmakers initiative has expanded on the scholarship program by promoting a community of women IT developers through retreats, meetups, as well as an online platform that provides an infrastructure for social support among women in the IT industry. Although these are valuable initiatives, some of the root causes of gender disparity in CS can be traced back to negative and highly gendered early educational experiences (Adya & Kaiser, 2005; Teague, 2002). Systematic efforts are needed to stimulate young girls' interest towards computing early in their educational careers in order to maintain interest in computing and technology-related careers.

Related studies in CS education literature have identified several motivational and social factors possibly underlying the gender disparity in the computing profession. In particular, Teague (2002) argues that a combination of personal, social, and structural factors including career stereotyping and related misperceptions contribute to these trends. Personal barriers are primarily related to self-perception and identity. In particular, personal barriers like lack of fluency in technology, lack of early positive experiences with technology, and lack of information about possible career options may drive women away from CS. Secondly, social barriers such as gender role expectations, or a lack of female role models may convince women that there is no place for them in the field (Werner, Campe, Bean, & Denner, 2005). Social norms, available training, professional development opportunities, as well as the amount of support granted to working parents affect women's decisions to pursue careers in computing (Abbate, 2003). Finally, structural barriers like girls' aversion towards narrowly or technically focused programming classes or instructional methods that prevent girls from becoming technical problem-solvers might contribute to their lack of preparation for employment in this field (Knobelsdorf & Schulte, 2005). Young girls who show interest in CS early in their educational careers may lose their interest over time due to lack of confidence, negative comparisons to peers, lack of effective pedagogical approaches, and/or biased environments (Margolis & Fisher, 2003; Schulte & Knobelsdorf, 2007).

We believe that some of these barriers can and should be addressed at the K-12 level. Students tend not to be interested in or identify with domains in which they lack specific knowledge (Markus & Nurius, 1986; Renninger, 2009). When students consider possible occupations, they fail to consider some options because they are either unaware of them or because they find them unappealing (Brophy, 2009). Among the options they consider to be appealing, some are eliminated because they do not feel confident about the requirements of those occupations (Brophy, 2009; Eccles, 2009). Therefore, carefully designed activities are needed as early as primary school to avoid the development of self-limiting attitudes towards CS among female students. Activities designed along the *identity exploration* framework (Kaplan, Sinai, & Flum, 2014, pp. 243–291) may be particularly effective at addressing this need because they emphasize scaffolded and engaging activities that encourage self-identification with the target profession. Related work in CS education suggests that game-design is a suitable genre to stimulate girls' interest towards computing as they enjoy playing video games (Stewart-Gardiner, Carmichael, Latham, Lozano, & Greene, 2013). Therefore, structuring a game-design activity along identity exploration principles can be a promising strategy for stimulating young girls' interest towards computing.

In this paper, we propose a game-design workshop structured along the identity exploration framework (Kaplan et al., 2014, pp. 243–291) and explore its effectiveness for changing young girls' attitudes towards CS as a profession through a case study. We aimed to evaluate the impact of identity exploration activities on young female participants' attitudes towards CS in a full-day workshop that features the scaffolded use of professional-grade game development tools. To that end, we used a validated survey instrument developed by Robertson (2013) before and after the workshop to identify how young girls' attitudes towards computing may have changed as a result of workshop participation. We also conducted focus group interviews after the workshop to obtain further insights into the participants' views on their game-design experience and their identities as prospective game developers. Finally, we conducted a content analysis of the games developed by the participants during the workshop to identify specific actions indicative of identity exploration.

The rest of this paper is organized as follows. The following sections paper reviews the gender disparity issue in CS as well as related research that aims to address this disparity by designing activities targeting girls. Next, we describe the *identity exploration* framework (Kaplan et al., 2014, pp. 243–291) and how we incorporated these principles into our workshop curriculum design. This is followed by a description of the instruments used for data collection and analysis. Next, we present the results obtained through pre and post surveys, focus group interviews, and game content analysis. The paper concludes with a discussion of the main findings and pointers for future work.

2. Gender disparity in CS practice & education

In general, the image of a computer scientist tends to be highly stereotyped (as cis-male and light skinned), which can cause female students to disclude CS from their existing gender identity (Black, Curzon, Myketiak, & McOwan, 2011; Cheryan, Plaut, Davies, & Steele, 2009). However, by portraying the diversity of CS identities early in K-12 education, female students can be granted more opportunities to consider CS as a viable career option. For example Stewart-Gardiner et al.'s (2013) findings suggest that girls' experience with specifically designed games showing that they can have societal impact by practicing CS can influence them to view themselves as being capable of designing computer programs in the future. If students can see themselves reflected in the range of possible CS identities, they will be more likely to attach themselves to the target identity and be motivated to behave in ways to preserve that identity (Oyserman, Bybee, Terry, & Hart-Johnson, 2004; Hewner & Knobelsdorf, 2008). When students are intrinsically motivated to learn a skill, they are more likely to spend time and effort in its mastery and feel positive about their accomplishments (Malone, 1981). Moreover, a positive attitudes towards CS affects female students' success in computer related subjects and their choice of career in CS in the future (Gürer & Camp, 2002). If female students have positive attitudes towards particular subjects, they might be more willing to invest their time and energy in learning them. Video game design activities may provide a fruitful context in which students can explore a new CS-related identity by enacting computational ideas and practices (Foster, 2008; Van Eck, 2006).

Related studies have reported that children who actively participate in the software design process demonstrate a greater understanding of and more positive attitude towards CS (Bonner and Dorneich, 2016; Denner, 2007, 2011; Eordanidis, Gee, & Carmichael, 2017; Kafai, 2003; Kafai, Franke, Ching, & Shih, 1998; Robertson, 2013; Stewart-Gardiner et al., 2013; Webb, 2013). These studies highlight the utility of creative, rather than consumptive media in changing students' attitudes towards CS (Lenhart & Madden, 2005). For instance, Kafai, Ching, and Marshall (1997) reported that when participants were asked to create their own educational multimedia applications, their understanding of CS and programming improved significantly. Similarly, Webb (2013) found that girls were more likely to engage with scaffolded examples, and through those examples gained comfort with the programming environment. Therefore, designing activities that elicit female students' active engagement with computing and programming is key to stimulating interest in CS.

Researchers who have employed game design workshops to improve girls' attitudes towards CS reported mixed results. For example, Van Eck (2006) observed that exposure to different video games and game design activities promoted both boys' and girls' attitudes towards technology. Similarly, Denner (2007) reported that an after-school workshop designed to utilize identity-building activities to encourage girls' engagement with technology helped them increase their knowledge and skills, and overcome their prejudice of information technology. However, Robertson's (2013) study on the effect of a game development project on participants' attitudes found that girls did not enjoy the project as much as boys, and the project was not successful in making female students more likely to study CS in the future. Overall, related studies suggest that workshop activities have the potential to empower girls to see themselves as a person who is enthusiastic about technology and encourage them to consider it as a viable career option in the future (Denner, 2007; Eordanidis et al., 2017; Stewart-Gardiner et al., 2013; Werner & Denning, 2009; Werner et al., 2005). However, mixed findings suggest that there may be additional unexplored factors that determine the effectiveness of such interventions.

3. Identity exploration

In psychology, the notion of identity is typically defined in reference to traits, roles, characteristics and social group memberships that define who one is (Oyserman, Elmore, & Smith, 2012). Identity is comprised of a person's self-concept. This identity provides anchor points for the person to interpret her/his own experiences and possible courses of action (Oyserman, 2007). When situations that cue specific identities (e.g. female) arise, the difficulties involved with carrying out courses of action that feel identity-congruent are interpreted as relevant and important, whereas the efforts related to actions that feel identity-incongruent are deemed irrelevant (e.g. "not for people like me") and pointless (Oyserman, 2009). Identity is intimately linked to one's motivation to engage with specific actions and challenges. Although identities are experienced as stable mental states where one tends to act in ways that feel congruent to them, identities are not necessarily immutable or static. Indeed, identities are dynamically constructed based on how they come to mind in the moment and how associated difficulties are interpreted (Erikson, 1968; Oyserman et al., 2012). For example, in a controlled study focusing on low-income students with specific racial/ethnic identities, Oyserman, Bybee, and Terry (2006) observed that a sequence of group activities designed to improve the congruence between school-based possible identities and students' racial/ethnic identities elicited significantly more in-class participation, more time-spent on homeworks, better attendance and higher grades as compared to the control group sampled from the same social group. Related studies conducted in several educational settings have found that there is a strong relationship between the sense of identity and academic success (Berzonsky & Kuk, 2000, 2005; Faye & Sharpe, 2008; Kaplan & Flum, 2012; Matsushima & Ozaki, 2013; Sinai, Kaplan, & Flum, 2012), and different identities affect students' career choices in significant ways (Brickhouse, Lowery, & Schultz, 2000; Holmegaard, Ulriksen, & Madsen, 2014). Since identity formation is an ongoing, dynamically changing process, identity exploration activities that successfully establish a congruence between current and possible identities are likely to increase students' motivation and academic success in the targeted domain (Flum & Kaplan, 2006; Foster & Shah, 2016; Sinai et al., 2012). As such, we used the Dynamic Systems Model of Role Identity (DSMRI; Kaplan et al., 2014, pp. 243–291) which is well suited for identity exploration experiences that involves learners taking on roles for experiencing possible identities. In doing so, the process involves triggering or encouraging exploration, promoting self relevance, providing a sense of safety, and scaffolding identity exploration in a dynamic and iterative process.

The findings of related work in educational psychology on identity-based motivation suggest that one of the root causes of the gender disparity in computing practice can be attributed to the mainstream social construction of both female and computing-related identities. Both of these identity constructions discourage or limit female participation in CS. Thus, the primary goal of our workshop curriculum was to bring together a set of activities that would help young female participants' change their attitudes toward CS by exploring a possible identity of a video game designer in a safe, supportive environment. According to the framework proposed by Kaplan et al. (2014, pp. 243–291), identity exploration facilitates positive attitude change by improving one's perceived level of competence and self-concept, and thus it can increase the likelihood of participants exploring software development as a personal interest or future career. Since lack of knowledge in a specific subject may result in limited interest in that subject (Renninger, 2009), identity exploration has implications for both cognitive and affective domains. Therefore, we developed objectives that would target both of these domains and aimed to facilitate 'value-based motivational thinking' (Brophy, 2009) among young girls.

Youth between the ages of 11 and 14 spend more time gaming than their counterparts in any other age group (Rideout, Foehr, & Roberts, 2010), and they demonstrate a high quality of engagement while playing (Kafai, 2001). Most students have had their first computer experiences while playing computer games, and this initial exposure continues as they continue to spend more time playing games. Thus, they gain an intuitive understanding of how computers work through fun experiences (Knobelsdorf & Schulte, 2005). We wanted to capitalize on this predisposition towards video games to promote young girls' interest in CS. We focused on facilitating a 'situational interest' (Renninger, 2009) in CS via activities that serve as 'catch factors' (Mitchell, 1993) for girls, which may develop into long-term individual interests in computing. Mitchell (1993) suggests that by presenting students with "catch factors," instructional activities and contexts that attract their attention, educators can create a situational interest in a subject. Even though students' interest in the subject may not be permanent, their situational interest may develop into a long-term interest in that subject if they perceive the "catch factors" as empowering. Similarly, Teague (2002) argued that while designing short-term workshops or projects that target changing women's attitudes towards programming, one should keep in mind that a single workshop may not be enough to deeply change their attitudes. Eliciting such a change requires additional supporting factors to keep women interested in programming. However, Teague (2002) also stated that in some cases a single positive experience can lead to a prolonged interest in programming among women.

Kaplan et al. (2014) argues that educational experiences should *promote self-relevance* through critical and reflective engagement with domain-specific knowledge, its use, and its meaning for the self. Academic content should be presented in relation to students' personal experiences as well as the world outside of the classroom. In our workshop, we provided participants with examples of female designers who have worked on well-known games to help them understand the relevance of this workshop to their lives and promote their self-identification with these designers. We encouraged girls to apply their personal knowledge of games (both playground, board, and digital) to demonstrate that many activities qualify as games, not just "hardcore" videogames. Borrowing from Bartle's (1996) work on multi-user dungeons (MUDs), during the workshop participants work with a facilitator to name games that exemplify four common player types: explorers, achievers, killers, and socializers. Participants are then asked to think about what kind of player they are and explore gaming as it relates to their personal identity.

In order to *encourage exploration*, Kaplan et al. (2014, pp. 243–291) suggests educators take students' personalities and background into account. Using this information as a baseline, facilitators can expose a "relevant difference" between students' current state and a target state. Students should feel the need to form an understanding of the new subject based on their understanding of this difference. We designed our curriculum to interact with students' background knowledge while providing new information and skills in exciting ways. For example, borrowing from Fullerton's (2014) exercise-based approach to game-design theory, we divide girls into groups of five and asked them to solve problems like "how can you turn eating a sandwich into a game?" Group activities encouraged participants to apply knowledge acquired earlier in the workshop to creatively and collaboratively solve problems. In this exercise, girls need to use their previous understanding of the characteristics of a game to successfully develop a game about eating a sandwich.

Identity exploration requires participants to leave their comfort zone and work in their zone of proximal development (Vygotsky, 1978). This departure may be accompanied by the natural discomforts of such vulnerability. According to Kaplan et al. (2014, pp. 243–291), the workshop should foster a perceived *safe environment* in which students feel safe and supported. As girls are introduced to the basics of a game-design engine called Unity during the workshop, they are allowed to explore the visual editor while the facilitator and female undergraduate game design students provide guidance and feedback. Near the end of the second workshop, girls are asked to write a script to "spawn" enemy characters at a particular location. In this phase, girls are given a "cheat sheet" with the script written out on it, and led through the script by the facilitator, who provides context and encouragement as students write and troubleshoot the code in their editors. Students were also encouraged to help their neighbors proofread and debug their code if theirs was working well.

Identity exploration is an ongoing dynamic process, and Kaplan et al. (2014, pp. 243–291) suggests that students should deliberately reflect on the process they are going through in relation to the self to *scaffold identity exploration*. To this end, we include written and verbal reflection activities in the workshop to scaffold identity exploration. During these activities, students are asked to reflect on their experiences in the workshop as it relates to their lives and future careers. It is possible that while an activity succeeds in encouraging identity exploration for one student, it may not generate the same effect on another. For that reason, we designed a variety of activities to create opportunities for reflection for all participants, and tried to observe them during the workshop and intervene when/if necessary.

4. Methods

A mixed methods approach (Creswell, 2014) was employed in this study. The study group was composed of 21 girls in grades five through eight. The participants were reached through our partner organization TechGirlz. The workshop was organized as a full day event during the weekend in order not to interfere with the girls' school schedule. Informed consent was obtained from parents before the participation of their children. The study was approved by the Institutional Review Board at Drexel University.

Before the workshop, participants filled a basic questionnaire including questions about demographics and past exposure to programming/gaming and completed a validated survey (Robertson, 2013) about their attitudes towards programming and gaming. The pre-survey included ten five-point, Likert-scale questions for the self-evaluation of computing-related skills.

During the first workshop, students were given a presentation on the history of gaming, existing game genres, and information about well-known women game designers/developers. They were then introduced to foundational knowledge about the Unity game development engine and the specific 2D game they would be improving during the day. After a lunch break, the second workshop was conducted where participants attempted to develop their games by following the guidelines provided by the organizers. A more detailed description of the workshop activities are provided in the next section.

At the end of the workshop, participants were asked to fill out a post-survey based on Robertson (2013). Eight of the attitude questions in the pre-survey were repeated in the post-survey to observe if the participants' responses had changed as a result of their experience. The post-survey included four additional Likert-scale questions to evaluate the workshop and whether they might be interested in pursuing a career in CS. Survey data were analyzed through descriptive statistics and non-parametric tests for pairwise comparisons for the repeated items. The goal of the survey analysis was to identify the girls' attitudes towards CS based on the distributions of their ratings to specific questions. Pairwise comparisons aimed to identify if there were any discernable change in attitude due to participation in the game-design workshop.

We obtained further feedback via focus group interviews conducted at the end of the workshop. Focus group discussions were voice-recorded, transcribed, and subjected to qualitative content analysis with *in vivo coding* and *pattern coding* methods (Saldaña, 2012). Each transcript was reviewed individually by two coders to identify major themes voiced in the participants' comments. The discrepancies among the coders were resolved through discussion. The qualitative analysis of the interviews aimed to identify in what ways factors highlighted in the identity exploration framework were featured in students' comments.

Finally, 13 games designed by the students were evaluated in terms of implemented features and artistic content using a rubric developed by the research team. The evaluation included loading and playing each game in the Unity development environment to collect evidence for the use of specific features as they related to the learning objectives of our curriculum. Out of the 21 games in our sample, the contents of eight games could not be analyzed due to corrupted game project files. The aim of the evaluation was to determine whether the target objectives were realized and to identify any unexpected learning discoveries. The rubric included nine dimensions for evaluation, focusing on the use of key game-design features in Unity such as prefabs, scale, rotation and transform tools, appropriate use of scripts and animations on the hero and enemy characters, proper implementation of the enemy spawner, the presence of any run-time or compilation errors, and finally, the overall playability of the game (see Appendix 1). Three game designers independently evaluated the contents of five randomly selected games by assigning ratings between 1 and 4 for each dimension. On average the evaluation of each game took around 10 min. A Krippendorf's alpha statistic computed over the ratings by using the K-Alpha script (Hayes & Krippendorff, 2007) indicated sufficient level of inter-rater reliability ($\alpha = 0.70$). The remaining eight games were graded by a single rater after the reliability of the rubric was established.

5. Workshop curriculum design

We organized the workshop in partnership with TechGirlz, a non-profit organization focusing on technology education for middle school girls. Barker, Snow, Garvin-Doxas, and Weston (2006) suggests that recruitment strategy for the workshop should be primarily geared towards appealing to the girls' motivations and interests, rather than changing them. Thus we chose to center our workshop on video game development, which has been shown to provide an accessible, interactive and intrinsically motivating form of software development (Kafai, 1995).

We utilized principles of identity exploration, namely relevance, exploration, safety, and scaffolding identity exploration (Kaplan et al., 2014, pp. 243–291) in the design of our two-part workshop. We emphasized some non-technical aspects of game design in the first workshop to encourage an interest in video game design and development. The first workshop included a survey of games (from board games, to playground games, to video games) and foundational principles of game design, alongside examples of female designers of well-known games. This approach was geared towards helping participants understand the relevance of game design to their lives and promote a self-identification with these designers. During the second workshop we focused on teaching participants technical skills relevant outside of the workshop learning context. This included a hands-on videogame development activity using Unity and MonoDevelop, Unity's proprietary scripting environment. During the second workshop participants added features to an existing game, applying the game design concepts learned during the first workshop.

We aimed to foster a safe environment for the girls by providing them with explicit instructions about basic functions within Unity, a pre-programmed 2D game environment within which they could augment game functionality, and cheat sheets to help them with simple script programming (Fig. 1). We invited the girls to a computer lab used by university students who major in digital media and design. The lab was equipped with high performance dual-screen computers typically used by professional digital media designers and game developers. Therefore, the participants were situated in a realistic game studio environment. In addition to this, the workshop was designed to be led by female facilitators because same-gender facilitators enhance student success in computer related experiences (Corsnton & Colman, 1996). By having

Fig. 1. The classroom in which the workshop took place. Girls had access to state-of-the-art game development PCs running Unity. They were supervised by female undergraduate students majoring in digital media and game design.

female facilitators, we sought to create a safe and authentic space for girls to explore CS-related identities, pose positive CS role models, and help participants explore CS as it might relate to their future-possible lives.

Existing educational game development tools like PythonTurtle (Rachum, 1986) and Scratch (Resnick et al., 2009, pp. 60–67) are designed to help students develop overarching computing concepts in contrived programming scenarios in the interest of facilitating educational goals. We opted to use a professional-grade tool like Unity to better serve the exploration of a CS-related identity, rather than a tool like Scratch that is ultimately designed to teach CS principles. The problems participants were required to solve were presented as relevant to their ultimate goal: to create a functioning and fun video game. Our main considerations for the development of this game included minimizing the complexity of the game and creating positive interactions with code.

We decided to utilize Unity's 2D development tools to limit the complexity of the game students would interact with. 2D games allow designers to interact with the game environment using X-Y coordinate values, a mathematical concept that should be familiar to students in this age group. This limited the locations at which they can place additional terrain objects and allowed them to utilize Unity's drag-and-drop visual editor. Participants were encouraged to play with the transform tool (see arrows in Fig. 2) as well as the rotate and scale tools. Fig. 2 demonstrates our use of what Unity calls "prefabs:" objects that are prefabricated to include sprites, animations, colliders, gravity, and any other materials or qualities baked-in, ready for participant use. Furthermore, by limiting the number of prefab options, we hoped to make the game approachable, as well as interesting enough to encourage participant discovery and exploration. Fig. 3 shows a screen shot of the game where these elements are put together by the students.

In order to reduce the complexity of the code, we separated larger scripts (written in C#) into smaller parts. Most of our scripts contained fewer than 20 lines of code, and often only declared one or two functions and variables. These shorter scripts were designed to allow participants to easily identify and change variables while providing immediate and highly visible feedback in the GUI scene editor. Furthermore, we annotated our basic scripts with comments that described their logic, should students care to explore them deeper or on their own.

The intervention is organized into stages that build on each other. The first workshop intervention focuses on supporting comfort and familiarity with the Unity environment, while the second workshop focuses on extending the capabilities of the heroine character through scripts. For example, in the first workshop, participants are presented with terrain prefabs already instantiated in Unity, as well as the heroine character, but the heroine cannot move. Participants then have to apply the character-movement script by dragging and dropping it onto their character prefab. This script enables the heroine to move across the screen to the left or right, but not jump over tall obstacles or holes. Participants then need to apply the character-jump script by dragging and dropping it onto the character prefab. After applying this script, the character is able to complete the pre-designed level and reach the end. In the second workshop, participants were asked to apply their knowledge of adding scripts as they created their own prefab to spawn enemy characters. This required students to write a script to spawn enemies every five seconds, create a new prefab, add the prefab to the Unity scene, and then add the script to the prefab. Throughout the first and second workshops, cause-and-effect demonstrations were used to demystify participants' perceptions of how computer programming works and make this first computer-programming task relevant to them as they work to achieve the goal of "completing" the game.

6. Results

This study is concerned with identifying if a workshop designed according to Kaplan et al.'s (2014) identity exploration framework influenced young girls' attitudes towards computing. In particular, we used a pre- and post-survey to observe if the workshop had any influence on young girls' self-evaluations of their computing skills and their general interest towards

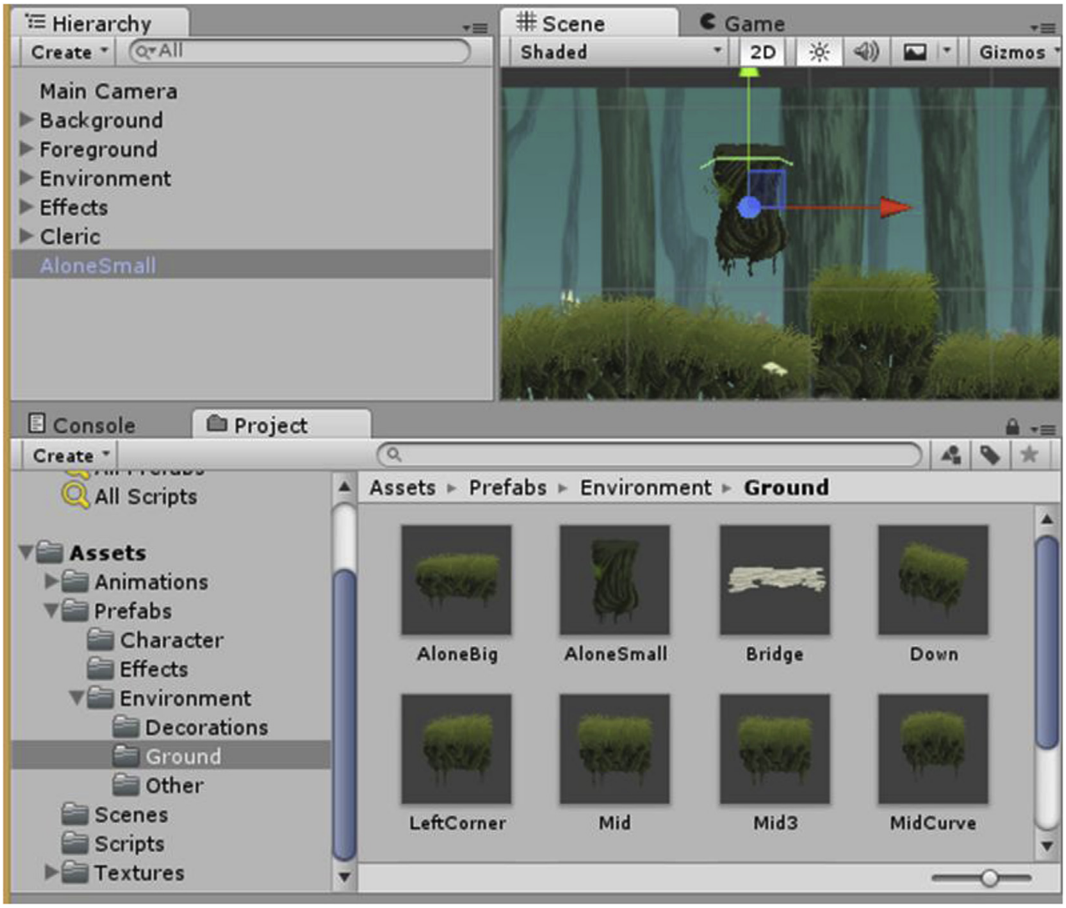

Fig. 2. The Unity game development interface used by the students.

Fig. 3. A screenshot of the 2D game that was modified and developed by the girls during the workshop. Girls completed a side-scrolling platformer in which a heroine character must evade mushroom-headed enemies.

computing. Focus group interviews aimed to provide further insight into girls' perception of the workshop in relation to identity exploration principles. Finally, content analysis of games developed by the girls aimed to identify evidence for specific actions related to identity exploration.

6.1. Survey results

Pre-survey results showed that 62% of the participants had some prior experience with programming. Participants' responses indicate that these students had some exposure to Scratch and JavaScript programming through previous workshops organized by TechGirlz. 43% of the participants reported that they play video games a few times a week, 29% declared that they play daily, whereas the remaining participants selected the once a week option. The initial questionnaire also included 10 five-point, Likert-scale questions to collect information about the general attitudes of the participants towards computing and game development. Some of the questions asked participants to self-evaluate their computing skills, evaluate their skills with respect to their friends and the level of support they get from their families. Figs. 4 and 5 summarize the distribution of the participants' ratings to the pre- and post-survey questions respectively, whereas Table 1 summarizes the mean, standard deviation and median ratings obtained for the pre- and post-survey questions.

The pre-survey answers suggest that most participants had a positive view of computing and game development, as they tended to agree with the statements "computers are fun" (86%), "I like computing" (81%), and "I want to find out more about computing" (81%). This is expected as all participants are members of the TechGirlz organization. Participants rated themselves as more knowledgeable than their peers (43%), and also indicated that their peers tended to like computers (52%), and their families encourage them to use computers (62%). Although the majority disagreed, 30% of the participants agreed with the statement "programming is hard." Moreover, 19% of the participants disagreed with "I am good at computing," 29% agreed with "computer jobs are boring," and 10% disagreed with "I like the challenge of computing." Even though the majority of the responses were positive to these questions, the non-negligible level of negative responses suggests that some of the participants did not have a strong positive attitude towards computing as a profession before the workshop.

There is a slight shift towards agreement in most positive items in post-survey responses. In order to test the statistical significance of the shifts in the opinions of the participants, their ratings for the eight questions that appeared both in the pre- and post-surveys were compared with Wilcoxon signed ranks tests. The tests showed that there is a significant shift towards agreement only for the item "I know more than my friends about computing" ($z = 1.667$, $p < 0.05$, one-tailed). The difference between the other seven items was not statistically significant. The post-survey included four additional statements that asked for the participants' overall assessment of the activity. Participants tended to strongly agree with the statements "this project was fun" (84%), "this project made me more interested in computers" (81%), and "I would recommend this project to a friend" (65%). Moreover, 81% of the participants agreed with the statement "I can become good at computing." When this is considered alongside the fact that the strongest shift to agreement was observed for the statement "I know more than my friends about computing," one can argue that the majority of the students believed that their experience at the workshop increased their knowledge in computing as compared to their friends. Moreover, 40% of the participants agreed with the statement "programming is hard" initially, whereas this percentage increased to 56% in the post-test. There is a similar minor shift towards disagreement for the statement "I am good at computing," which indicates that some of the participants lowered their ratings possibly due to the challenges they might had with the workshop activities. However, the strong positive responses to "this project made me more interested in computing" and "I can become good at computing" suggest that the challenges did not undermine their attitudes towards computing.

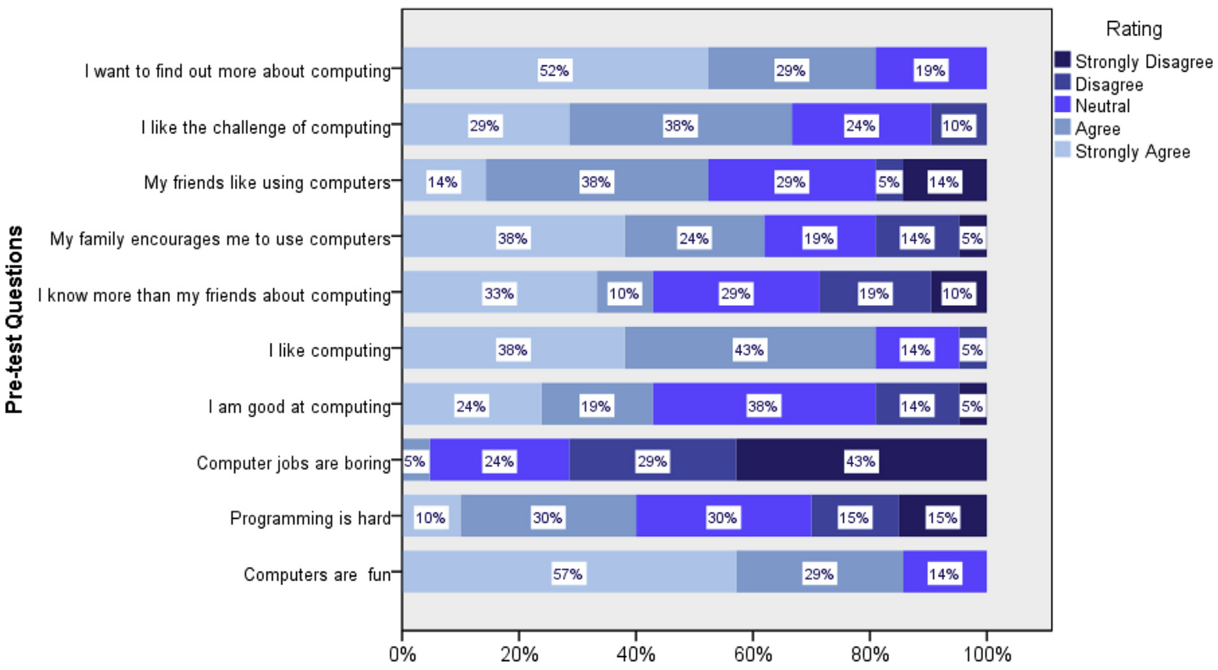

Fig. 4. Stacked bar chart of responses given to the pre-survey items.

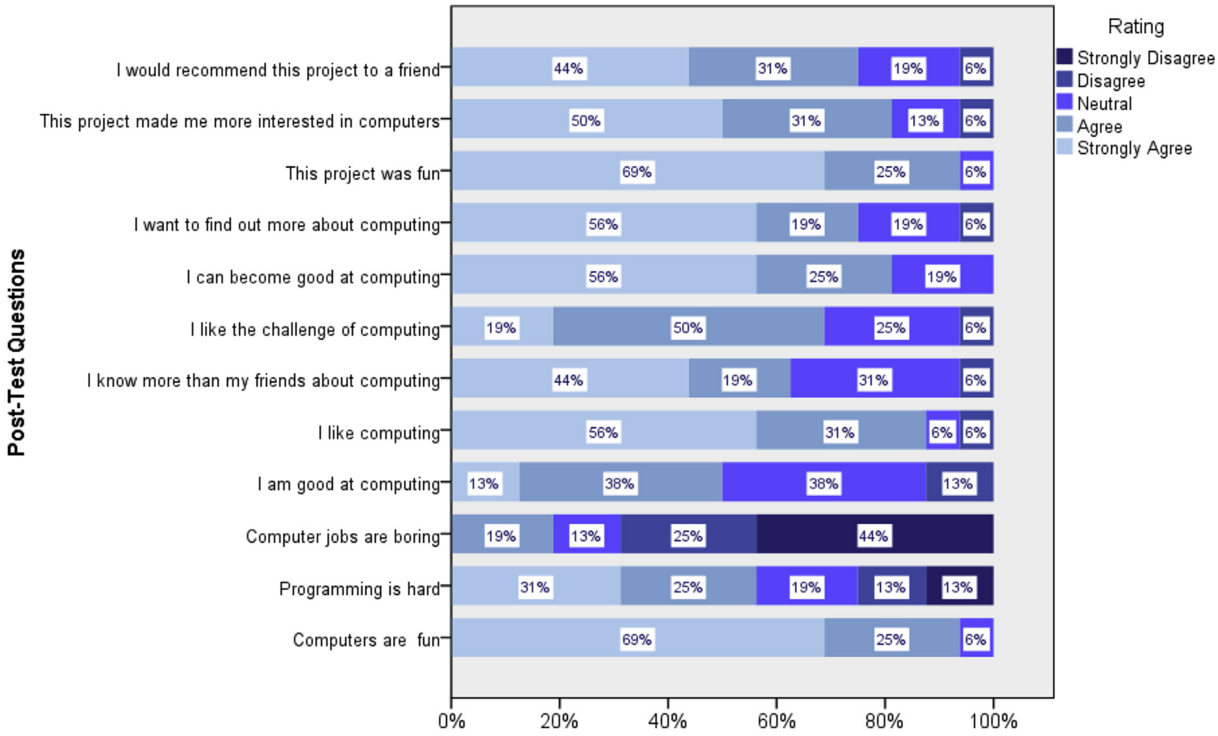

Fig. 5. Stacked bar chart of responses given to the post-survey items.

6.2. Interview results

The analysis of the semi-structured focus group interviews was geared towards identifying the recurring themes in the participants' comments regarding their workshop experience and about how they view themselves as prospective game designers. The themes are related to the concepts voiced in the participants' statements pertaining to the identity exploration framework (Kaplan et al., 2014, pp. 243–291) The below sections are organized around four identified themes:

6.2.1. Improved confidence in game design & programming

In several of the interviews students expressed that they learned things they did not know about game design before: "I learned how much actually goes into game design." For example, one of the students mentioned: "I did not know that you can make games, just by yourself without having like a bunch of extra software and stuff." Others commented about the actual code writing part of the workshop: "… it requires your own code, instead of just dragging and dropping code that was already set." Students' responses also suggest that engaging with different aspects of game development such as design and coding can actually affect their feelings and ideas about designing games, which is illustrated in the following comment from another participant,

Table 1
The central tendency indicators for matching questions between pre and post survey.

	Pre-survey			Post-survey		
	Mean	SD	Median	Mean	SD	Median
Computers are fun	4.43	0.75	5	4.63	0.62	5
Programming is hard	3.05	1.23	3	3.50	1.41	4
Computer jobs are boring	3.95	1.02	4	3.75	1.24	4
I am good at computing	3.43	1.17	3	3.50	0.89	3.5
I like computing	4.14	0.85	4	4.38	0.89	5
I know more than my friends about computing	3.38	1.40	3	4.00	1.03	4
I like the challenge of computing	3.86	0.96	4	3.81	0.83	4
I want to find out more about computing	4.33	0.80	5	4.25	1.00	5

> "… based on the stuff I did today, it was easier than I thought. Before the workshop, I didn't know about the designing part, just the coding part, so it was very basically just stay away from it – I don't understand it at all. It's still confusing but I understand it better."

These comments also suggest that the workshop created a safe environment for the participants to explore new identities.

6.2.2. Affective engagement with game design

Participants reported that they "liked the programming" and described the experience as a "fun activity." In another comment related to this theme, one of the participants mentioned, "I never thought of game design as to be fun to me or interesting, but it helped me realize that it could be fun to me." Another participant commented, "It's interesting and you can do anything you want with it." Participants showed positive attitudes towards the game design task used during the workshop. They were motivated to work on the task and learn because it was something new and fun for them, "I thought it was nice because it was something I've never done before, and I've always wanted to. And now I know how to." Another participant made a similar comment indicating interest in further engaging with game design activity: "It's really fun and challenging, and after the first class I really wanted to come back and do the second one. So, I did."

6.2.3. Personalization as a mode of self-expression

Most of the participants commented on the customization options on the Unity interface: "I really liked how everyone had the same game at first, but then they changed it and everybody's game was different." Customization not only enabled participants to choose specific functions/options but also made them feel more personally attached to their games, "I think that the best part was being able to customize the map and add more ground to move on and more obstacles and more enemies and the size of them and that stuff." Another participant made a similar statement regarding customization features:

> "I really liked how we could just do anything with it. I play a lot of phone games, and they give you like an option to make like your own level. But it's not like you're going into a system that you can create your own game not just using a game with already created details."

Participants created and made the experience unique from their perspective, as it was highlighted in the following comment: "You got to personalize it the way you wanted it." In short, these comments suggest that participants appreciated the possibility of personalizing their games, which helped them to express their individual preferences in game design.

6.2.4. Stimulating interest towards game design practice

Several participants mentioned that they enjoyed the game design activities in the first workshop, commenting that it made them feel as though they could design games, too:

> "Like I've thought of it like whenever I play a game that … how cool it would be to have that game like become a very, very popular one. But now I realize I can do it pretty much at any age and start learning how to design my own games."

Another participant said: "Well, before I came to this class, I didn't think that I would ever, ever go into game design, but now I think like it's more of a possibility." Participants showed interest in putting more work on their games as suggested by the following comment:

> "I thought like maybe even a third day (of the workshop) to edit the characters or like edit the background in Photoshop. Maybe a designing your character, like be able to change stuff about it like the length, the size of the hair, and stuff and that …"

Most of the students mentioned they would love to learn more about animations, "I would have liked to have learned more about the animation of the game because we just got a lot of default characters. How to make them and how animations work." In short, these comments suggest that the workshop experience stimulated the participants' awareness and interest towards more specific aspects of game design practice.

6.3. Game analysis results

Students' games were evaluated for several targets; use of the transform, scale, and rotation tools; implementation of the character move, jump, and fire scripts; implementation of the enemy move, jump, and spawn scripts; and unexpected learning outcomes. These targets were chosen because they were key instructional milestones within the workshop. Fig. 6, below, summarizes the distributions of the ratings assigned to 13 student-designed games along nine dimensions.

Our analysis of the games suggest that most students succeeded in building a playable game ($M = 3.23$, $SD = 0.32$) with minimal run-time or compilation errors ($M = 3.54$, $SD = 0.27$). They were able to use the select tool to drag prefabs into the scene – of the 13 games, 12 displayed good or excellent use of prefabs ($M = 3.62$, $SD = 0.24$). In one example, a student appeared to drag in all prefabs at once, causing the Unity engine to cycle through all of these prefabs very quickly, creating a "glitched" animation effect (Fig. 7), which could be considered as a positive or a negative indicator. On the one hand, this may indicate that a student has a solid understanding of Unity's file structure and has sought to exploit a glitch for artistic effect or stumbled upon the effect and kept it as an artistic choice. On the other hand, it could indicate a lack of understanding of how

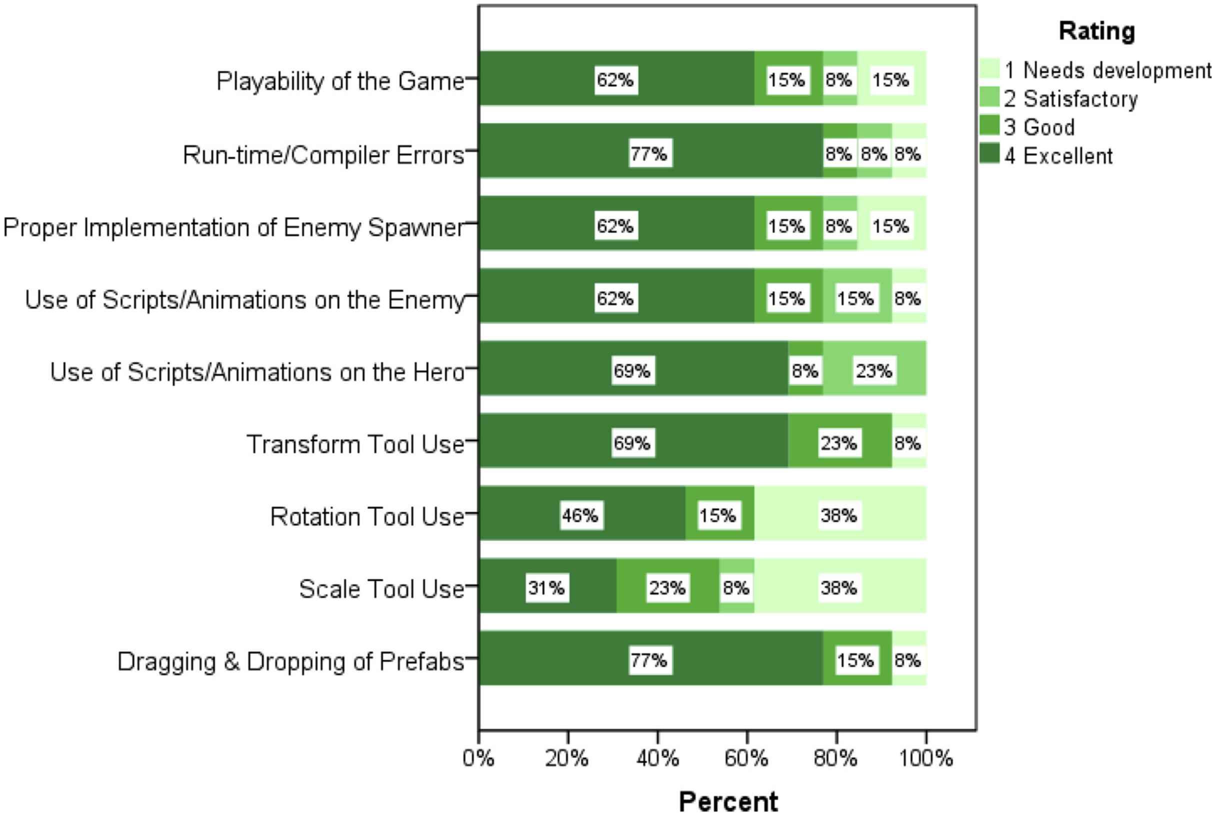

Fig. 6. Stacked bar chart of ratings for the 13 games along each evaluation dimension.

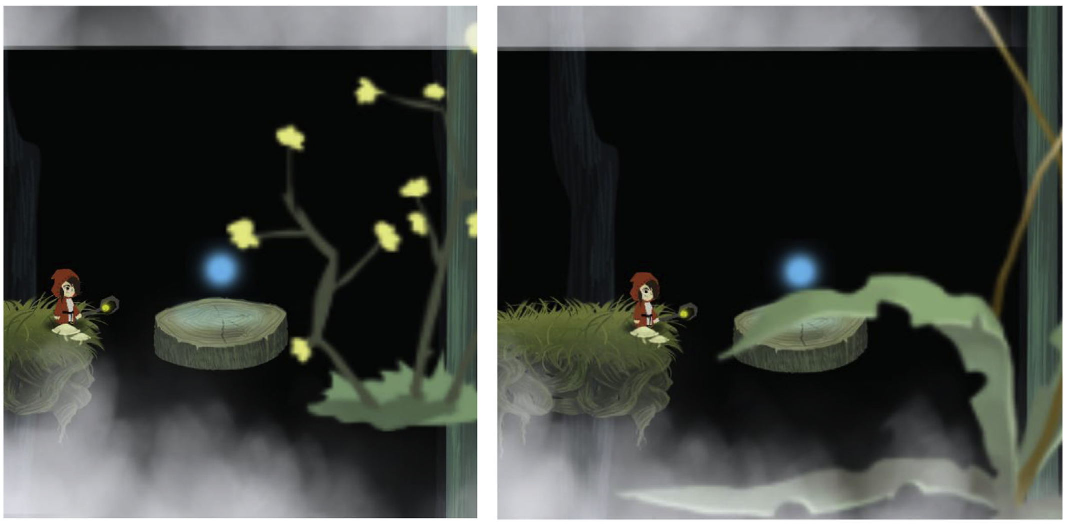

Fig. 7. The glitched animation effect achieved by one of the participants.

to use prefabs and their inability to troubleshoot their mistake. In any case, this example illustrates a creative contribution by the student.

Correct usage of the scaling ($M = 2.46$, $SD = 0.37$) and rotation ($M = 2.69$, $SD = 0.40$) tools appeared to be more challenging for the participants, oftentimes resulting in the scaling, rotation, or transformation of parts of a sprite instead of the entire game object (Fig. 8). This kind of error may be attributed to a misunderstanding of how to select entire game objects using the

Fig. 8. The enemy sprite (mushroom) has been improperly scaled – only the head component of the sprite has been scaled, while the rest of the body remains in its original size.

hierarchy view, rather than a conceptual misunderstanding of what the scale and rotate tools are and how they can be used to manipulate game objects within a scene. Participants tended to make better use of the transform tool ($M = 3.54$, $SD = 0.24$).

Additionally, the majority of the students were able to assign the hero character ($M = 3.46$, $SD = 0.24$) and the enemies ($M = 3.31$, $SD = 0.29$) move, jump and, fire scripts with minimal errors. Students seemed adept at dragging and dropping scripts and animations into the inspector pane in Unity. However, the distribution of the ratings indicate that some of the participants had more difficulty with applying the enemy move, jump, and spawn scripts to the enemy prefab than to the hero character. This might be attributed to the fact that during this portion of the lesson, students were asked to take the additional step of viewing these scripts in MonoDevelop, the scripting editor used by Unity, before adding them to the enemy prefab. In general, prefabs seemed to be conceptually challenging for some of the students.

In the second workshop students were asked to create a "Portal" game object. The goal was to create a game object that would spawn enemy prefabs at a regular interval. The facilitator would lead students in a step-by-step process to write a new script called "EnemySpawner," create and name a new game object, and drag their new script onto this game object. The final step was to save this "Portal" as a prefab, allowing students to drag and drop this prefab into the scene just as they had with other prefabs. The majority of participants were able to implement the enemy spawner without any issues ($M = 3.23$, $SD = 0.32$). However, 15% of the games we analyzed lacked a proper implementation of enemy spawners, suggesting that some of the participants struggled with this multi-step process.

Creative changes not explicitly mentioned or requested during the class involved students changing the color of particular game objects using the inspector. This can be seen in Fig. 8, where this student altered the color of the fog to make it pink, and changed the color of the right-most platform, making it appear brown. Moreover, Fig. 9 illustrates cases where students used objects like stumps and vine balls in creative ways to customize the 2D platform. Such custom uses of the Unity tools, while not explicitly asked of students, evidence their interest in exploring the Unity editors as well as their enthusiasm for customizing these games to make them their own.

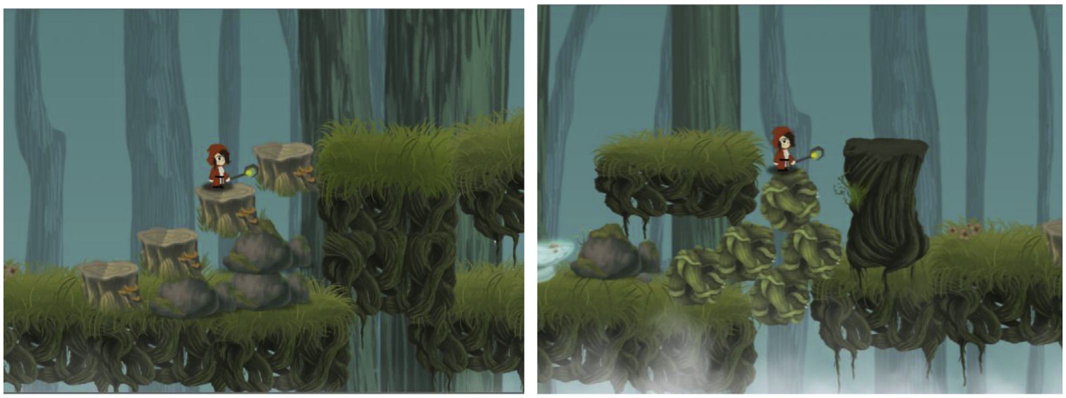

Fig. 9. Two separate instances where stumps and vine balls were used by the participants to create platforms to guide/constrain the character's movements.

7. Discussion

Computing technologies are transforming the world, and women should be a part of this change. In order for this change to include women's' voices and perspectives, women need to be included as contributors, designers and producers of computer technology (Margolis & Fisher, 2003). In the present study, we aimed to investigate the effectiveness of a game design workshop that was designed according to the identity exploration framework on female students' attitudes towards computing. Our findings from pre/post surveys as well as exit focus group interviews suggest that the workshop positively contributed to female students' attitudes towards computing careers. In addition to this, our game analysis revealed that female students were able to meaningfully engage with the game-design task by making use of the programming resources provided to them in creative ways. In this section we discuss the possible effects of our curriculum design on these outcomes as they relate to findings in previous work employing similar approaches for stimulating young girls' interest in computing.

Previous studies explored various kinds of workshops and courses designed to solicit girls' interest towards computing and reported mixed results. For instance, Van Eck's (2006) and Denner's (2007) findings suggest that game design workshops can improve girls' attitudes towards CS. Similarly, Peters and Pears (2012) also found that, as a result of an introductory course in CS, students developed positive attitudes towards computing. However, Robertson's (2013) study found that the workshop was ineffective in improving female students' attitudes towards CS. In contrast, the results of our study highlight the importance of exposure and positive hands-on experiences in shaping the attitudes of girls towards CS. In particular, our survey analysis revealed a positive shift in the girls' attitudes towards computing after participating in the workshop. In addition to this, game analysis and focus group interviews also corroborate with the survey results, which together suggest that this game-design workshop experience enhanced the participants' knowledge of game design and development.

From a theoretical perspective, we attribute these positive outcomes to the way the workshop curriculum encouraged positive identity exploration among the participants. Our workshop curriculum aimed to utilize identity exploration principles by presenting videogame design as an application of computer science. In a similar setting, Peters and Rick (2014) explored the effectiveness of a 6-week long software development activity designed along identity exploration principles in the context of a high school introductory programming class, and found that the designed learning environment positively contributed to students' identity development in CS due to psychosocial and sociocultural elements present in this environment. Psychosocial elements were identified as experiences in which students developed an understanding of what is involved with engaging in computing, which helped them imagine circumstances in which they could fulfill specific roles as a software developer. Sociocultural elements were described as a combination of the social relationships among specific roles and the context of the activity in which computing practices are situated and enacted. Peters and Rick (2014) argued that the interactions among psychosocial and sociocultural aspects potentially contribute to students' self-awareness as a "computer person" (or someone who identifies closely with using a computer), and hence stimulate their identity development through participation.

Peters and Rick (2014) focused primarily on software project management practices employed by professionals to help students position themselves as part of a real software development team working towards a common goal. Unlike our study, Peters and Rick's study did not focus on girls' identity development in computing and the activities did not employ professional grade tools used by software developers. Despite these differences, our findings corroborate Peters and Rick's arguments regarding factors that stimulate identity exploration through psychosocial and sociocultural means. In this study, we considered a workshop capturing some of the important aspects of game development practice and the interactions taking place among developers in a typical game development studio. Given young girls' strong interest in gaming, we focused on a game development context so as to increase young girls' identification with computing professions. The scaffolded use of Unity, a professional game engine, seemed to have contributed to the psychosocial aspects of identity exploration. During focus group interviews, students stated that they developed a better sense of what game development is like and realized that game development is not merely about coding but also about designing an experience. Both of these comments reflect key insights for professional game designers.

As the game content analysis results suggested, students were able to participate in game design practice through customizing the game elements in creative ways. The various ways in which the participants customized their games and explored the features of the game development environment can be treated as sociocultural indicators of identity exploration. Moreover, participants were also explicitly asked to play the game designed by a peer and provide feedback for potential ways to improve the game experience. Such design critiques are also practiced in game studios (play-testing) and can be considered sociocultural elements in game design practice. Participating in pair evaluations can contribute to students' awareness that they are designing experiences for others, and play an important psychosocial role as well. As reported by Peters and Pears (2012), giving students a chance to be creative and encouraging them to develop a program for other people's use can evoke positive emotions about CS and improve their confidence in their CS skills. Our survey and interview findings corroborate Peters and Pears' (2012) findings.

Although students were engaged by the workshop activities and commented positively on their experience, there were also signs of challenges indicated by negative shifts in survey items such as "I am good at computing" and "programming is hard." Moreover, a minority of the students did not produce a fully playable game at the conclusion of the second workshop. The challenges of learning professional grade tools and time limitations may have contributed to this outcome. However, the success of the majority of the participants in following the guidelines suggest that the workshop activity had a balanced level of complexity. Since the majority of the students mentioned interest beyond the workshop experience, one can argue that the workshop succeeded in providing an optimal learning experience for young girls despite its challenging aspects. According to Teague (2002), the factors that have the most impact on women's choices to pursue a career as a programmer include experiencing the attractive characteristics and sophistication programming can offer as well as developing the perception that they possess the necessary skills for a programming career. In some cases, it is only after they are exposed to programming experience that women come to realize they actually like programming.

Another way in which the workshop aimed to help young girls explore a sense of identity as a game designer was through the introductions of female role models in the game industry. The importance of having female role models for such purposes was also emphasized by Corston and Colman (1996). Similarly, Townsend (1996) conducted three studies with female students in ninth grade in which they watched videos of female computer scientists talking about themselves in relation to CS. They reported that students who watched the videos had more positive attitudes towards CS. In the present study one may also argue that the positive change in girls' attitudes towards CS can be partly attributed to their increased awareness of influential female game designers and their games. Such an awareness may also potentially help young girls imagine themselves as game designers, an important psychosocial element fostering identity exploration.

In short, our results suggest that when young girls are provided a safe environment and an opportunity to explore a new identity they tend to embrace the experience by exploring and personalizing the target identity. The use of activities targeting identity exploration and providing a supportive setting in which young girls can meaningfully participate in a real-life, professionally-relevant design challenges were key factors in facilitating key psychosocial and sociocultural elements for effective learning through identity development.

Despite its promising results, our study has some limitations. Our time with students was very limited, so the game design and development principles explored in our workshop were cursory. Preferring breadth to depth (e.g. copying code, rather than writing it from scratch), we focused more on the affective and immediate cognitive effects rather than long term learning and transfer effects. In other words, although we could not focus on long-term learning effects, our content analysis of the games revealed some important insights regarding the extent to which participants were able to understand and apply the guidelines in their games. Our sample size for this study was small, meaning that we cannot make strong generalizations about the effect of our workshops on students. However, we do note that the workshop had a small positive impact on students' opinions of CS that can be attributed to its identity exploration aspects. While the workshop was well received and the available customization options were appreciated, results indicated that participants desired more options for customization and personal expression. In future work we will design a corresponding set of teacher tools to enable non-technical instructors to lead these workshops, increasing the potential reach of our curriculum. We also intend to improve the curriculum, placing further emphasis on identity exploration, and holding a second study to observe if the trends observed in our initial study will hold for a larger, more diverse group of female students in the same age range.

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Appendix 1. The rubric used for the evaluation of games designed by the participants.

TechGirlz Game Rubric

Game Number: __________

	4 Excellent	3 Good	2 Satisfactory	1 Needs development	Comments (if any)
1. Does the game show evidence of dragging and dropping prefabs (aka "decorators")?					
2. Does the game show evidence of the use of the scale tool?					
3. Does this game show evidence of the use of the rotation tool?					
Does this game show evidence of the use of the transform tool?					
4. Are scripts properly applied to the hero character? Are the animations assigned properly?					
5. Are scripts properly applied to the enemy character? Are the animations assigned properly?					
6. Is the enemy spawner properly implemented in game?					
7. Are there any errors being recognized by the engine (compiler errors, etc.)?					
8. How playable is the game? Are you able to get from one end to the other?					

9. Are the any novel discoveries in this game?

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