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The influences of computer gameplay and social media use on computer science identity and computer science career interests

Zohal Shah [a,*], Chen Chen [b], Gerhard Sonnert [c], Philip M. Sadler [d]

[a] Digital Promise; Harvard Graduate School of Education
[b] Faculty of Education, The University of Hong Kong; Science Education Department, Harvard | Smithsonian Center for Astrophysics
[c] Harvard College Observatory
[d] Science Education Department, Harvard | Smithsonian Center for Astrophysics

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ABSTRACT

Computer gameplay and social media are the two most common forms of entertainment in the digital age. Many scholars share the assumption that leisure-time digital consumption is associated with computer science (CS) affinity, but there is a dearth of research evidence for this relationship. Female students generally spend less time on gaming and more time on social media than do male students, so a gender comparison perspective is helpful. Using multinomial logistic regression analysis on a national sample of 10,197 U.S. college students in introductory CS courses, we found that frequent computer gameplay was strongly associated with an increase in the probability of CS career interest relative to a Non-STEM career interest (β = -0.17, se = 0.06, $p < .01$) for both male (N = 7214) and female students (N = 2659). In contrast, increased social media use predicted a higher CS career interest relative to a Science/Engineering career interest (β = 0.12, se = 0.06, $p < .05$) for female students by 8%, however, a lower interest for male students by 4%.

"Growing up in a digital world empowers [adolescents] to think about not just being the user, but being the builder" –Mehran Sahami, Interviewed by [75], para.16.

It is a common assumption that computer activities that are typically done for leisure can incidentally promote the development of computer literacy and identity [2,5,57]. This assumption is an intuitive one. If an activity or a tool motivates individuals to dedicate time to the task, their experience is likely to generate the self-efficacy required to stimulate intrinsic motivation for further interest and identity development in this activity or tool [7,12,16,48,60,92]. In 2018, 90% of American teens reported participation in video gameplay on computers or handheld devices [1]. 45% of teens reported active social media use on a near-constant basis, and those teens also claimed it had neither positive nor negative effects on them [1]. There has been abundant research about the connection between computer gaming and academic interest (e.g., [7,16,22,47,68,79]). However, given how prevalent both social media and computer games are in the lives of adolescents, evidence about the connection between social media use and academic interests is surprisingly scarce. Most of the discussion on this topic is based on self-reported survey data and anecdotal evidence [2,12,16,47,60,79,83,86,89,97]. This article aims to understand and compare the associational effects of computer game playing and social media use on learners' computer science (CS) identity and CS career interests.

We also wish to advance understanding of the gender aspects in the relationship between leisure computer use and CS identity and career interests. Some stakeholders have argued that one way to remediate the gender gap in computing interests is to encourage more leisure use of computers among female students [2,12,86]. To achieve that, it has been recommended to make leisure computer use more prosocial, as currently many games heavily emphasize aggressive features rather than opportunities for networking and collaboration [8,10,12,32,38,46,65,66,97]. Following this line of reasoning, social media may be particularly useful for drawing women into computing because of their social aspects. Yet, there is a paucity of empirical research to examine this intuition.

In this study, we addressed this dearth by analyzing a national sample of U.S. college students in introductory CS courses who reported their current career interests and CS identity, as well as their hours playing video games and using social media during their high school years.

1. Literature review

For the purpose of this article, we will use the terms "video game" and "computer game" interchangeably. In a strict sense, video games

* Corresponding author.
E-mail address: zshah@digitalpromise.org (Z. Shah).

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are a form of computer software that can be accessed through a console, handheld device, or a PC [4], whereas computer games are only accessible through a PC. Because this distinction is largely absent within existing works on gameplay, the following review will reference literature that discusses computer and video games alike, with the underlying assumption that the discourse is applicable to both activities.

1.1. Expectancy value theory

In educational technology research, the expectancy value theory (EVT) is widely used to probe student academic motivations and intentions [3,26,82]. The EVT framework is valuable in helping us understand the potential effect of gaming and social media use on CS identity and interest. EVT states that an individual's perspective on their task ability and on the task relevance regarding a specific activity determines their motivation, achievement, and persistence [48,92]. The task relevance encompasses the individuals' interest, relationship to their goals, associated cost, and attainment value. When individuals perceive that they are able to succeed in an academic task, they are more likely to engage in behaviors associated with attaining academic achievement [40,68,90,91] and entering the associated career pathway [23,49]. Furthermore, Eccles and Wigfield [24] emphasize the role of situated experiences; each situation in which individuals find themselves fosters a decision-making process in which the choices are shaped by their prior experiences.

Experience with leisure computer use may help instill the intrinsic motivation and expectancy of success necessary for the development of a CS identity [5,50,63,86]. Computing/CS identity has been defined as consisting of recognition, interest, and performance beliefs [5,54,55,63]. Mahadeo et al. [55] further describe recognition as the extent to which individuals' are seen as computer persons, performance beliefs as individuals' confidence in the successful execution of a computer-related task, and interest as their affinity to computing foci. The positive experiences with computer gaming come in different forms: solving a puzzle, upgrading a gear, creating or sharing a mod (a modification patch of a game), or upgrading/installing a graphic card. Such tasks, although challenging, are usually perceived to be playful, which increases intrinsic motivation in the task [16] and the relevance of the task [7].

Abundant research has substantiated the connection between game-playing and CS self-efficacy or literacy, but empirical evidence that links social media use and CS interests or literacy is scarce (as described below). Compared with computer games, social media pose fewer challenging tasks because such platforms are usually designed to be as intuitive, and as little puzzling, as possible. Yet, to be social, to edit media material, and to gain traction from viewers can still be playfully challenging. Thus, such tasks may still afford opportunities to assess the real-life relevance of, and the expectancy of success in, personal computing.

1.2. Influence of computer games

Over the years, studies have shown that computer games have exerted an increasing influence on youths' developing confidence in computer literacy and interest in CS. Although some have suspected that these games negatively affect career and academic advancement–a perception that is known to prevail within professional contexts [78]–research has shown that video games offer an opportunity to interact with technology in comfortable settings while simultaneously allowing the player to comprehend the logic within computer programs in an authentic environment (Sevin & Decamp, 2015).

Findings suggest that games are support mechanisms for exploring and forming identity through learner agency [70,72,79]. Gameplay offers agency to learners to explore and learn with very few constraints, allowing them to independently develop a sense of an identity [59]. In related works, researchers have seen students associate themselves with a CS context after learning specific skills [79]. For instance, Shaw et al. [79] had high school students create reflective portfolios on their e-textile projects in an introductory CS course. In these portfolios, students connected themselves with a CS identity through the development of coding, circuitry, and crafting skills. Further, Persico et al. [70] found that the relationship between players and games offered personalized learning experiences that were crucial to identity and knowledge development, arguing for greater allocation of control to the student and for personalization of the learning experience.

Playing computer games also introduces creative components of computing [65,71,95], sparks curiosity in game development, provides a platform for problem solving [68], 3D spatial recognition, critical thinking, and decision making, thus enabling a direct pathway into CS (Sevin & Decamp, 2015). Findings suggest that an exposure to a variety of games can bolster pattern recognition and application for players (Sevin & Decamp, 2015). In fact, Kazimoglu et al. [47] discovered that students who were enrolled in CS or related programs reported that specific games could increase problem-solving abilities for those who are learning programming at an introductory level. The game used for their study, *program your robot*, was intentional about incorporating computational thinking and programming constructs as integral parts of the gameplay [47].

In a study done with secondary students, Bourgonjon et al. [7] revealed that students viewed games as opportunities to learn, where the utility and the ease of using video games strongly predicted their acceptance of video games as an educational platform. This finding has strong implications for all educators; it explicitly posits that the incorporation of video games in curriculum and lesson time would benefit all students. In addition, several empirical studies have used computer card games (CCGs) and educational computer card games (ECCGs) and found that students retain positive attitudes and motivation when ECCGs are incorporated in the learning process [52]. The comfort afforded by pre-existing knowledge of computer games offers students an opportunity to focus on their learning rather than being challenged by underlying game constructs [52].

1.3. Duration of gameplay

Among extant studies, there is no consensus about the effects of the duration of gameplay. Toker and Baturay [85] noted that findings of negative effects of gameplay have been particular to studies focusing on the time spent playing games, whereas research presenting positive associations between gameplay and academic performance has focused on game construct and cognitive processing. Increased duration of educational gameplay, Johnson and Mayer [42] argue, does not guarantee cognitive processing of embedded academic content; the entertaining components of the game could limit the transfer of knowledge due to concentrated efforts on the perceptual-motor activities. Studies have also found no decline in mathematics or English scores and no effect on peer relationships and school activities when children played 15 or less hours of computer games per week [18,20]. In fact, Eow and Baki [25] found that, in Malaysia, the highest academic-achieving groups, students categorized in the 'excellent' academic bracket based on their results from the previous year's national exam, had the highest computer gameplay hours on average, about 14.5 h per week. In comparison, intermediate academic-achievers were found to play less than 5 h per week on average [25]. Similarly, Hofferth and Moon [37] discovered a positive association between computer gameplay and the level of achievement on tests of passage comprehension and applied problems. Another study found that avid gameplay predicted computer literacy [2]. This study revealed a stronger positive association between computer gaming and computer knowledge on a theoretical and practical level, in comparison with the effect of the duration of computer usage at school and at home for schoolwork [2].

By contrast, a higher frequency of computer gameplay in early and late high school has also been found to be associated with weaker academic orientation [97]. A study involving undergraduate students revealed negative associations between excessive gameplay and academic performance and self-esteem. Although self-esteem could be encouraged by gameplay accomplishments through built-in features (feedback, player interaction, scoring, etc.), it could also significantly decrease through problematic player behaviors, such as excessive gameplaying, addiction [85], and verbal aggression [38]. Pereira Santos et al. [69], however, found no correlation between self-esteem and player behavior, but an association between self-esteem and player self-evaluation of performance.

There is still uncertainty about the amount of gameplay that is considered excessive, and the amount that is right, for cultivating a CS interest. Sevin & Decamp (2015) discovered that the duration of gameplay was not significant on its own, whereas exposure to a variety of games encouraged self-efficacy and interest in computers.

1.4. Influence of social media

Due to theirs dominance among adolescents and their compulsive attributes, social media have become transformed into a medium for incidental learning [2,57,58]. Appel [2] posits that adolescents may be more inclined to learn what an IP address is if they must fix the internet to log into Facebook (p. 1340). Through social networking platforms, students can receive instantaneous feedback from peers on assignments and find supplemental resources for their work [56]. Institutions of higher education have also recognized the appeal and popularity of social media among students, incorporating various social networking platforms into their curriculum, and students seem to retain positive attitudes to this approach. However, studies show mixed results about the impact of social media on overall academic performance [44,45,56,76]. One study found that positive engagement and academic development resulted from incorporating Twitter-use educationally [45]. Another study found that students and faculty members did not typically use social networking sites, such as Facebook, for educational purposes; however, students were more likely to find it convenient to do so whereas faculty members were more likely to not see it as an educational tool [76]. Similar research has found that an increase in the time spent updating Facebook statuses and chatting puts students at greater risk for low academic achievement [44].

Prior research suggests that we can examine the effect of social media also through the lens of computer gameplay. Both computer activities are main forms of entertainment for adolescents that provide greater informal exposure and development of computer literacy [30,43]. Computer games and social media use can consume time and become addictive, but there is no large-scale empirical evidence about the effect of the duration of these activities on the cultivation of computer literacy, or on the development of a CS identity or CS career interest. Excessive use has not been defined quantitatively. Studies have used varied measures in defining “excessive use,” limiting our knowledge about the exact value of social media or computer gameplay consumption that can be beneficial or harmful [61,81,83].

Similar to the prevalence of computer gameplay among adolescents, social media have dominated the leisure time on the devices of adolescents, becoming a stimulus for compulsive behavior [9,61] as well as a mechanism for self-presentation and self-disclosure ([88], p. 122). Compared with computer games, which may contribute to aggressive and antisocial behaviors [10,25,28,31,38,46,84], advocates for social media in education anticipated the networking platforms to afford the opportunity to be social and pro-social in students’ leisure time [56,76,86]. However, social media can also become a vehicle for bullying and other antisocial behaviors, and some studies suggested that excessive social media use may inhibit in-person social behavior in private and professional settings [9,39,61,87].

Literature has also highlighted differences in how social media and computer games may influence students’ academic development. Computer games have been associated with an increase in both practical (e.g., how to close a browser without a mouse) and theoretical (e.g., understanding the purpose of the SQL programming language) computer knowledge whereas social media use has been associated singularly with higher scores on practical computer knowledge [2]. This difference may be attributed to the underlying problem-solving framework of computer games, promoting critical thinking and pattern recognition (Sevin & Decamp, 2015), such as going through a maze to upgrade gear. By contrast, social media have been shown to be a tool for social communication rather than a medium for problem solving (the interfaces are designed to be as intuitive as possible) [56]. Students do not naturally consider using social media as a medium for learning, suggesting that social media may need to be intentionally used with a pedagogical purpose to be an effective resource for learning and teaching [56,86]. In this sense, we may observe a very different effect of social media use, compared with computer game playing, on CS interests and identity.

1.5. Gender and computing identity

Gender disparities in the current landscape of computing are still prevalent, with women holding only 18% of all CS bachelor’s degrees in the U.S., and girls’ interest in CS decreasing through their school years, starting from elementary education [93,94]. Numerous studies have noticed a gender difference in computing identity [50,65,77,89]. Mooney et al. [64] discovered that female students’ majoring in CS were less likely than their male counterparts to identify themselves as part of the CS community. Wong [94] found that the construction of computing identity among students goes beyond digital literacy and includes certain distinct characteristics (e.g., quiet, anti-social, glasses-wearing, male) [63,94]. Further, Cheryan et al. [14] found that stereotypes about CS can be conveyed through media, computer scientists in the field, and learning environments, and when these stereotypes are prominent, they can deter girls and women from feeling a sense of belonging in the field. In fact, Master et al. [62] found that sense of belonging predicted interests in CS for girls’ after controlling for the value they placed on CS and their expectations of success. The same study also found that classrooms that did not spread CS stereotypes caused girls to express more interest in taking CS in contrast to classrooms where CS stereotypes were more prominent [62]. Moreover, He and Freeman [35] discovered that, when controlling for computer anxiety, computer knowledge, and current computing experiences, gender did not impact computer self-efficacy. Their empirical results strongly suggest that computer experiences and anxiety are mediators of the gender effect. Markedly, inequalities in experience can limit choices and opportunities, influencing the computing identity students form and maintain [50,77].

Bourgonjon et al. [7] found that increased experience with games positively influences perceptions of game utility, learning, and comfort. Notably, early exposures to computing often come through the form of computer games. However, the gaming industry has not made active efforts to incorporate the interests of girls [51,65]. The negative and misrepresentative portrayals of women in games; including the hyper sexualization and tokenism of women characters, affect both consumers and the gaming industry [51]. Due to the lack of representation of strong women, games with women characters do not sell. This gives the false impression to game developers and publishers that games with women characters do not sell [51]. Furthermore, differences in leisure activities further segregate the genders, because male toys tend to be mechanical in nature, whereas female toys have a more domestic appeal [65]. While game-design workshops have been shown to effectively encourage young girls in shaping positive identity and attitudes towards computing [8], differences in the characteristics of customary leisure activities, such as toys and summer camp experiences, can give male students an additional boost toward CS.

The paucity of female role models in CS, the broader STEM discipline, and in female-oriented computer games can adversely impact the computing identity development for girls in their formative years [36,65]. Yet, studies have also notably found that female role models are not more effective than male role models in fostering interests in CS for women and girls [13,80]; whether the role model embodies current stereotypes of the field is more predictive of their expectancy of success [13,15]. In an interview with *Marketplace*, Melinda Gates, a CS graduate herself, talks about a greater representation of women in CS during her time at university than today [6]. She notes a shift from gender-neutral games to male-marketed games in recent years and relates this trend to the decline of female enrollments [6,96]. The lack of female inclusion in computer games can cultivate stereotypes about computing identity, further alienating girls from developing a computing identity and re-affirming the notion that boys fit the identity better [51,65]. Scholars also highlighted the distaste and disconnect female users feel from violence-centered and male-marketed games [32,51], which are often action- and adventure-based and focus on aggression and competition [84]. In fact, violent games have been shown to increase stress and frustration for female users [27] as their preferences are oriented toward more interpersonal, non-violent games [41].

There are also markedly different digital consumption patterns between male and female users. Prior research has shown that male adolescents were more likely to describe their main computer activity as playing video games, while female adolescents were more likely to say it was e-mail or instant messaging [41,86]. Oh and Syn [67] found that motivations for social media use were predominantly influenced by learning and social engagement as users expect to receive new or updated information through social exchange (p. 2055). However, female users have shown to be more strongly motivated by social engagement in comparison to male users ([67], p. 2053). Lin and Lu [53] found that female users were influenced by the number of peers using social media whereas male users were not. Similarly, women studying online have also appeared to be more self-confident and willing to learn from others in comparison to men [74]. It is important to further examine the interconnected relationship of personal student experiences with their computing interests [30,63,89]. This will lead to a deeper understanding of how to motivate and strengthen affinities to computing in an evolving diverse society [55]. In fact, recognizing the motivations of all players makes it possible to incorporate their primary interests in gameplaying and social networking, informing developers on how to augment their incentives to participate [73].

2. Research questions and hypotheses

This study contributes to the field of computing education by examining and comparing the associational effects of computer game playing and social media use on learners' CS identity and career interests. Given the recent statistics from the Pew Research Center (2018) on the prevalence of computer gameplay and social media use among U.S. high-school teens, we are particularly interested in understanding how these leisure time computer-uses during high school may be associated with computing interests at the beginning of college.

We aim to find out to what extent the *duration* of computer game-playing and social media use during high school is associated to CS identity and CS career interest of students at the beginning of college. We are aware of the possibility that the duration of gameplaying or social media use may not have a linear relationship with CS identity and CS career interest: too little or too much may not be helpful, but a moderate amount may be optimal.

We are also interested in understanding if any forms of computer leisure use are particularly useful for male or female students. This may help stakeholders develop out-of-school time computer-based activities that are friendly and effective for female students.

Specifically, our research questions were:

RQ 1: To what extent, at the beginning of college, is the duration of daily computer gameplay and social media use during the high school years associated with students':

a) CS identity?
b) CS career interests?

RQ 2: Does the association of the duration of daily computer gameplay and social media use during high school with CS identity or CS career interests differ between the genders?

We hypothesize that higher amounts of daily computer gameplay and social media use encourage both male and female students to cultivate a CS identity and increase the likelihood of having a CS career interest relative to other career interests. We further hypothesize that these relationships are curvilinear. We also hypothesize a gender difference in the relationship of the duration of gameplay and social media use with CS identity and CS career interest. Specifically, we hypothesize that higher amounts of gameplay will encourage male students more than female students and higher amounts of social media use will encourage female students more than male students in cultivating a CS identity and the likelihood of having a CS career interest.

3. Methods

3.1. Survey

The survey {masked} included questions about college students' demographic characteristics, high school course taking history, and prior computer experiences. It also asked about participants' attitudes about CS and their future career (not limited to CS) plans. This national retrospective survey was administered to students in the Fall of 2014 in their college introductory CS courses across the U.S. We conducted pilot testing to establish validity and test-retest reliability. To our knowledge, this is the most recent dataset of this size and can serve as a baseline for future studies.

3.2. Sample and variables

We used a stratified random sample of U.S. institutions of higher education, based on school type and school size. The first stratification criterion was the distinction between two-year and four-year institutions. Each of the institutional types was stratified further by size – small, medium, or large. The six stratification bins were randomized, and instructors who taught introduction to CS were recruited in each bin. Instructors who agreed to participate received paper surveys and administered them to their students at the start of the Fall 2014 semester. The surveys were distributed during class, guaranteeing high student participation rates. At the conclusion of the semester, the professors added the student's final grade to the questionnaire, removed the cover sheet with the student's name for anonymity, and returned the questionnaires to us. This data is relevant for today's context given the increased prevalence of computer gameplay and social media use in recent years. With increased access and use, the duration of leisure computer use may be substantially higher, and this data can serve as a foundation for future work.

Among the large two-year schools, 8 participated, with 24 instructors and 776 students. Of the medium two-year schools, 7 participated, with 7 instructors and 325 students. The corresponding numbers for the small two-year schools were 8 participating schools, with 8 instructors and 329 students. Among the small four-year schools, 49 participated, with 49 instructors and 1857 students; among the medium four-year schools, 32 participated, with 51 instructors and 4781 students; and among the large four-year schools, 14 participated, with 20 instructors and 2131 students. There were a total of 118 participating schools, 159 instructors, and 10,199 students.

From the IPEDS Completion Survey, retrieved through WebCaspar, we estimated the CS enrollment in each of the bins by computing the number of BA and AA degrees granted in "Computer and Information Science, General" (CIP 11.0101) in each bin. This gave us target proportions for our sample, which we matched reasonably well. All bins were slightly underrepresented except for the medium four-year school bin, which was overrepresented in our sample.

3.3. Outcomes

Students' CS identity was the average score of four 6-point Likert scale items (0 = No, not at all, 5 = Yes, very much) in response to the following question, "Do the following people see you as a computer science person?". The items were "Yourself", "Parents/Relatives", "Friends", and "Computer science/programming high school teacher". We treated the average score of the four items as the CS identity outcome, a continuous variable. This operationalization of CS identity follows analogous measures of STEM identities that have been used extensively in the literature [17,19,21,29,33,34,55]. Students were also asked to pick their current career goal from 15 choices. Those were then consolidated into four broader categories: CS, Science/Engineering, Medicine/Health, and Non-STEM.

3.4. Predictors

There were two key predictors in our models: the duration of daily computer gameplay and the duration of daily social media use. Both predictors had the following options to select from: 1 = none at all, 2 = less than 1 h, 3 = 1 h, 4 = 2 to 3 h, 5 = 4 to 6 h, and 6 = 7 or more hours. To convert the responses to a continuous variable for analysis, we adapted the responses to a linearized scale. The new values were (in hours per day): 0, 0.5, 1.2, 2.5, 5, and 8.

3.5. Covariates

The questionnaire collected a catalog of covariates, including race/ethnicity (White, Black, Asian, Hispanic, and Other, which included Multi-Racial, Pacific Islander, and American Indian or Alaskan Native responses due to their small sample sizes), gender (Female = 0, Male = 1), level of parental education (No high school, high school, some college, four years of college, graduate school), hours of daily computer use (Likert Scale 1–6, which was linearized into hours per day), sum of computer related activities before college (a summed total of the activities listed by each respondent), family's interest in CS (binary variables for the following statements: CS is involved in parent's job, CS is a way to have a better career, CS was not an interest for the family, parents were able to help with CS), grade in last high school English course, and grade in pre-calculus/trigonometry (both grades on 4-point scales) (Table 1).

3.6. Analytic models

To predict CS identity, we built a series of models that included our key predictors (daily hours of social media use linearized, daily hours of computer gameplay linearized, quadratic terms of both predictors, and the interaction effects between these predictors and gender) as well as our control variables. Shown in Table 2, Ml.1 consisted of the main effects of social media use, gameplay, and gender on CS identity. M1.2 added a quadratic term of computer gameplay to allow for a non-linear relationship between computer game hours and CS identity. Analogously, M1.3 included a quadratic term of daily hours of social media use. Owing to the absence of any significant gender interactions, the interaction model is not shown.

Next, we built multinomial logistic models, shown in Table 3, to predict career interest at the beginning of college (placing CS career interest as the reference category versus Medicine/Health, Non-STEM, and Science/Engineering career interests) as a function of daily hours of computer gameplay, daily hours of social media use during high school, and other covariates. M2.1 contained the main effects of gameplay, social media use, and gender on CS career interest. M2.2 additionally specified the interaction effects between daily hours of computer gameplay and gender as well as daily hours of social media use and gender. M2.3 further specified a quadratic term for daily hours of computer gameplay; a quadratic term for social media use was found to be non-significant and was therefore omitted.

4. Results

4.1. Predicting computer science identity

In M1.1 (Table 2), we found that the main effect of computer game hours on CS identity was significant and positive ($\beta = 0.07$, se = 0.01, $p < .001$, effect size = 0.1 SD). By contrast, we found the main effect of social media hours to be significant and negative ($\beta = -0.05$, se = 0.01, $p < .001$, effect size = −0.05 SD). Furthermore, male students had a higher average CS identity than did female students by 0.22 SD units ($\beta = 0.34$, se = 0.01, $p < .001$). To compare the gender gap with the effects of gameplay or social media hours, we note that female students' CS identity was predicted to be the same as the male students' if female students played computer games 5 h more per day, or if female students spent 5 h less on social media, than did their male counterparts, after controlling for the other covariates.

In M1.2, we found that the quadratic effect of daily hours of computer gameplay was significant and negative ($\beta = -0.01$, se = 0.00, $p < .001$). The linear effect of daily hours of computer gameplay in M1.2 remained significant and positive ($\beta = 0.17$, se = 0.03, $p < .001$). In combination, this indicated that, at the lower end of computer game hours (< 6), the predicted CS identity increased as computer game hours increased. However, the slope gradually attenuated, and CS identity reached its ceiling at computer game hours = 6 (0.33 SD higher than the predicted value of CS identity when computer game hours = 0). In fact, there is minimal variation in the predicted CS identity between computer game hours 4 and 8 (the variation ranged between 0.006 to 0.03 SD). Therefore, we can consider this range a flat ceiling. This relationship is illustrated in Fig. 1 (the y-axis ranges between 1 and 4 to cover the range of +/- 1 SD around the sample mean). The interaction effect between game hour and gender was not statistically significant.

In Ml.3, we found that the quadratic effect of daily hours of social media use was significant and positive ($\beta = 0.02$, se = 0.01, $p < .01$). Taken together with the main effect of daily hours of social media in M1.3 ($\beta = -0.15$, se = 0.03, $p < .001$), this indicated, at the lower end of social media hours (<5), the predicted CS identity decreased as social media use increased. However, the decreasing slope gradually attenuated, and CS identity reached its floor at social media hours = 5 (0.24 SD lower than the predicted value of CS identity when social media hours = 0). After 5 h, the predicted CS identity started to increase, and the increased amount relative to social media hours = 5 was equal to 0.1 SD when hours of social media use was 8. According to a post-hoc test, the CS identity at the right-hand tail (hours = 8) was significantly higher than the CS identity at the minimum point of hours = 5 ($\beta = 0.26$, se = 0.09, $p < .01$), but was not significantly different from the CS identity at hours = 0 ($\beta = -0.07$, se = 0.10, $p = .48$). This relationship is illustrated in Fig. 2. The interaction effect between social media hours and gender was not statistically significant.

4.2. Predicting computer science career interest

Table 3 presents the results of the multinomial logistic models that predicted participants' CS career interest at the beginning of college. In M2.1, we see that the main effect of daily hours of computer gameplay was significant and negative for Medicine/Health ($\beta = -0.19$, se = 0.06, $p < .01$), Non-STEM ($\beta = -0.20$, se.= 0.03, $p < .01$), and Science/Engineering ($\beta = -0.15$, se = 0.02, $p < .001$) career interests, relative to a CS career interest. Reversing the reference group to Non-STEM and exponentiating the coefficients, we found that 1 h of computer gameplay was associated with a 22% increase in the odds of a CS career interest vis-à-vis a Non-STEM career interest. Furthermore, the main effect of gender was significant and negative for Medicine/Health ($\beta = -1.16$, se = 0.17, $p < .001$), Non-STEM ($\beta = -0.52$, se = 0.1, $p < .001$),

Table 1
Descriptive statistics for all variables used in the analysis.

	Male (N = 7214, 73%)		Female (N = 2659, 27%)	
	(Mean or%)	SE	(Mean or%)	SE
Average CS Identity (on a Likert scale from 1 to 6)	2.95	0.02	2.34	0.03
Daily Hours of Computer Gameplay	1.98	0.02	0.92	0.03
Daily Hours of Social Media Use	1.33	0.02	1.96	0.03
Daily Hours of Computer Use	3.66	0.03	3.58	0.04
Computer Related Activities Average	1.16	0.02	0.75	0.03
Highest Level of Education				
For Father/Male Guardian	2.51	0.02	2.62	0.03
For Mother/Female Guardian	2.46	0.01	2.56	0.02
Family's Interest in Computer Science				
CS in involved in parent's job	0.23	0.004	0.29	0.01
CS is a way for you to have a better career	0.37	0.01	0.36	0.01
CS was not an interest of my family	0.49	0.01	0.44	0.01
My family was able to help me in CS	0.08	0.003	0.1	0.01
Grade in Last HS English Class	3.54	0.01	3.78	0.01
Grade in PreCalc/Trig	3.51	0.01	3.67	0.02
CS Career	55%		34%	
Medicine/Health	2%		8%	
Non-STEM	16%		29%	
Science/Engineering	27%		29%	
Race				
Asian	22%		33%	
Black	8%		8%	
Hispanic	13%		12%	
White	53%		43%	
Other	3%		2%	

and Science/Engineering career interests (β= −0.29, se = 0.09, p < .01). The results indicated, for instance, that male students had 69% higher odds than female students of a CS career interest vis-à-vis a Non-STEM interest. By contrast, we found no significant main effects of daily hours of social media use for any of the career interests relative to a CS career interest.

In M2.2, we found the interaction effect of hours of social media use and gender to be significant and positive for Non-STEM and for Science/Engineering careers (Non-STEM, β = 0.12, se = 0.06, p < .05; Science/Engineering, β = 0.12, se = 0.06, p < .05), relative to a CS career interest. This indicates that male students had a 16% (1 − exp(0.03 + 0.12) = −0.16) decrease in the relative odds of a CS career interest over a Non-STEM career interest and a 4% (1 − exp(−0.08 + 0.12) = −0.04) decrease in the relative odds of a CS career interest over a Science/Engineering career interest for every additional hour of social media use. On the other hand, female students, for every additional hour of social media use, had only a 3% (1-exp(0.03) = −0.03) decrease in the relative odds of having a CS career interest over a Non-STEM career interest and a 8% (1 − exp(−0.08) = 0.08) increase in the relative odds of having a CS career interest over a Science/Engineering career interest. In other words, social media hours had a stronger negative effect for male students than for female students on a CS career interest relative to a Non-STEM career interest. Relative to a Science/Engineering career interest, social media hours had a negative effect on a CS career interest for male students, but a positive effect for female students. Translating the results to the probability scale (controlling other covariates at their means), as shown in Fig. 3 (left panel), the probability of a CS career interest increased from 29% at social hours = 0 to 35% at social hours = 8 for female students and decreased from 44% to 30% for male students.

In M2.2, we also found that the interaction effect of hours of computer gameplay and gender was significant and negative for Non-STEM careers (β = −0.17, se = 0.06, p < .01), relative to a CS career interest as the reference category. This indicated that male students had a 21% (1 − exp(−0.07–0.17) = 0.21) increase in the relative odds of a CS career interest against a Non-STEM career interest for every additional hour of computer gameplay. By contrast, female students had only a 7% (1 − exp(−0.07) = 0.07) increase in the relative odds of a CS career interest against a Non-STEM career interest for every additional hour of computer gameplay. In other words, the effect of computer game play duration on CS career interest was much stronger for male students than for female students. We checked if there was a quadratic effect for daily hours of social media use; however, it was not significant.

In M2.3, we examined both the linear and quadratic effects of daily hours of computer gameplay on different career interests. We found negative and significant linear effects for Non-STEM, Science/Engineering, and Medicine/Health career interests relative to a CS career interest (Non-STEM; β= −0.25, se = 0.08, p < .01; Science/Engineering; β = −0.33, se = 0.06, p < .001; Medicine/Health; β = −0.37, se = 0.15, p < .05). We also found positive and significant quadratic effects for Non-STEM and Science/Engineering career interests, relative to a CS career interest (Non-STEM; β = 0.03, se = 0.01, p < .01; Science/Engineering; β = 0.03, se = 0.01, p < .001). For Medicine/Health, there was no quadratic effect of computer gameplay hours. For Non-STEM and Science/Engineering career interests, combining the linear and quadratic effects indicated that interest in these two careers relative to a CS career interest would first decrease, then plateau, as computer gameplay increased. For Science/Engineering career interests, this plateau occurred when the duration of computer gameplay reached 5 h, and we found that the interaction effect between gender and computer gameplay was not significant. Similarly, the effect of computer gameplay plateaued at 4 h for Non-STEM career interests relative to CS career interests (at a probability of 21% for female students and 10% for male students; the difference between 4 and 8 h was 6% for female students and 3%

Table 2
Models predicting computer science identity.

	M1.1		M1.2		M1.3	
	β	s.e.	β	s.e.	β	s.e.
Intercept	1.89	0.17***	1.84	0.17***	1.96	0.17***
Daily Hours of Computer Gameplay	0.07	0.01***	0.17	0.03***	0.07	0.01***
Daily Hours of Computer Gameplay squared			−0.01	0.00***		
Daily Hours of Social Media Use	−0.05	0.01***	−0.05	0.01***	−0.15	0.03***
Daily Hours of Social Media Use squared					0.02	0.01**
Daily Hours of Computer Use	0.08	0.01***	0.07	0.01***	0.08	0.01***
Sum of Computer Related Activities	0.22	0.01***	0.22	0.01***	0.22	0.01***
Last English Grade in HS	0.05	0.04	0.05	0.04	0.05	0.04
Grade in Precalc/Trig	0.03	0.03	0.03	0.03	0.02	0.03
Highest Level of Education						
Mother	−0.01	0.02	−0.01	0.02	0.00	0.02
Father	−0.07	0.02***	−0.07	0.02***	−0.07	0.02***
Family’s Interest in Computer Science						
CS in involved in parent’s job	0.07	0.06	0.07	0.06	0.07	0.06
CS is a way for you to have a better career	0.43	0.05***	0.43	0.05***	0.43	0.05***
CS was not an interest of my family	−0.34	0.06***	−0.34	0.06***	−0.34	0.06***
My family was able to help me in CS	0.27	0.07***	0.27	0.07***	0.27	0.07***
Gender (male = 1, female = 0)	0.34	0.05***	0.31	0.05***	0.33	0.05***
Race						
Hispanic	0.04	0.06	0.05	0.06	0.04	0.06
Black	0.00	0.08	0.01	0.08	−0.01	0.08
Asian	−0.22	0.05***	−0.22	0.05***	−0.21	0.05...
Other	−0.19	0.12	−0.18	0.12	−0.19	0.12
R squared	0.21		0.21		0.21	

Daily hours of computer gameplay, social media use, and computer use are linearized.·
Notes:
*** $p < .001$,
** $p < .01$,$^{*}p < .05$, . $p = .05$; $N = 9873$.

for male students). Similar to M2.2, the interaction effect of hours of computer gameplay and gender was significant and negative for Non-STEM careers ($\beta = -0.17$, se = 0.06, $p < .01$). We converted the odds to the probabilities in CS career interest, while fixing all covariates at their means (Fig. 4). This yielded a maximum probability of a CS career interest of 42% for female students and 58% for male students at computer game hours around 5 to 6. For both genders, the difference in the probability of a CS career interest between 5 and 8 h was only 3%.

All the covariates previously mentioned in the methods section were controlled for in each of the models. The coefficients are included in Tables 2 and 3 for reference. However, because they were not the focus of the analysis, we do not further elaborate on their interpretation.

5. Discussion

5.1. Summary of results

To a varied degree, our findings support the notion that informal leisure computer activities cultivate a CS identity and CS career interest. Here is a summary of our answers to the research questions:

RQ1.1 (To what extent, at the beginning of college, is the duration of daily computer gameplay and social media use during the high school years associated with students’: (a) CS identity?; (b) CS career interests?): We found that

(1.1). up to approximately 4–5 h of daily use, computer gameplay is associated with an increased CS identity ($\beta = 0.17$, se = 0.03, $p < .001$) and an increased probability of a CS career interest, relative to other career interests (Non-STEM ($\beta = -0.20$, se.= 0.03, $p < .01$), Medicine/Health ($\beta = -0.19$, se = 0.06, $p < .01$), and Science/Engineering ($\beta = -0.15$, se = 0.02, $p < .001$)). For CS identity, the quadratic effect was significant and negative ($\beta = -0.01$, se = 0.00, $p < .001$) and in combination, this indicated that CS identity reached its ceiling at computer game hours = 6. For CS career interests, we found positive and significant quadratic effects for Non-STEM and Science/Engineering career interests, relative to a CS career interest (Non-STEM ($\beta = 0.03$, se = 0.01, $p < .01$), Science/Engineering ($\beta = 0.03$, se = 0.01, $p < .001$)). Combining the linear and quadratic effects indicated that interest in these two careers relative to a CS career interest would first decrease, then plateau, as computer gameplay increased.

(1.2). By contrast, up to 5 h of daily use, social media was significantly associated with a decreased CS identity ($\beta = -0.05$, se = 0.01, $p < .001$).

(1.3). However, after 5 h of daily social media use, there was an increase in CS identity ($\beta = 0.02$, se = 0.01, $p < .01$). Combining the linear and quadratic effects of daily hours of social media, this indicated, at the lower end of social media hours (<5), the predicted CS identity decreased as social media use increased. However, the decreasing slope gradually attenuated, and CS identity reached its floor at social media hours = 5. After 5 h, the predicted CS identity started to increase.

(1.4). In respect to CS career interests, we found no significant main effect of daily hours of social media use.

RQ1.2 (Does the association of the duration of daily computer gameplay and social media use during high school with CS identity or CS career interests differ between genders?): We found that

Table 3
Models predicting computer science career interest.

	M2.1						M2.2						M2.3					
	Med/Health		Non-STEM		Science/Engineering		Med/Health		Non-STEM		Science/Engineering		Med/Health		Non-STEM		Science/Engineering	
	β	S.E.	β	S.E.	β	S.E.	β	S.E.	β	S.E.	β	S.E.	β	S.E.	β	S.E.	β	S.E.
Intercept	−2.46	0.73***	−1.03	0.37**	−0.91	0.31**	−2.25	0.74**	−0.96	0.38*	−0.72	0.33*	−2.35	0.74**	−1.04	0.38**	−0.81	0.32*
Daily hours of computer gameplay	−0.19	0.06**	−0.20	0.03**	−0.15	0.02***	−0.24	0.11*	−0.07	0.05	−0.16	0.06**	−0.37	0.15*	−0.25	0.08**	−0.33	0.06***
Daily hours of social media use	0.06	0.05	0.11	0.03	0.00	0.03	−0.01	0.07	0.03	0.04	−0.08	0.05	0.06	0.05	0.10	0.03**	−0.01	0.03
Daily hours of computer use	−0.07	0.05	−0.02	0.03	−0.07	0.02**	−0.07	0.05	−0.02	0.03	−0.07	0.02**	−0.06	0.05	−0.01	0.03	−0.06	0.02**
Sum of Computer-Related Activities	−0.38	0.07***	−0.39	0.04***	−0.2	0.02***	−0.38	0.07...	−0.4	0.04***	−0.2	0.02***	−0.38	0.07***	−0.39	0.04***	−0.20	0.02***
Last English grade in HS	0.34	0.17*	0.23	0.08**	0.06	0.07	0.34	0.17*	0.22	0.08**	0.05	0.07	0.34	0.17*	0.22	0.09**	0.05	0.07
Precalc/Trig Grade	0.06	0.12	−0.06	0.06	0.35	0.06***	0.06	0.12	−0.05	0.06	0.35	0.06***	0.06	0.12	−0.06	0.06	0.35	0.06***
Highest level of education															0.07			
Mother	−0.04	0.09	0.07	0.05	0.07	0.04	−0.05	0.09	0.07	0.05	0.07	0.04	−0.04	0.09		0.05	0.07	0.04
Father	0.26	0.09**	0.15	0.05***	0.09	0.04*	0.26	0.09**	0.16	0.05***	0.09	0.04*	0.26	0.09**	0.15	0.05***	0.09	0.04*
Level of CS involvement in parent's job	−0.49	0.25*	0.04	0.13	−0.17	0.11	−0.49	0.25*	0.04	0.13	−0.18	0.11	−0.49	0.25*	0.04	0.13	−0.17	0.11
CS is a way for you to have a better career	−1.53	0.23***	−0.72	0.11***	−0.76	0.09***	−1.53	0.23***	−0.72	0.11***	−0.76	0.09***	−1.53	0.23***	−0.71	0.11***	−0.76	0.09***
CS was not an interest of my family	−0.55	0.25*	0.23	0.13*	0.04	0.11	−0.56	0.25*	0.24	0.13	0.04	0.11	−0.56	0.25.	0.24	0.13	0.03	0.11
Family was able to help in CS	−0.49	0.33	−0.11	0.16	−0.01	0.13	−0.49	0.33	−0.11	0.16	−0.01	0.13	−0.49	0.33	−0.11	0.16	−0.01	0.13
Gender(male = 1, female = 0)	−1.16	0.17***	−0.52	0.1***	−0.29	0.09**	−1.46	0.27***	−0.58	0.16***	−0.5	0.14***	−1.18	0.21***	−0.31	0.12**	−0.21	0.11*
Race																		
Hispanic	0.39	0.26	−0.11	0.14	−0.20	0.12	0.38	0.26	−0.12	0.14	−0.21	0.12	0.38	0.26	−0.12	0.14	−0.21	0.12
Black	1.14	0.27***	−0.01	0.18	−0.32	0.16*	1.13	0.27***	−0.02	0.18	−0.33	0.16*	1.13	0.27***	−0.03	0.18	−0.34	0.16*
Asian	0.82	0.19***	0.13	0.1	−0.24	0.09**	0.81	0.19***	0.11	0.10	−0.25	0.09	0.83	0.19***	0.13	0.1	−0.23	0.09*
Other	0.06	0.61	−0.20	0.29	0.15	0.2	0.06	0.61	−0.23	0.29	0.15	0.2	0.05	0.61	−0.24	0.29	0.13	0.21
Gender* Computer Game Hours							0.09	0.12	−0.17	0.06**	0.01	0.06	0.09	0.13	−0.17	0.06**	−0.01	0.06
Gender* Social Media Hours							0.13	0.10	0.12	0.06*	0.12	0.06*	0.11	0.10	0.10	0.05~	0.10	0.05~
Daily Hours of Computer Gameplay squared													0.02	0.02	0.03	0.01**	0.03	0.01***
pseudo-R squared	0.09						0.09						0.10					

N = 9873 Daily hours of computer gameplay, social media use, and computer use are linearized.
Notes:
*** $p < .001$,
** $p < .01$,
* $p < .05$, . $p = .05$.

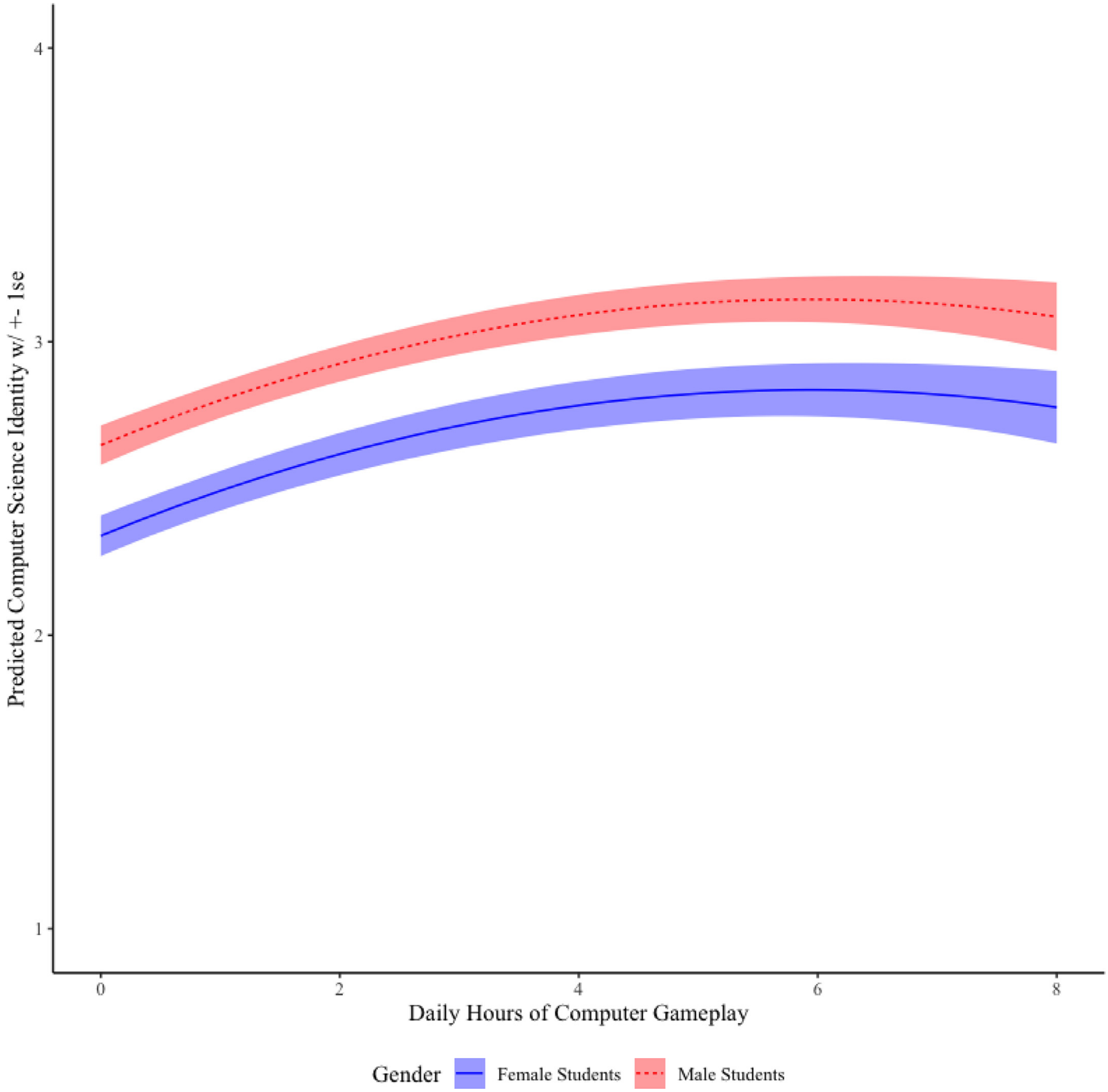

Fig. 1. Daily hours of computer gameplay predicting CS Identity (with +/- 1 se confidence interval), according to Model 1.2. All covariates were fixed at their means.

(2.1). No significant interaction existed between gender and social media use or computer gameplay in respect to CS identity.

(2.2). However, there were significant interaction effects between gender and computer gameplay for a Non-STEM career interest ($\beta = -0.17$, se = 0.06, $p < .01$), and between gender and social media use for Non-STEM ($\beta = 0.12$, se = 0.06, $p < .05$) and Science/Engineering ($\beta = 0.12$, se = 0.06, $p < .05$) career interests, relative to CS career interests.

(2.2.1). Daily hours of computer gameplay were associated with an increase in the probability of CS career interest relative to a Non-STEM career interest for both genders ($\beta = -0.17$, se = 0.06, $p < .01$), but the increase was greater for male students (21%) than for female students (7%).

(2.2.2). Hours of daily social media use were associated with a decrease in the probability of CS career interest relative to a Science/Engineering career interest ($\beta = 0.12$, se = 0.06, $p < .05$) for male students (4%), but an increase for female students (8%).

(2.2.3). Comparatively, daily hours of social media use were associated with a decrease in the probability of CS career interest relative to a Non-STEM career interest for both genders ($\beta = 0.12$, se = 0.06, $p < .05$); however, the decrease was greater for male students (16%) in comparison to female students (3%).

5.2. *Computer gameplay*

Extant research found that computer gameplay can boost computer literacy and knowledge by providing an authentic environment for

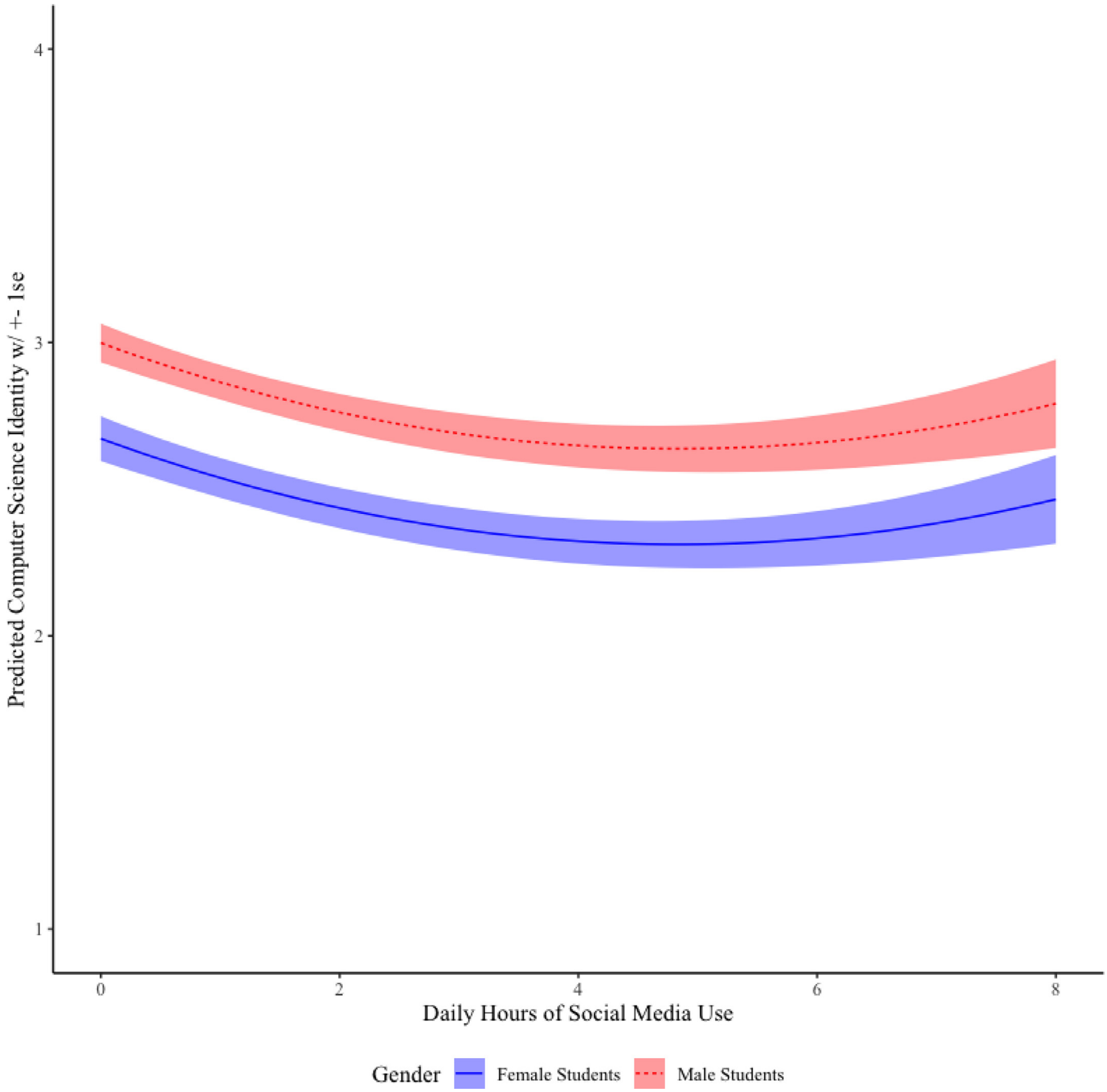

Fig. 2. Daily hours of social media use predicting CS identity (with +/- 1 se confidence interval), according to Model 1.3. All covariates were fixed at their means.

learning ([2]; Sevin & Decamp, 2015). Consistent play not only exposes users to computing, but also promotes confidence in users, thus solidifying a CS identity (Sevin & Decamp, 2015). From an EVT perspective, we can postulate that students who have greater experience with gameplay, will cultivate self-efficacy along with a positive perspective on their computer-related task ability, nurturing an expectancy of success. This can also lead to students' perception that CS is indeed relevant to their daily activities. However, prior research has also shown that increased gameplay does not necessarily equate to increased cognitive processing or pro-academic behaviors [42]. Our analysis with the quadratic function of computer gameplay duration gave partial support to both arguments: within the range from 0 to 4 or 5 h of computer gameplay, there was a significant and positive association between gameplay duration and CS identity, but this effect disappeared beyond 5 h of computer gameplay.

Playing for more than 5 h per day might lead to mismanagement of time through excessive gameplay [38]. Before entering this range, students' might have already reached their peak confidence in computing ability. Or perhaps the excessive hours devoted to gaming might have offset the students' interest in, and foreclosed opportunities of, CS careers. Further, not playing computer games (game hours = 0) may distance students from leisure time computer use often done through gaming [2], hindering any potential added benefit towards the development of a CS identity or CS career interests.

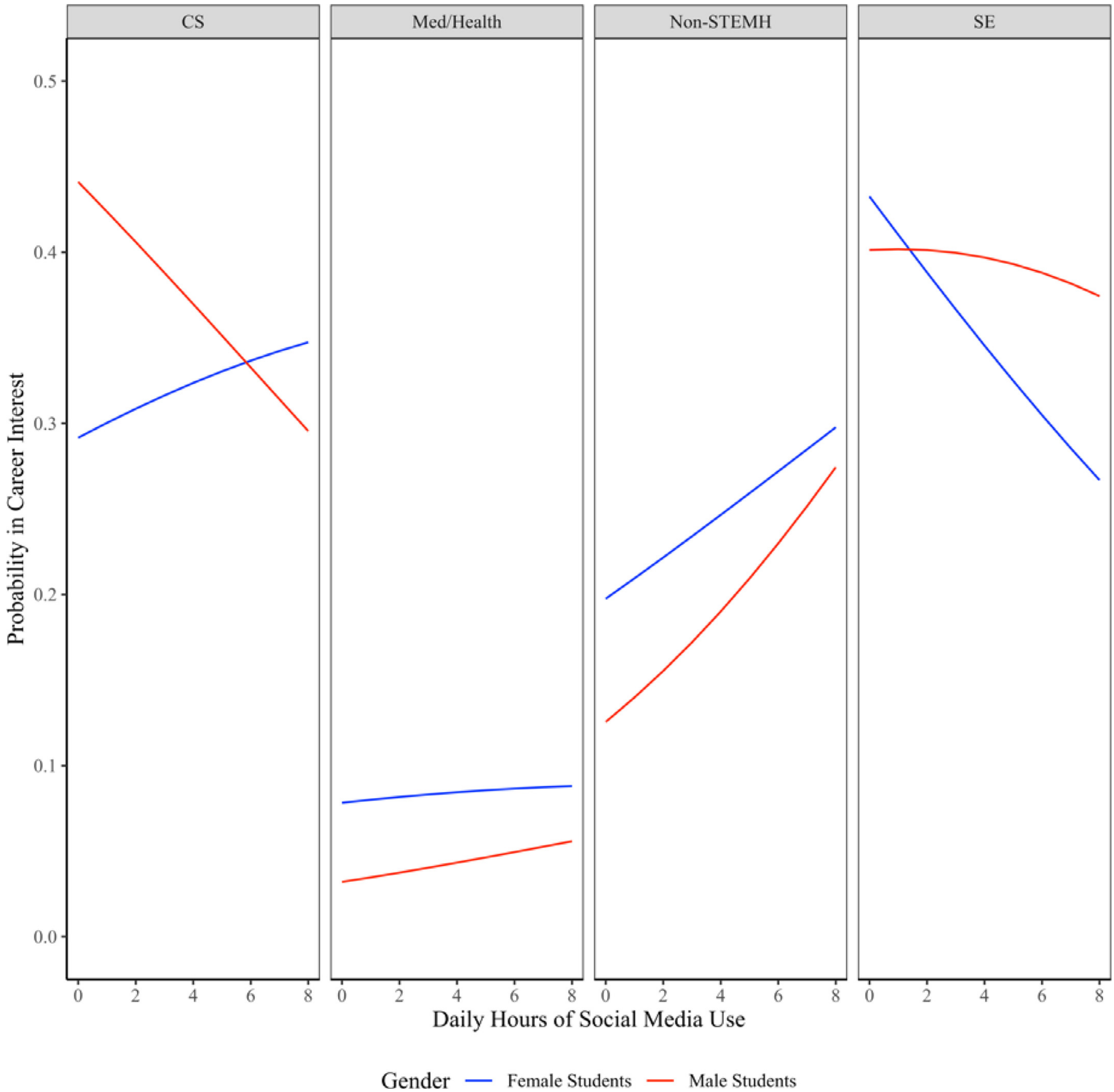

Fig. 3. Daily hours of social media use predicting career interests, with a gender interaction, according to Model 2.2.

5.3. Social media

Our findings showed that the duration of daily social media use, opposite to the effect of computer gameplay, had a negative association with CS identity at the lower end of social media use (<5 h). Moreover, the hours of social media use did not have an effect on CS career interest relative to Medicine/Health, Non-STEM, and Science/Engineering career interests. This may be due to the underlying environment of social media, which is more communication-based rather than a place for problem-solving. Prior research has shown social media use to be associated with practical computer knowledge, yet no evidence of a relationship with theoretical computer knowledge that is necessary for CS has been found [2]. It also appears possible that avid social media users, although tech savvy enough to navigate the social media platforms, perceive computing only as a tool rather than as a career goal. They might have set their interests on other (perhaps more immediately social) careers.

Upon analysis of the quadratic effect of social media use on CS identity, we found that the predicted CS identity reached a low point after 5 h of social media use per day. Between 5 to 8 h per day, CS identity increased with social media use. To make sense of this interesting finding, one might speculate that students who were consuming social media at those high rates might be more likely than casual users to identify as creators rather than consumers of media [30]. Prior research has shown that an atmosphere conducive for engagement can motivate students to be producers rather than consumers of a platform [45]. When students are highly invested in their social media account, they might want to produce or edit media to gain more traction. They might even see social

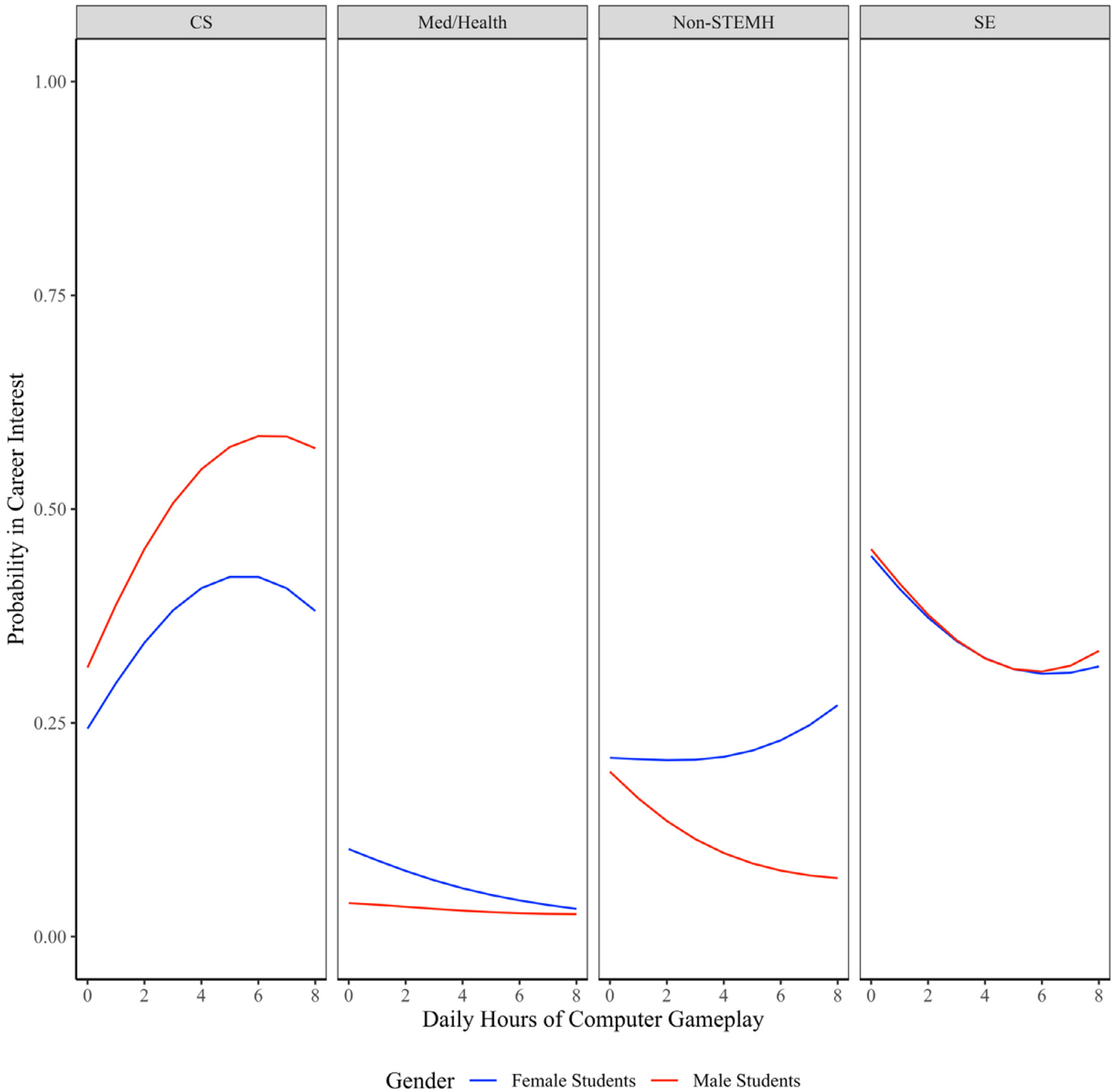

Fig. 4. Daily hours of computer gameplay predicting career interests, with a gender interaction and quadratic of computer gameplay, according to Model 2.3.

media as a venue for entrepreneurship. Such bolstered technical skills and perceived relevance of CS in daily lives might foster a stronger sense of CS identity, according to the EVT framework [30,43,48,92]. To test this speculative explanation, future work should tease out the effects of media use duration and media content.

5.4. Gender

5.4.1. Computer science identity

We found a significant main effect of gender on CS identity, but no significant interaction effects between gender and social media use or computer gameplay on CS identity. Female students were predicted to have the same CS identity as male students if they played 5 more hours of computer games daily or spent 5 h less on social media than did their male counterparts. Of course, we do not advocate forcing female students to play 5 h of computer games or cut 5 h of social media use per day. We use this comparison between effects only to illustrate the huge gender gap.

The common explanation of the gender gap in CS identity has been gendered daily experiences (e.g., toys, media exposures) that cultivate gendered learning or career expectations. These daily experiences often contribute to the female-unfriendly stereotypes connected with computing tasks and professions [63,64,89,94]. These stereotypes may be related to, or rooted in, inequities in opportunities [89], such as differences in leisure activities and disparities in technology access [5], and a lack of effort in promoting inclusivity for young girls in CS and the computer game industry. Yet, according to our analysis, the gender gap remained after controlling for computer gameplay and social media use, suggesting that these leisure interactions with computing, often considered the source of the stereotypes, could not fully explain this gap. A variety of experiences and stereotypes [5,63,89] outside of hands-on computing experiences, such as communal goal affordance [11,94] or gender representation [65], may factor into this gender gap.

5.4.2. Computer science career interest

We found an interaction effect between gender and duration of daily computer gameplay, as well as an interaction effect between gender and duration of social media use, on having a CS career interest. Computer gameplay was positively associated with CS career interest for both genders, but this association was stronger for male students than for female students. One possible explanation was that most of the computer games (especially the highly popular and time-consuming games) contain main figures, storylines, or missions marketed toward male players, focusing on masculine traits, such as aggression [84]. For male players, it may be easier to find playmates or teammates whereas female players may be marginalized. Male players might be more likely than female players to perceive that the programmers and game developers behind the games had developed the game for them. Such a male-dominant culture in gaming might be perceived to be more welcoming to male players than to female players. Female gamers, even heavy gamers, might need to overcome these cultural barriers to take an interest in the profession behind the game.

Furthermore, additional hours of social media use were shown to be associated with a decrease in CS career interest for male students and an increase for female students. This interaction effect was very interesting, but we did not have data to provide a definite explanation of it. Our speculative explanation was that female students with heavy social media use may see the potential of having a career in computing to engage in and to promote pro-social interactions. Male students with heavy social media use, on the contrary, appear not interested in combining a career in CS with social interests. They might have already decided that they wanted to have a socially focused career, which they would not believe a CS profession could provide.

6. Conclusion & implications

Our paper has key implications for the influence of computer gameplay and social media consumption on CS identity and CS career interests. This study, to our knowledge, is unique in using a nationally representative sample of U.S. college students taking introductory CS classes to examine the influence of the duration of computer gameplay and social media use during high school on CS identity and CS career interests at the beginning of college, and whether the association differed between male and female students. Our study calls for greater implementation and integration of informal activities (i.e., computer gameplay, social media) into daily practice in school and out-of-school contexts. Further investigation should delve into how the programmatic integration of computer gameplay and social media use can be beneficial and appeal to the CS identity development and career interest of both female and male students. Lastly, our study calls for educational technology research to include social media consumption when using EVT as a framework to investigate student motivations in pursuing CS. The results of this study suggest platforms like social media may offer opportunities for individuals to succeed in personally relevant tasks that can promote behaviors that are associated with developing interests and identities in CS [23,40,49,68,90,91].

6.1. Computer gameplay

Stakeholders should not solely rely on encouraging leisure time computer consumption for the development of a CS identity, nor should they encourage excessive gaming hours. Nonetheless, our results suggest that stakeholders should encourage school districts, educators, and parents to incorporate computer games in curriculum and leisure activities at a moderate duration, along with other informal and formal activities that have proven to increase CS interest as well as to reduce the gender gap. Though the effect of gameplay on CS career interest is weaker for female students, there is a potential to reduce barriers to entry in CS for female students, especially if such a focus is programmatically incorporated. A strategy would be that the computer gaming industry incorporates more social and community elements in their games, which may then help bring more female adolescents into gaming at a younger age. Such different computer games may also provide beneficial prosocial behavioral outcomes for students who may already be prone to aggressive behavioral tendencies from excessive gaming.

6.2. Social media use

Social media offer a platform for individuality and community-building [88], providing an outlet for social behavior. If the goal is to avoid its negative effect on CS identity and augment its positive effect on CS career interest for female users, stakeholders should consider approaches to advance skills in media creation, editing, promotion and storytelling, and to highlight the contribution of CS professionals in promoting a more social and pro-social environment [86].

7. Limitations

First, the survey was administered in 2014. Given the rapid increase of social media platforms and computer games and the growing presence of adolescents on these technologies, the duration of social media use and computer gameplay may be considerably higher. Gaming and social media have become more user-centric and accessible over recent years, so the effects we observe in this paper are anticipated to be stronger. To our knowledge this is the only dataset of this size since then and can serve as a baseline for future work.

Second, this correlational study cannot prove any causal relationships. The term “effect” is used to denote statistical significance of an association, while controlling for all other covariates in the regression models.

Third, the study sample (students in introductory college CS classes) represents a restricted range of CS interest and affinity. College students who do not take introductory CS courses and high school students who do not attend college at all are not considered. Nonetheless, there has been substantial variability in this sample. For instance, only 55% of the male students and an even lower percentage of the female students (33%) intended a CS career. This may be because an introductory CS course is recommended or required in many other STEM majors and even some Non-STEM majors.

Fourth, the survey administered was not inclusive of all gender identifications. Survey participants were only provided the option of choosing male or female as their gender identity, thereby potentially limiting them in presenting their authentic self. This may have led to potential inaccuracies in both the main and interaction effects of gender analyzed in the regression models.

Fifth, whereas the main predictors were continuous time variables (duration of daily computer gameplay and duration of daily social media use), we do not have insights into whether the students played a variety of games and or used a variety of social networking sites or if they stuck to 1–2 games and/or social networking sites. Prior studies have shown evidence of self-efficacy and computer interest through game variety [78], limiting our interpretation of the duration of gameplay alone. Similarly, there is a dearth of literature about the use of multiple social networking platforms and its relationship to CS identity and career choice, which limits our interpretation of the effect of the duration of social media use.

Sixth, we did not know the specific games and social media activities that the students engaged in. Hence, we cannot examine the mechanism of how they specifically might influence CS identity. Moreover, the gaming and social media industry has been everchanging in the past 7 years.

Future research should collect more nuanced information, such as the genre of social media and or games and the type of engagement the student partakes in [38]. Future work should also adopt a dynamic developmental perspective to understand how leisure-time digital activities interact with computing identity in a longitudinal research design.

Seventh, our variables of interest (duration of daily computer gameplay and duration of daily social media use) were based on students' self-reports, which introduces potential inaccuracies. Future research that uses observational techniques may constitute a useful complement.

Lastly, career interests at the beginning of college do not necessarily indicate career interest and or choices at the end of college. Our outcome variable, CS career interest, was comprised of responses from students who were in enrolled in an introductory CS course but had not gone through the semester or their remaining coursework. We remain cautious in our interpretation that increased gameplay will help dismantle barriers to CS for female students as well as further increase CS career interest for male students. There is the possibility that university experiences may demotivate female and male students alike from moving toward a CS career, or that other, unrelated, coursework may stimulate interest in different careers.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.teler.2022.100040.

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