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Video gaming and digital competence among elementary school students

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ABSTRACT

Engagement with video games can potentially advance student digital competence however, there is a digital skills gap by the time young people progress into adolescence. This current research explores how elementary school students' digital self-efficacy might relate to experiences in video game environments to influence perceptions of digital competence. We examine the differential impact of sex, self-efficacy, and socioeconomic status (SES) on 7–10-year-old students' (*N* = 613) perceptions of video gaming and their digital skills. Analysis revealed the unexpected finding that SES was inversely related to enjoyment for gaming and digital technology, with students in the lower-SES category responding more positively compared to students in higher SES categories. As expected, boys self-reported digital skills higher than girls across all SES categories. We argue for the use of gaming pedagogies to support learning in classrooms that accounts for nuances in students' digital self-efficacy moderated by gender and SES.

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Video games; digital skills; gender; disadvantage; technology

Introduction

Engagement with video games can potentially advance young people's digital competence (Höyng 2022), however, there is a digital skills gap by the time young people progress into adolescence (Ren, Zhu, and Yang 2022; Wong and Kemp 2018). While research is increasing in relation to adolescence digital skills (e.g., Gnambs 2021; Gunbatar and Karalar 2018; Ren, Zhu, and Yang 2022; Wong and Kemp 2018), there is a gap in studies related to younger children and the way demographic variables influence digital competence. To facilitate successful digital pedagogies for learning, educators not only require personal digital competence for technology integration but also an evidence-informed understanding of how student digital competence is mediated by factors that interplay with personal interest, enjoyment, and self-efficacy with technology. This current research explores how elementary school students' digital self-efficacy relates to experiences in video game environments, and how factors such as gender and socioeconomic status (SES) may influence students' perceptions of digital competence. This exploration is critical now with the escalation of digital technologies in education and the need to understand how gender and SES potentially impact differentiated digital experiences (Lin and Johnson 2021; Ren, Zhu, and Yang 2022; Selwyn 2012; Scholes, Mills, and Wallace 2021).

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To address the gap in the research related to younger children, this study focuses on 7–10-year-old elementary school students to ask one overarching question: *In what ways does the differential impact of sex and SES interplay with students' digital self-efficacy and their potential engagement with digital pedagogies?* Answering this question is key to informing educators' pedagogical practices as they support students with diverse digital competence. Previous research has shown that there is a significant relationship between self-efficacy and achievement in many domains, yet the link between individual's self-efficacy in video gaming and one's associated beliefs has not been explored (Gegenfurtner, Quesada-Pallares, and Knogler 2014).

This article begins by reviewing literature related to the triad of influences that previous studies identify as salient (sex, self-efficacy, and SES) to understand student perceptions in relation to digital technologies, including video games. We then propose two hypotheses based on the literature to answer the research question noted above. Then, the methods section details the survey (n = 614) of students aged between 7 and 10 years of age (n = 614) from 21 elementary schools and analysis of the data. In the final sections we highlight the findings and discuss implication for practice.

Literature review

Recent years, especially during the pandemic, have seen the rapid pivot of education toward digital technologies to continue daily life, rendering digital technology skills vital for societal participation (OECD 2020). While the role of digital technologies in a global knowledge economy has been growing in pre-eminence for over three decades (Mills, Unsworth, and Scholes 2022a), few can deny that almost all levels of schooling now require reliable access and use of digital technology.

Within these global shifts toward the digitalization of education, video games are rapidly being integrated into pedagogical approaches in educational contexts as they impact positively on student engagement, motivation, and learning (Höyng 2022; Mills, Unsworth, and Scholes 2022a; Picton and Clark 2021). Research has shown the value of including pleasurable or playful games, where learners are intrinsically motivated to engage in affinity groups with those who share their gaming identities (Dezuanni 2018; Gee 2005; Scholes, Mills, and Wallace 2021). Such involvement in gaming could lead to greater enjoyment for such experiences and digital skill development (Laakso, Korhonen, and Hakkarainen 2021; Wong and Kemp 2018). In recent years, the emphasis has turned to validating digital out-of-school practices in their own right and determining relationships with academic achievements for specific games and learning outcomes. Such trends are often considered in the broader context of differences among various social groups characterized by gender (Beavis, Muspratt, and Thompson 2015), age (OECD 2010), geography (DiMartino and Schultz 2020), ethnicity (Warschauer and Tate 2018), and SES (Collins et al. 2016). These variables are often considered in isolation. In this study we focus on the influence of gender (identified as self-reported sex) and SES on young student self-efficacy with digital technologies including video gaming – which is increasingly recognized as a valuable pedagogical tool in education (Höyng 2022).

Triadic influences on digital technologies and gaming: SES, sex, and self-efficacy

As previously noted, the present study seeks to explore how several interrelated variables shape the perceptions of young students in relation to digital technologies. The three key variables we explore are SES, student self-identified sex, and their self-reported self-efficacy. Because these variables remain the primary focus of this study on digital technologies and gaming, we refer to them collectively as a 'triad of influences'. We now summarize some of the background literature on each of these variables in relation to digital technologies and gaming.

Socioeconomic (SES) profile and technology in schools

SES plays an important role in student access to and engagement with digital technologies, including video games, e-readers, and computers (Ren, Zhu, and Yang 2022). Aesaert and van Braak (2015), for instance, found that SES, particularly maternal education level, is positively associated with both technical ICT skills and higher-order competencies, such as searching for and appropriately applying information from the internet. It is important to understand the role of SES on student experience as digital pedagogies have become increasingly important, perhaps even vital, in schooling environments affected by the global COVID-19 pandemic, where the risk of transmitting the virus in face-to-face teaching contexts has led schools with sufficient resources to become increasingly reliant on online modes of learning; while schools that lack such resources have been forced into temporary and even sustained closures (OECD 2020).

The importance of the relationship between home technology resources, SES, and educational outcomes is further demonstrated by the OECD's attempts to measure wealth and home possessions as key influences on success in the Program for International Student Assessment (PISA). Among the items used within a standardized questionnaire, students in the PISA were asked to report on whether and to what extent they had access to computers for school work, educational software, internet, cell phones with internet, tablet computers, and e-book readers (OECD 2020). Results in Australian schools found the SES of students, inclusive of digital technology resources, had a significant influence on performance in reading, mathematics, and science (Thomson et al. 2019). For example, Australian students in the highest SES quartile performed one proficiency level, equivalent to almost three years of schooling, above Australian students in the lowest quartile (Thomson et al. 2019).

SES contours then create issues of access to digital technology resources including access to infrastructures, devices, and connectivity which, in turn, undermine the development of digital skills as the digital divide between the rich and poor widens across the globe (Warschauer and Tate 2018). With these disparities in mind, educators cannot make assumptions about their students' level of digital competence or their self-efficacy in digital spaces.

Sex and technology in schools

In addition to the socio-economic divide in access to digital experiences, previous research also highlights how gender stereotypes about interests start early and may limit student engagement in digital spaces and their long-term trajectories, particularly in fields such as computer science (Master, Meltzoff, and Cheryan 2021). It may well be that boys' increased interest and enjoyment for gaming puts them ahead of girls in terms of digital skills and encourage their long-term participation in related experiences (Drabowicz 2014; Wong and Kemp 2018). Previous research illustrates that boys tend to exhibit superior gaming skills to girls correlated with more time spent gaming compared to girls (Øystein and Silseth 2019). Boys also tend to place a higher premium than girls on engaging in collaborative play within gaming peer groups as an important part of their socialization and identity formation, and indeed, can provide peer currency (Pelletier 2008). Many young boys identify as 'gamers' within a culture stereotypically considered a male affinity space that can be unwelcoming for girls (Fisher and Jenson 2017; Garcia 2017) with implications for boys' beliefs, and digital skill development (Drabowicz 2014). Societal stereotypes that girls are less interested and skilled than boys may potentially limiting girls' pursuit in male-dominant fields (Master, Meltzoff, and Cheryan 2021).

While the stereotypical perception that video gaming spaces are the sole domain of young males still persists, games are being developed to overcome essentialist notions and assumptions about women (Richard and Gray 2018). Representation of women in the gaming world may be shifting due to growing markets that are not targeting the stereotypical white, male gamer and may account for the increase in women who play games – for instance, female players in the United States increased to 45% in 2021 (Clement 2021). We do not know, however, how contemporary young boys and girls rate their level of enjoyment or frequency of game play, nor their perceptions of their level of digital skills.

Self-efficacy of boys and girls and digital technology

A key explanation as to why more boys tend to more frequently engage in gaming and use of digital technologies compared to girls relates to their self-efficacy toward digital technology use. Such beliefs have been shown to have causal links to the increased frequency of game play and technology use in both recreational and educational settings (Tømte and Hatlevik 2011). The notion of self-efficacy is typically defined as one's beliefs about their ability to influence and have agency over important life events and outcomes (Bandura 1977).

In schooling contexts, self-efficacy plays an essential role in catalyzing and maintaining motivations to engage in activities that may impact important learning outcomes in specific domains, such as mathematics, sports, and use of technology (Zimmerman 2000). For example, if a student believes they can achieve a desired learning goal to complete a video game or write basic code, they may be more likely to undertake these kinds of activities; the reverse also holds in that students who judge themselves as inefficacious at such tasks are less likely to undertake activities in this area, further compounding their low levels of self-efficacy. This cycle resembles what Bandura (1977) described as a 'selection process', whereby personal efficacy beliefs influence important choices about the range of activities with which one engages or avoids. These factors may explain, in part, why self-efficacy shares a significant association with performance in games-based learning environments (Nietfeld 2020).

Importantly, self-efficacy is not always reflective of reality. Students who adopt beliefs about their abilities based on potentially harmful stereotypes and gender norms may find themselves underachieving in domains where self-efficacy is low relative to their true potential. For example, lower perceptions of self-efficacy and computer aptitude have been used to explain girls' lower levels of enjoyment for using computers and engagement in ICT (Wong and Kemp 2018). Over-efficacious beliefs, sometimes manifesting as 'overconfidence', can also have harmful consequences to student learning outcomes in this domain, where gains in self-efficacy may exceed gains in actual gaming performance (Nietfeld 2020).

The question of how we understand student gamer demographics, and gaming and digital technology-related behaviors, is vitally important due to the rapidly changing digital landscape and implications for digital pedagogies and learning. In this study, we specifically hope to address this question by exploring how this triad of influences relate to digital technology and gaming through the responses of children in grades 3–5 (ages 7–10 years).

Hypothesis based on the literature

To answer our research question, we formulated two hypotheses based on the literature reviewed above. Of interest in our study is the impact of SES on students' enjoyment of digital technologies and gaming. First, we hypothesized that students from higher SES would have more ready access to technology and therefore:

> Lower, medium, and higher SES will differentially affect students' self-reported enjoyment of digital technology and gaming, with the expectation that enjoyment of digital technology and gaming will be positively related to SES.

In addition to the impact of SES on student experiences that needs to be considered in pedagogical approaches with young people, how boys and girls may interact with technology in differential ways also needs to be examined. We wanted to explore the differential impact of SES on boys' and girls' self-rated digital skills, which we interpret in the broader context of domain-specific self-efficacy. Given the tendency for boys to exhibit higher levels of confidence and self-efficacy in relation to digital technologies and gaming (Scholes, Mills, and Wallace 2021; Whitton 2014.) we wanted to explore, if, and to what extent, these self-ratings differ between young boys and girls. We approach this aspect of our study with the expectation that boys will typically rate themselves higher than girls

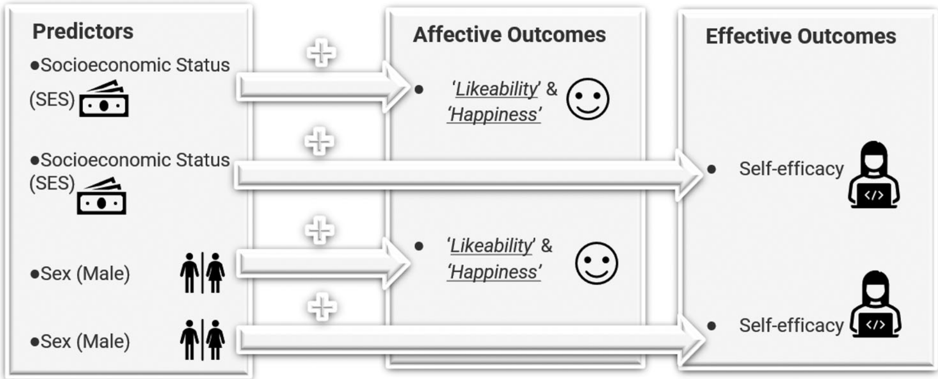

Figure 1. Summary of hypotheses.

when it comes to their self-rated digital and gaming skills and will do so across all dimensions of SES. Therefore, we propose a second hypothesis that:

> Lower, medium, and higher SES will differentially effect students' self-rated digital skills, with the expectation that self-rated digital skills will be positively related to sex (male) and SES.

Our two hypotheses, therefore, explore the relationship between a triad of influencing variables including SES, self-efficacy, and gender, and the role they play in shaping attitudes, beliefs, and behaviors surrounding digital technologies and video gaming (see Figure 1).

Little is known about how this triad combines to influence digital competence with such understanding essential for elementary teachers wanting to support younger students through digital pedagogies.

Materials and methods

Research model and procedure

This article builds on an Australian Research Council study (DE170100990) that involved a survey instrument – *School Activities Attitude Questionnaire (SAAQ)* – previously developed and validated by the first author that asked elementary students about their engagement in a range of school-related activities (see Scholes 2019). The present study extends this inquiry using a quantitative approach, including null-hypothesis significance testing (NHST), that draws upon student responses to the SAAQ to test the two hypotheses noted above against the 'null hypothesis' using a single-test alpha rate (false positive tolerance) of $p < .05$. This approach provides a basis for statistical inference in the context of exploratory research as long as the familywise error rate, which is defined by the long-run rate of false positive findings across multiple statistical tests, is adjusted accordingly (Rubin 2017) – which we do using the Bonferroni method. Although, we implore readers to consider our findings as generating further hypotheses to be independently tested and replicated, rather than as confirmatory in any way.

The SAAQ survey was administered as a paper and pencil questionnaire to a cross sectional cohort of students. The survey was completed by participants in approximately 15 minutes and participants were offered reading assistance by the researchers upon request.

Research context and sample

Participants included 613 (female = 304) students attending elementary school years 3, 4, and 5 (7–10-year-olds) from 21 elementary schools, including state ($n = 17$) and independent schools ($n = 4$), in Australia. Schools were randomly selected based on the Index of Community Socio-Educational Advantage (ICSEA). After ethical clearance from the relevant university and education departments, school principals were approached to consent to students participating in the study. Following principal approval, we obtained informed consent from teachers and the students in their classes. A maximum variation, purposeful sampling strategy was used to document responses in diverse sites (Creswell and Poth 2018). We deliberately included schools representing different populations (inner city, metropolitan, regional) within different education systems (faith based, government, independent). Additionally, we recruited participants until we had an acceptable sex balance and some representation of ethnic diversity – children from a variety of cultural and ethnic backgrounds. All children in year four, five, and six in the consenting schools were then invited to participate in the survey through their classroom teacher, with approximately 50% of students returning informed consent.

Instrument

The study draws on elementary school student responses to dimensions of the SAAQ (Scholes 2019). Perceptual data were obtained through a questionnaire comprising self-report items with differing scale referents according to the type of item. We explore survey responses combined from the aggregation of data collected . For example, items related to students' self-reported enjoyment of video games in a broad sense on a 3-point Likert scale (options of like a lot, like a little, don't like) and 'How do you feel when … ' before branching off into a specific item such as 'Using a computer' (options of happy, alright, unhappy). A three-point Likert scale was used for these items with an understanding that younger children may not have the cognitive ability to make a relevant five-point differentiation, and this was validated as a reliable instrument for this age group (Scholes 2019).

Students were also asked to self-report their frequency of using digital devices (iPads, computers, gaming consoles, smart phones and so on) on a five-point scale that ranged from (i) hardly ever, (ii) a few times a fortnight, (iii) once per week, (iv) a few times a week, or (v) every day. We also recorded student's perceived level of digital skills on a five-point scale that ranged from (i) poor; (ii) average; (iii) good; (iv) very good; or, (v) excellent. These items used a five-point scales as they were deemed less cognitively demanding. Finally, SES information was collected about the ICSEA value obtained from the Australian Curriculum, Assessment and Reporting Authority (ACARA) website was also recorded for each school.

Analysis procedures

This study comprised three main variables of interest: (1) Sex (as self-identified), (2) Socioeconomic Status (SES), and (3) Attitudes and self-efficacy beliefs about digital technology and gaming. We operationalized sex according to whether students self-identified as either 'boys' or 'girls' with no students identifying as 'other' on the survey. SES was operationalized at the school-level using the ICSEA index of educational advantage between Australian schools (see https://www.myschool.edu.au/media/1820/guide-to-understanding-icsea-values.pdf) where students attend schools in their local area. The ICSEA is formulated on the basis of 'parent data'; this pertains to parental occupation, parental education, and parental non-school education obtained through student enrollment records. Value anchor around a median score of 1000 (SD = 100) and range from approximately 500 (extremely disadvantaged student backgrounds) to 1300 (extremely advantaged student backgrounds). In the present study, we use the ICSEA score as a proxy for SES, and further operationalize this variable according to which third they belong to (Upper, Middle, Lower-SES) in relation to their within-sample rank-order SES distribution. The final variables of interest involved the attitudes and perceptions of students in relation to digital technology and gaming on the items described above.

The main analysis involved comparing relationships between the three variables of interest. Specifically, we were interested in the influence sex and SES may have on various attitudes and beliefs about digital technology and gaming among students. Our primary analysis considered sex and SES to be the primary predictor variables, while items referring to attitudes and beliefs about digital technology and gaming were mostly considered to be outcome variables. This combination of nominal variables as predictors (sex and SES) and ordinal variables as dependent outcomes (e.g., don't like, like a little, like a lot) led us to employ ANOVA models as part of the primary analyzes.

Secondary analyzes involved closer scrutiny of trends that emerged from the primary analysis, particularly in relation to differences in attitudes and beliefs between males and females. Attempts were made to replicate results between parallel item sets (e.g., Feelings of happiness in response to vs. Likeability of – digital technology and gaming).

Results

We tested our first hypothesis (*Hypothesis 1* $= H_1$) using a one-way ANOVA. This revealed a small trend in the direction opposite to our expectations, where SES was inversely related to self-reported levels of likeability of digital technology and gaming, $F(2, 608) = 3.59$, $p = .028$, $\eta^2 = 0.012$. Specifically, when asked '*How much do you like these activities* [video games]?' students in the lower-SES category typically responded more positively ('*Like a lot*') compared to students in the middle-SES category, and to an even greater extent compared to the upper-SES category (see Figure 1).

Respondents from upper-SES backgrounds not only liked video games less than other SES categories, but did so with a higher degree of variability ($M = 1.48$, $SD = 0.75$, $n = 205$) compared to middle ($M = 1.54$, $SD = 0.65$, $n = 203$) or lower-SES ($M = 1.66$, $SD = 0.61$, $n = 203$) respondents. Testing the assumption of equality of variances between SES categories using Levene's test revealed a significant difference between the lower, middle, and upper-SES categories, $F(2, 608) = 11.49$, $p < .001$; with variability increasing in ascending order such that the least variable responses came from the lower, and most variable from the upper-SES categories of respondents.

The results were relatively unchanged after using Welch's homogeneity correction, $F(2, 403) = 3.68$, $p = .026$, $\eta^2 = 0.012$. Visual inspection of standardized residuals in the Q-Q Plot (a test for violations of 'normality') showed deviations from the diagonal at the upper quartile, suggesting that a Kruskal–Wallis test may be considered. The Kruskal–Wallis H-test provides a suitable alternative to ANOVA for non-parametric data comparing two or more independent samples using rank-based procedures (Ostertagova, Ostertag, and Kovac 2014). The results again showed a small but significant trend in the unexpected direction, $H(2) = 6.35$, $p = .042$, thus, reinforcing earlier findings that respondents are less likely to 'like' video games as their SES increases from lower to higher categories.

Extending this analysis, we examined the relationship between sex, SES, and likability of video games. Based on prior studies, we expected higher likeability of video games for males compared to females, and with a similar pattern between SES categories as the previous analysis (although, we reiterate that our original expectations prior to our analysis was that SES would relate positively to liking video games). We conducted a two-way ANOVA and found a large difference between males and females, $F(1, 605) = 81.83$, $p < .001$, $\eta^2 = 0.116$. Closer inspection suggested that most variance in the model derived from the females' responses where they were both less likely to 'like' video games compared to males, with the differences becoming increasingly stark as SES increases (see Figure 2). Consequently, we partitioned the data into separate groups for 'boys' and 'girls', before conducting a separate one-way ANOVA on each. There was no significant effect across the SES divisions for boys, $F(2, 305) = 0.16$, $p = .85$, $\eta^2 = 0.001$. In contrast, results from the ANOVA of the girls' responses showed a significant and moderate effect $F(2, 300) = 6.52$, $p = .002$, $\eta^2 = 0.042$; however, *post-hoc* tests adjusting for multiple comparisons using the Bonferroni method suggested the only significant difference in the model was between the girls' upper and

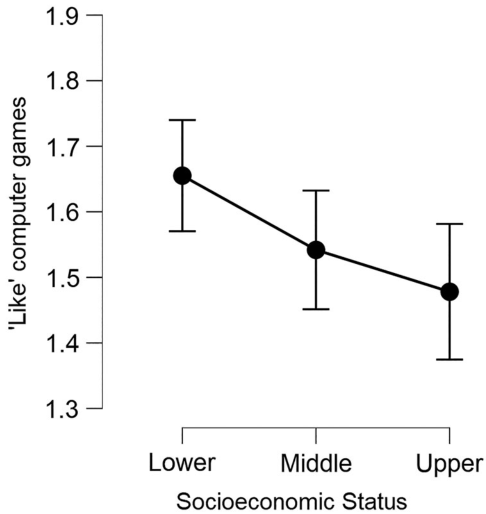

Figure 2. Line plot showing mean and 95% CIs for lower, middle, and upper-SES student responses to the question 'How much do you like video games?' (Like a lot, Like a little, or Don't like).

lower SES categories (Cohen's $d = 0.49$, $p_{\text{bonf}} = .001$). Because the Q-Q Plot raised the possibility that assumptions of normality were potentially violated, a Kruskal–Wallis test was conducted and showed a large and significant effect, $H(2) = 11.66$, $p = .003$, thus, confirming suspicions that the original trend derived exclusively from the girls' responses. That is, girls were less likely to 'like' video games as SES increases from lower to higher categories, while boys showed no such trend (Figure 3).

In short, the males' responses were consistently high throughout; while the females' responses were more variable and showed an inverse relationship with SES that was also lower overall for all three categories. It remains possible that range restrictions, in the form of ceiling effects, were present in the males' responses and future studies could benefit from a wider set of scale options (e.g., 5 or 7-point). Therefore, almost all variance in the original ANOVA model derived from

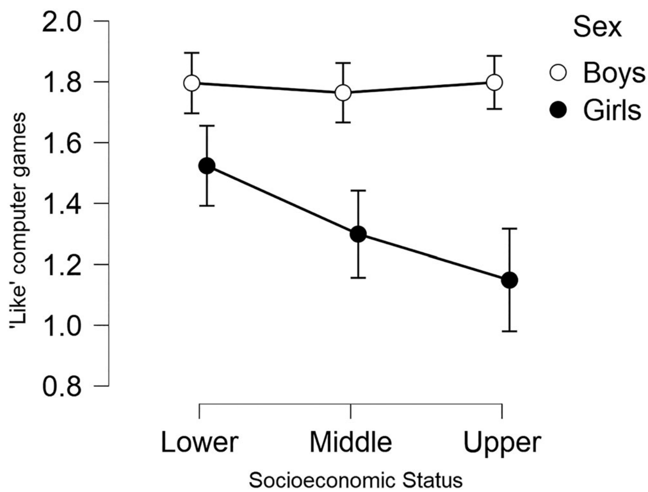

Figure 3. Line plot showing mean and 95% CIs for lower, middle, and upper-SES for boys' and girls' responses to the question 'How much do you like video games?' (Like a lot, Like a little, or Don't like).

Table 1. Descriptive statistics for the effect of Sex and SES on students' responses to the item 'How much do you like digital games?'.

SES	Sex	Mean	SD	*N*
Lower	Female	1.524	0.681	105
	Male	1.796	0.497	98
Middle	Female	1.299	0.710	97
	Male	1.764	0.508	106
Upper	Female	1.149	0.853	101
	Male	1.798	0.449	104

Note. Response options were anchored on a 3-pt Likert-type scale, including Like a lot (2), Like a little (1), or Don't like (0).

female responses, where they were less inclined to 'like' video games as SES increased from lower, to middle, and to upper-SES categories (see Table 1).

A key survey design feature involved asking similar questions across slightly different constructs (e.g., Likeability vs. Happiness). This approach enabled us to perform various corroboratory functions (e.g., checking for similar patterns to slightly different items) and additional robustness checks (e.g., bogus responses, random responding, confused responding) in our analysis. One such item that closely matched that reported in the previous analysis involved asking students '*How do you feel when playing video games*?'. As with the previous item, response options were anchored around a 3-pt Likert-type scale ranging from '*Happy*', '*Alright*', to '*Unhappy*'. Results from a two-way ANOVA closely replicated those involving males' and females' responses to the question of how much they liked video games, which found a large difference between the two sexes, $F(1, 603) = 68.55$, $p < .001$, $\eta^2 = 0.10$. We suggest the mirroring of results strengthens the overall credibility of our findings (see Figure 4 below).

We tested *Hypothesis 2* (H_2) using a one-way ANOVA. This revealed a small trend in the direction opposite to our expectations, where SES was inversely related to self-rated digital skills, $F(2, 609) = 4.71$, $p = .009$, $\eta^2 = 0.015$. Specifically, when asked to '*Rate your digital skills*? (internet, games, google searching, social media)' students in the lower-SES category typically responded more positively (closer toward '*Excellent*') compared to students in the middle-SES category, and to an even greater extent in comparison to the upper-SES category (see Figure 4).

Respondents from upper-SES (Figure 5) not only rated themselves lower on digital skills than other SES categories, but did so with a slightly higher degree of variability ($M = 2.65$, $SD = 1.12$, $n = 205$) compared to middle ($M = 2.79$, $SD = 1.07$, $n = 202$) or lower-SES ($M = 2.98$, $SD = 1.06$, $n = 205$) respondents (see Table 2). Testing the assumption of equality of variances between SES categories using Levene's test was not significant, and therefore, did not reveal variability estimates to be indicative of divergent population groups ($F(2, 609) = 0.54$, $p = .582$). Visual inspection of

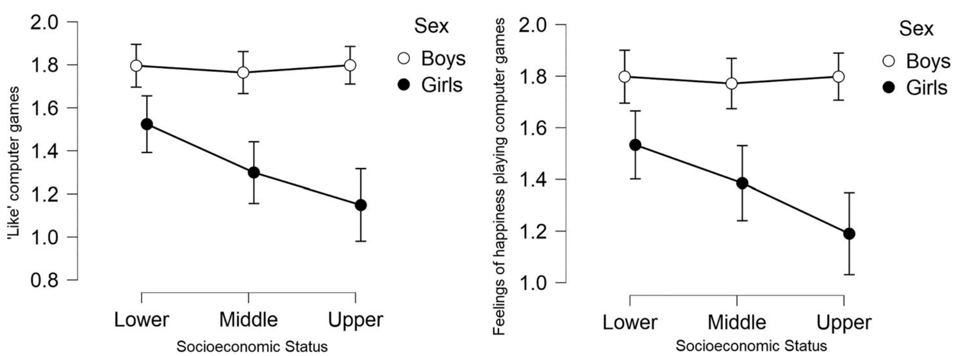

Figure 4. (A) Line plots comparing means and 95% CIs for lower, middle, and upper-SES males and females to the questions 'How much do you like computer games?' (Like a lot, Like a little, or Don't like). (B) 'How do you feel when playing video games? (Playstation, X-box, PSP, etc)' ('Happy', 'Alright', to 'Unhappy').

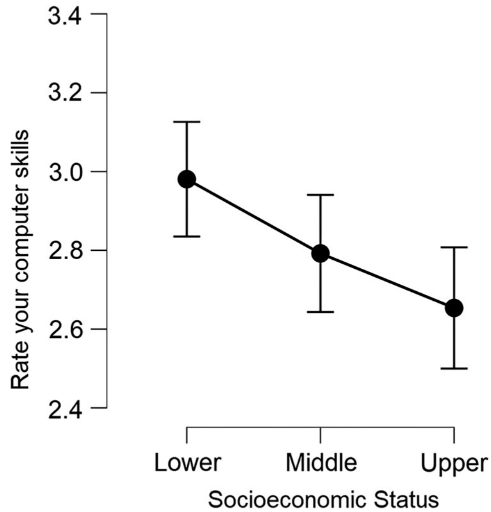

Figure 5. Line plot showing mean and 95% CIs for lower, middle, and upper-SES student responses to the item 'Rate your digital skills (internet, games, Google search, social media)' [Poor (0), Average (1), Good (2), Very Good (3), and Excellent (4)].

standardized residuals in the Q-Q Plot showed deviation from the diagonal at the upper quartile, suggesting a Kruskal–Wallis test may be helpful as it does not require the assumption of a parametric distribution. The results continued to show a small but significant trend in the same direction as the main ANOVA ($H(2) = 9.09$, $p = .01$), reinforcing the finding that self-rated digital skills tend to decrease as SES increases (see Table 2).

We next examined the relationship between sex, SES, and self-rated digital skills. Based on prior studies, we expected higher self-ratings of digital skills for males compared to females, and with a similar pattern between SES categories as the previous analysis (again, we reiterate that our original expectations prior to these analyzes was that SES would relate positively to self-rated digital skills). We conducted a two-way ANOVA and, per Figure 6, and found a moderate to large difference between males and females, on average, across each of the three SES categories, $F(1, 608) = 34.87$, $p_{bonf} < .001$, $\eta^2 = 0.048$, $d = 0.45$.

Levene's test for equality of variances was not significant, $F(5, 606) = 0.49$, $p = .79$, suggesting additional tests to accommodate incommensurate variability among subgroups were not necessary (also see Table 3 for descriptive statistics). As with the previous analysis, visual inspection of standardized residuals in the Q-Q Plot showed a deviation from the diagonal at the upper quartile, suggesting a Kruskal–Wallis test may be helpful. Results revealed a relatively large and significant between-sex difference for the overall model, $H(1) = 31.58$, $p < .001$, reinforcing earlier findings that suggest males and females differ significantly in how they rate their own digital skills across all three SES categories. As with the previous analysis, we separated 'boys' and 'girls' for a one-way ANOVA. In relation to self-reported digital skills, there was no significant effect across the SES divisions for boys, $F(2, 306) = 2.43$, $p = .09$, $\eta^2 = 0.016$, where girls' responses showed a small but significant trend, $F(2, 300) = 3.16$, $p = .044$, $\eta^2 = 0.021$; however, adjustment of p-values for multiple

Table 2. Descriptive statistics for the effect of SES on students' responses to the item 'Rate your digital skills'.

SES	Mean	SD	*N*
Lower	2.980	1.057	205
Middle	2.792	1.073	202
Upper	2.654	1.117	205

Note. Response options were anchored on a 5-pt Likert-type scale, including Poor (0), Average (1), Good (2), Very Good (3), and Excellent (4).

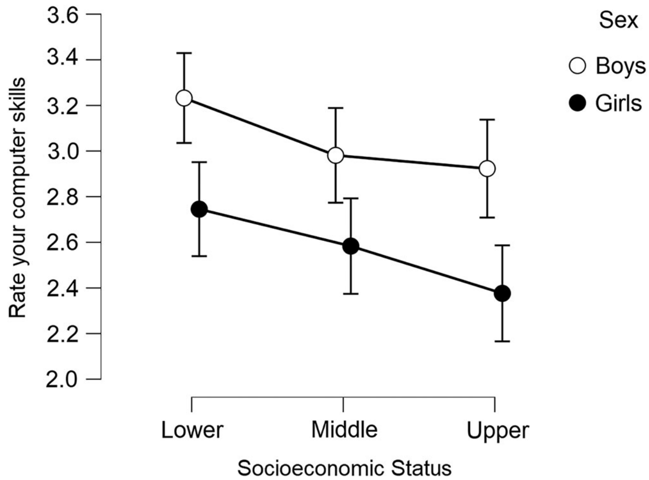

Figure 6. Line plots showing mean and 95% CIs for sex-related differences across lower, middle, and upper-SES categories. Responses relate to the item 'Rate your digital skills' [Poor (0), Average (1), Good (2), Very Good (3), and Excellent (4)].

Table 3. Descriptive statistics for the effect of Sex on students' responses to the item 'Rate your digital skills' across lower, middle, and upper SES categories.

SES	Sex	Mean	SD	*N*
Lower	Female	2.745	1.070	106
	Male	3.232	0.988	99
Middle	Female	2.583	1.033	96
	Male	2.981	1.078	106
Upper	Female	2.376	1.066	101
	Male	2.923	1.103	104

comparisons meant that the only significant individual comparison in the model was between the girls' upper and lower SES categories (Cohen's $d = 0.35$, $p_{\text{bonf}} = .038$). Levene's test was negative and no assumptions of normality were violated for this subset of responses (see Table 3).

In summary, the males' self-reported digital skills were, on average, consistently higher than females' responses across each of the three SES categories; and discrepancies between sexes remained consistent as scores declined from lower to middle, and from middle to upper-SES categories – with the largest differences occurring between lower-SES males ($M = 3.23$) and upper-SES females ($M = 2.38$).

Discussion

Differential impact of sex, self-efficacy, and SES on student digital skills

In response to our research question we found nuances in the differential interplay of SES on boys' and girls' digital self-efficacy and argue that the triad (sex, self-efficacy, and SES) of influences need to be considered by educators implementing digital pedagogies such as gaming to support student learning. Understanding boys' and girls' self-efficacy in the selection cycle (Bandura 1977) and how this interplay with SES at an early age is critical as beliefs influence important choices about the range of activities students engage with, or avoid, and one's own ability to meet situational demands to perform tasks in digital spaces. Educators may need to scaffold some students, particularly higher SES girls who have less interest and lower self-efficacy in digital spaces. Lower SES boys' higher levels of interest and self-efficacy in digital spaces offers opportunities for educators to engage with digital pedagogies such as gaming to advance learning across the curriculum.

The first hypothesis that students would express increasingly positive attitudes (i.e., likeability, feelings of happiness) toward video games as SES increases was not supported (H_1). Instead, we were surprised to see students' positive sentiments toward gaming and digital activities decreased as SES increased from lower, to middle, to upper-SES categories. These findings were corroborated when students were asked to express both how much they *like* these activities (e.g., digital games, video games, using the computer), with options including 'Like a lot', 'Like a little', to 'Don't like', and also when asked how they *feel* when engaging in these activities (e.g., happy, alright, unhappy). This suggests the results were relatively robust to item-related error. The pattern in the data was more pronounced for the girls in our cohort who reported less positive attitudes than boys, with lower levels of enjoyment increasing with SES.

Our findings align with previous studies that show positive attitudes toward video games (e.g., likability, feelings of happiness) among young girls may be lower compared to young boys, particularly as the former are increasingly exposed to environments that shape gender-norms and reinforce these with opportunities that shape attitudes away from gaming, and toward behaviors that may be in-keeping with 'female' norms (Fisher and Jenson 2017; Jenson and De Castell 2018). These factors may, in turn, either serve to reinforce or repel positive perceptions of video games for males and females respectively. This interpretation reflects the work of Master, Meltzoff, and Cheryan (2021) who found children as young 6 years old age endorse stereotypes that girls are less interested than boys in computing and suggests that educators have a role to play in encouraging girls in digital experiences. However, this does not necessarily explain the within-sex differences among females; where there is a tendency for females to become increasingly less likely to express positive attitudes toward video games as their status shifts from lower, to middle, and finally to upper-SES categories that has implications for gaming pedagogies and needs further investigation.

The second hypothesis that predicted boys would rate themselves more favorably than girls in relation to their digital skills and across all SES divides was supported. Though some of the results highlight the possibility of ceiling-effects for male respondents, they nevertheless show a degree of sensitivity toward floor-effects, where, rather surprisingly, higher-SES males had a propensity to rate their digital skills below their lower-SES male counterparts. This trend was even more pronounced among females, who rated themselves as significantly lower in digital skills compared to males across each of the SES-categories. While our findings were based on self-reports, they contrast with previous studies that show more advanced skills using technology as SES increases (Ren, Zhu, and Yang 2022) although meta synthesis illustrates the correlation between students' ICT literacy and SES is weaker than those reported in other educational domains, such as mathematics and reading (Scherer and Siddiq 2019). As previous research shows gaming experience is associated with digital competence, presumably students who played games intensively reported more fluent proficiency with technical aspects of digital technologies than those who did not play games (Laakso, Korhonen, and Hakkarainen 2021).

Girls' lower self-efficacy in digital spaces aligns with self-reported digital competences indicated in previous studies (Laakso, Korhonen, and Hakkarainen 2021) but contrasts with work by Aesaert and van Braak (2015) that found gender differences in performance-based ICT in favor of girls. We ague however, based on our findings that gender disparity in self-efficacy needs to be disrupted in the early elementary school years by educators who specifically engage girls in game play pedagogies including game design and programming as pedagogically meaningful ways of engaging students to foster digital competencies (Gunbatar and Karalar 2018; Laakso, Korhonen, and Hakkarainen 2021; Mills, Unsworth, and Scholes 2022a). Facilitating digital pedagogies related to gaming is vital for educators seeking to promote gender equity in post-school pathways, as girls (13–14 years old) who play over nine hours of video games a week are 3.3 times more likely to study STEM than those who do not (Hosein 2019).

While a limitation of this study was the reliance on self-reports that may be subject to bias, constraining the inferences we can draw about relationships with real-world measures, the major contribution of this study is reporting the attitudes and beliefs of a relatively large cohort of young students (7–10 years), seldom sampled in such studies on digital technologies and gaming. Future research, however, could look at correlations between digital self-efficacy and digital competence measures and the ways self-efficacy within games translates to the alteration of an academic self-concept in the early years of school. More in-depth understandings around the role of diverse games (Whitton 2014) on students responses and why boys in lower SES over-report self-efficacy and girls across SES report less enjoyment and self-efficacy are also important directions for further research.

Conclusion: implications for learning

The present study contributes to pedagogic transformation by advancing understandings about boys' and girls' self-efficacy in digital spaces, supporting educators advocating for gaming pedagogies to provide a meaningful way of motivating students from lower SES and engaging students in knowledge-creating learning that connects students' formal and informal learning (Laakso, Korhonen, and Hakkarainen 2021). Building on self-efficacy theory that highlights how young people develop such beliefs (Bandura 1977) in this study we have shown how young students' self-reported digital competence interplays with their gender and their SES background. As traditional schools transform into hybrid schools to provide students with ongoing education and technology supported learning (Mills, Scholes, and Brown 2022b) gaming pedagogies provide one way for educators to adapt to the transition from face-to-face learning and to potentially advance their students digital competence. As such, the findings in this study have numerous educational implications.

We suggest that gender-norms surrounding general predilections and self-efficacy toward video games and digital technologies are formed as early as 7 year of age and may become subject to Bandura's aforementioned 'selection process'. Video gaming has been connected to beneficial effects such as better computer-literacy and increased technological skills inferring a general gap with regard to technology aptitude could be limiting for non-players (Sharma et al. 2021) and suggesting the vital role gaming pedagogies from an early age. As avid gamers engage in play, they develop skills to promote problem solving, creativity, critical thinking and the ability to develop new cognitive learning templates (learning to learn), due to enhanced perception, attention, and cognition to become better players (Mills, Unsworth, and Scholes 2022a). Students who work within technology-enabled spaces also develop the ability to engage in networked learning and collaboration and our findings show that students from lower SES may hold higher self-efficacy in such digital spaces. These beliefs can potentially be harnessed by educators to advance their students' learning and employment trajectories.

Digital skills developed during gaming may prepare students for careers that require sophisticated technology aptitude – such as computer science pathways, few females however opt to participate beyond the basic level of digital interaction, or the passive consumption of digital content provided by others and remain under-represented in the technology industry (Master, Meltzoff, and Cheryan 2021; Sharma et al. 2021; Wong and Kemp 2018). There remains concern that girls' lack aspirations toward careers where they are creators of digital technology, such as in computer sciences (Master, Meltzoff, and Cheryan 2021). However, our findings have implications for both boys and girls.

Valuing boys' interests in the classroom context, educators can use gaming pedagogies to complement traditional practices to enhance problem solving, critical thinking skills, creativity, teamwork, and cooperation skills (Beavis, Muspratt, and Thompson 2015; Scholes, Mills, and Wallace 2021). Additionally, as boys from low SES communities traditionally underperform in literacy, such activities can be used to enhance outcomes as video games provide pathways to practices such as reading and improved confidence, as players read related materials such as in-game communications, reviews, blogs, and fan fiction (Picton and Clark 2021) and improve their media literacy (Dezuanni 2018). The findings suggest low SES boys feel agentic in gaming spaces, hence they may feel more likely to succeed with academic activities embedded into video game pedagogical approaches.

For young girls, however, the motivational context may instead undermine their self-efficacy in this domain (Jenson and De Castell 2018), and thus perpetuate a vicious cycle that reinforces their lack of time, effort, interest, and skill development in digital technologies and games. Girls' level of enjoyment for video games, their frequency using digital devices, and their perceptions of their digital skills may influence their ongoing engagement with digital spaces (ergo, the 'selection process'). We could speculate that these factors potentially contribute to the digital skills gap that manifests post-schooling, especially in computer science, which is often gendered as a male domain (Master, Meltzoff, and Cheryan 2021), and the decrease in the number of girls pursuing STEM subjects and entering traditionally male-dominated STEM-related professions (Scholes and McDonald 2022). It may well be that engaging girls in gaming pedagogies at a young age may lead to increased enjoyment and improve how they perceive a career in related fields such as computer science (Sharma et al. 2021) and STEM (Hosein 2019). However, as game play is shaped by social and cultural environments, teachers may need to directly challenge gender stereotypes to address the ways in which girls are discursively set up as subordinate in relation to boys within the digital games industry and culture at large (Fisher and Jenson 2017; Jenson and De Castell 2018).

If educators are to promote girls' involvement in the area of digital technologies and gaming, a space in which females are often underrepresented, we must do more to remove the psychological barriers that are before them from a very early age – barriers that serve to derail this 'selection process' (Fisher and Jenson 2017; Jenson and De Castell 2018). Boys' general level of overconfidence may be attributed to more experience playing video games, however, girls can perform as well as boys in classroom game-based learning environments when given such opportunities (Nietfeld 2020). Our findings suggest that the largest gains to be made may be through differential educational interventions aimed at girls from both upper and lower SES settings.

Ethics approval

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