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The Effectiveness of Game Coding Education on Problematic Internet Gaming

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Objective Problematic internet gaming in adolescents is associated with various negative outcomes, such as low self-esteem, depression, anxiety, and attention problems. We hypothesized that game coding education, by improving adolescents' self-esteem, would be more effective than game literacy education in mitigating problematic internet gaming.

Methods A total of 126 adolescents who voluntarily applied for the game coding education and game literacy education program of the "Visiting Game Class" project operated by the Game Cultural Foundation participated in this study. We collected data on demographics, gaming patterns, and psychological status, including positive or negative perceptions of online games, depression, and anxiety. We designated those with scores higher than 40 on Young's Internet Addiction Scale as the "problematic internet gaming" group.

Results Only game coding education was significantly effective in decreasing internet use, lowering depressive symptoms, and improving self-esteem. In the hierarchical logistic regression analysis, more frequent education time, coding education, stronger negative perceptions of gaming, and high self-esteem predicted decreased internet gaming among participants exhibiting problematic internet gameplay.

Conclusion Game coding education effectively mitigates problematic gaming by improving adolescents' self-esteem. Thus, it may be beneficial to increase education time and devise game education programs tailored to adolescents' psychological status.

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Keywords Internet gaming disorder; Game coding education; Self-esteem; Depressive symptoms.

INTRODUCTION

Current status of adolescents' problematic internet gaming

Online games are considered the most widely used and popular activity in modern society. Since the games' initial development, participation in online gaming has increased dramatically worldwide, with adolescence being recognized as a particularly vulnerable period.[1] In Asia, the prevalence of internet addiction ranges from 2.4% to 37.9% among adolescents and young people.[2] Specifically, about 74.4% of Korean teenagers play online games, and the number of those at risk for internet addiction continues to rise. Accordingly, problematic internet gaming is being seriously considered as a major public health problem.[3,4] Recently, due to the coronavirus disease-2019 pandemic, online classes have been implemented, accompanied by an increase in youth's total screen time and internet gaming.[5]

Self-efficacy, depression, and anxiety problems associated with gaming disorder

Increasing internet gaming is linked to various negative outcomes, including obstacles to academic and social activities, job loss, and family conflict.[6] In turn, these are linked to several psychological problems, such as depression, anxiety, and social phobia.[7] Problematic internet gaming is also associated with lower self-efficacy. Self-efficacy refers to individuals' perceptions of control over life events and is linked to performance in various domains. Self-efficacy affects behavior because it is related to self-esteem and stems from the belief that individuals can control their behavior on their own.[8] It can determine the degree of individuals' effort or how long they endure psychological suffering such as frustration and depression. One study found that adolescents with lower self-efficacy were more likely to suffer from internet gaming ad-

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diction.[9] According to Young,[10] gamers who feel socially awkward, isolated, and insecure in real life can transform themselves into socially confident, connected, and self-assured individuals in the gaming environment.

Self-efficacy and self-esteem are also related to depression. In fact, Bandura and colleagues[8,11] found that those with higher self-efficacy exhibited lower depression symptoms. Additionally, it is widely known that depression is related to attention and anxiety problems, and changes in self-efficacy are thought to affect these problems as well.

Treatment of problematic internet gaming and effectiveness of game coding education

While studies have reported several negative outcomes of problematic internet gaming, research on prevention and treatment programs for internet gaming disorder (IGD) is insufficient.[12] Just as media literacy education emerged from an apparent crisis with respect to protecting teenagers from the negative effects of television and movies, "game literacy" education is currently being discussed. Game literacy is the demonstration of players' ability to effectively use game-related information. It involves the ability to understand, approach, interpret, and evaluate games considering human factors.[13] However, in a rapidly changing and developing world, teaching younger generations how to create new programs could be more important than simply using and understanding existing ones.[14] Because traditional education methods are book-based and teacher-centered and students are reluctant to learn abstract subjects, there is often less participation and less motivation in class.[15]

Some countries have integrated coding education into their curricula to foster students' problem-solving skills, logical reasoning, and computational and algorithmic thinking.[16] Game coding education that requires directly producing games and utilizing coding may help improve adolescents' self-efficacy by developing such skills.[17,18] Soykan and Kanbul[17] found that 11- and 12-year-old students who received coding education exhibited higher self-efficacy compared to those who did not receive coding education. Coding education appears to make students active learners and improves their communication, critical-thinking, problem-solving, and collaborative skills. Another study showed that problem-solving and computational skills improved due to a robotic coding education program, which involved using algorithms to solve existing problems.[18] For young gamers who feel awkward and insecure and have low self-esteem, treatment and prevention of IGD should focus on developing the problem-solving and social skills necessary to foster one's self-esteem and identity, rather than simply attempting to impart an understanding of gaming itself.[10]

Hypotheses

We hypothesized that by improving self-esteem, game coding education would be more effective in mitigating problematic internet gaming compared to game literacy education. Further, we predicted that reduced problematic internet gaming would be associated with the improvement of depressed mood, anxiety, and attention problems.

METHODS

Participants and recruitment process

Through an online advertisement on the homepage of the Korean Game Culture Foundation (http://www.gameculture.or.kr/), 53 elementary schools and 47 middle schools in seven regions of South Korea voluntarily participated in ongoing programs called "Visiting Game Class." In each school, 3–4 students were randomly assigned to a game coding education or a game literacy group.

Initially, a total of 317 students (163 literacy group, 154 coding education group) participated in the programs. A total of 183 students and parents agreed to participate in this study. Among these 183 students, 57 students did not provide complete information; therefore, data from 126 students were used in the analyses. There was no compensation for participation, but participants could receive game education at no cost. This study was approved by the Institutional Review Board at Chung-Ang University (1041078-202201-HR-052).

Procedures and assessment

Game coding education and game literacy education

Participants were randomly assigned to a game coding education or a game literacy education program. Both programs consisted of eight sessions lasting 40–45 minutes each over the span of four weeks. Coding education sessions taught the game planning and development process and allowed students to directly create game characters, stages, and tutorials by using "Scratch program," a free coding program (https://scratch.mit.edu/). There were some differences in content depending on the grade level, but all coding education sessions involved game coding. The "flappy game," whose goal is to make the main character fly for a long time without falling down, and "run game," in which a character runs to avoid obstacles and score points, were the main content for the elementary school students. On the other hand, "shooting game" and "3D maze game" were the main content for the middle school students.

Game literacy education sessions taught the rationale for gameplay, how to enjoy games, and rules and etiquette when playing games. In this program, participants shared opinions about and perceptions of the types of games that they actually play. They also discussed the pros and cons of gaming and game etiquette.

Demographics and internet use patterns

Demographic data included age, gender, education year, and education frequency. Additionally, participants completed items assessing their internet use.

Psychological variables

The Social Phobia Inventory (SPIN) is a 17-item self-report inventory assessing three dimensions of social anxiety.[19] Cho et al.[20] created a Korean version (K-SPIN), reporting an internal consistency of α=0.91.

The Generalized Anxiety Disorder-7 (GAD-7) is a 7-item scale developed to screen patients for GAD.[21] Ahn et al.[22] validated the Korean version of the scale, reporting an internal consistency of α=0.93.

Young's Internet Addiction Scale (YIAS), which comprises 20 items rated on 5-point Likert scales,[23] is commonly used to assess the severity of addiction to the internet or any online activity. The internal consistency of the scale's Korean version (K-YIAS) has been reported to range from 0.90 to 0.93.[24]

The Internet Game Literacy Scale (IGLS) examines whether individuals have a positive or negative perception of internet games. The scale includes 9 items rated on a 5-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree"). The IGLS's internal consistency has been reported as α=0.89.[25]

The Patient Health Questionnaire 9 (PHQ-9) was used to assess depression. Each item is rated on a Likert scale ranging from 0 to 3, and a score of 10 (out of 27) is the cutoff point for depression.[26] Park et al.[27] validated the Korean version of the PHQ-9, reporting an internal consistency of α=0.81.

The Dupaul attention-deficit/hyperactivity disorder (ADHD) scale is an ADHD symptom severity scale (ARS) composed of 18 items (9 items assessing inattention and 9 items assessing hyperactivity).[28] So et al.[29] validated the Korean version of the ARS scale (K-ARS), with the internal consistency being reported to range between 0.77 and 0.89.

The Two-Factor Self-Esteem Scale is based on a modified version of the Rosenberg Self-Esteem Scale. Here, self-esteem is defined as an individual's sense of worthiness, which integrates self-respect and self-confidence.[30] This scale consists of 10 statements assessing general feelings toward oneself. Participants report the extent of their agreement on a 4-point Likert scale ranging from 1 ("agree not at all") to 4 ("agree completely"). The internal consistency of the Korean version of the scale (SE Scale-Korean) has been reported as α=0.79.[31]

Data analysis

Participants were classified into two groups: 1) problematic internet gaming and 2) non-problematic internet gaming. The first group included individuals with scores on the YIAS of 40 or higher.

We compared participants in the two programs (gaming coding and game literacy) in terms of gender, age, education year, and education frequency using chi-square tests and independent samples t-tests. Additionally, we assessed differences across conditions in terms of psychological variables—YIAS, IGLS, K-SPIN, PHQ-9, SE Scale-Korean, and K-ARS—using independent samples t-tests.

To determine the influence of the variables of interest on improvement of problematic internet gameplay in the full sample, we performed hierarchical logistic regression analyses designating the latter as the dependent variable. We added a discrete set of hierarchical variables: Model 1=demographic factors; Model 2=demographic factors+gaming education program type (game coding education vs. game literacy education); Model 3=demographic factors+gaming education program type+internet use; and Model 4=demographic factors+gaming education program type+internet use+psychological status. As mentioned previously, problematic internet gameplay was operationalized as YIAS scores higher than 40.[32,33] Improvement of problematic internet gameplay was defined as scoring higher than 40 on YIAS at baseline but scoring less than 40 on YIAS after the education program. Furthermore, among participants exhibiting problematic internet gameplay, we performed hierarchical logistic regression analyses using the same set of variables to determine effects on problematic internet gameplay. Finally, we conducted a repeated-measures ANOVA to assess the differences between the game coding group and the game literacy group with respect to changes in internet use patterns and psychological status.

RESULTS

Demographics

There were no differences in age, gender, education year, education frequency, or internet use between the game coding group and the game literacy group (Table 1). The average age of the full sample was 12.1 years. They had completed 3.5 gaming education sessions on average, and their average internet use was approximately 2.5 hours a day.

There was no significant difference in the number of participants exhibiting problematic internet gameplay between the game coding group (n=25; 43.1%) and the game literacy group (n=30; 44.1%; χ^2=0.01, p>0.99). However, there were more participants in the coding group (n=23; 39.7%) whose

Table 1. Demographic data of participants

	Literacy education (N=68)	Coding education (N=58)	Statistics
Age (yr)	12.6±1.6	12.4±1.3	t=0.7, p=0.51
Gender, boys/girls	33/35	33/25	χ^2=0.8, p=0.22
Education year (yr)	6.6±1.6	6.3±1.3	t=0.7, p=0.50
Class frequency	3.4±1.2	3.6±0.9	t=-0.9, p=0.37
Internet use (h/d)	2.5±1.0	2.6±1.2	t=-0.7, p=0.47

Values are presented as mean±standard deviation or number

problematic internet gameplay improved compared to the game literacy group (n=14; 20.6%; χ^2=5.49, p<0.001).

Hierarchical logistic regression

Analysis of full sample

Of the four models tested in the current study, three yielded results consistent with improvement of problematic internet gameplay in the full sample. Model 2 yielded χ^2=24.255 (p<0.001) and Nagelkerke's R^2=0.249 (24.9% of the variance in the dependent variable explained), indicating that the model was adequate for predicting the effect of game education program type. With stepwise χ^2=19.138 (p<0.001), game education program type was a significant predictor of the improvement of problematic internet gameplay. Model 3 yielded χ^2=46.971 (p<0.001) and Nagelkerke's R^2=0.443 (44.3% of the variance in the dependent variable explained), indicating that the model was adequate for predicting the effect of game education program type. With stepwise χ^2=22.716 (p<0.001), internet use was a significant predictor. Model 4 yielded χ^2=59.487 (p<0.001) and Nagelkerke's R^2=0.607 (60.7% of the variance in the dependent variable explained), indicating that the model was adequate for predicting the effect of game education program type. With stepwise χ^2=10.516 (p<0.044), psychological status was a significant predictor. Based on the Wald statistics for all independent variables, more frequent education, coding education, stronger negative perceptions of gaming, and high self-esteem significantly predicted the effect of game education (Table 2).

Analysis of problematic internet gameplay group

We conducted the same analysis while limiting the focus to the problematic internet gameplay group. Model 2 yielded χ^2=21.303 (p<0.001) and Nagelkerke's R^2=0.434 (43.4% of the variance in the dependent variable explained), indicating that the model was adequate for predicting the effect of game education program type. With stepwise χ^2=19.344 (p<0.001), game program type was a significant predictor. Model 3 yielded χ^2=34.961 (p<0.001) and Nagelkerke's R^2=0.636 (63.6% of the variance in the dependent variable explained), indicating that the model was adequate for predicting the effect of game education program type. With stepwise χ^2=13.657 (p<0.034), internet use patterns were a significant predictor. Model 4 yielded χ^2=47.021 (p<0.001) and Nagelkerke's R^2=0.777 (77.7% of the variance in the dependent variable explained), indicating that the model was adequate for predicting the effect of game education program type. With stepwise χ^2=12.061 (p<0.017), psychological status was a significant predictor. Based on the Wald statistics for all independent variables, more frequent education, coding education, stronger negative perceptions of internet gaming, lower depression, and higher self-esteem all predicted improvement of problematic internet gameplay within the problematic gameplay group specifically (Table 3).

Comparison of changes in internet use patterns and psychological status between coding education group and game literacy education group

There were significant differences in the changes of internet use patterns, PHQ-9 scores, and self-esteem scores between the coding education group and the game literacy education group (Table 4 and Figure 1). As indicated by the post-hoc tests, the coding group's internet use decreased, but the literacy education group showed no change in internet use. The coding group exhibited decreased PHQ-9 scores, but the literacy education group showed no change in PHQ-9 scores. Lastly, the coding group exhibited increased self-esteem, whereas the literacy education group showed no change in self-esteem.

When limiting the scope of analysis to those exhibiting problematic internet gameplay, there were significant differences in the changes of internet use patterns and self-esteem scores between the coding education group and the game literacy education group. As indicated by the post-hoc tests, the coding group exhibited decreased internet use, but the literacy education group showed no change in internet use. The coding group also exhibited increased self-esteem, whereas the literacy education group showed no change in self-esteem (Table 5 and Figure 2).

Table 2. Hierarchical logistic regression analysis (full sample)

Independent variables		Model 1			Model 2			Model 3			Model 4		
		B	Wald	OR	B	Wald	OR	B	Wald	OR	B	Wald	OR
Demographics	Gender	1.335	5.559	0.263	-1.335	5.559	0.263*	-1.080	1.473	0.339	-0.708	0.476	0.493
	Age	1.968	4.374	7.154*	1.968	4.374	7.154*	1.259	1.185	3.521	1.381	0.880	3.978
	Education	-1.379	2.427	0.252	-1.379	2.427	0.252	-1.318	1.433	0.268	-1.711	1.486	0.181
Game education	Frequency				0.787	6.904	2.197**	0.633	3.967	1.884*	0.683	3.939	1.981*
	Type				-1.584	8.729	0.205**	-1.711	7.039	0.181**	-1.893	6.965	0.151**
Internet use patterns	Time							1.607	12.095	4.989*	0.831	8.463	2.296**
	Activity							-	3.469	-	-	3.680	-
	Game							0.482	0.274	1.619	0.388	0.740	1.474
	Video							0.481	1.698	1.617	-1.036	3.408	0.355
	Study							-0.179	0.376	0.836	-0.201	0.358	0.818
	SNS							0.020	0.006	1.021	13.634	2.469	1.181
	IGLS-Pos							0.101	2.116	1.107	0.093	1.226	1.098
	IGLS-Neg							0.181	10.804	1.198*	0.223	9.128	1.374*
Psychological status	PHQ-9										-0.111	1.409	0.895
	K-ARS										-0.022	0.162	0.978
	KSPIN										0.046	2.155	1.047
	Self-esteem										0.239	4.139	1.387*

Indices	Model 0	Model 1	Model 2	Model 3	Model 4
-2LL	152.165	147.441	128.303	105.587	95.070
Step χ^2/p	N/A	5.117/0.163	19.138/<0.001**	22.716/0.001**	10.516/<0.044*
Model χ^2/p	N/A	5.117/0.163	24.255/<0.001**	46.971/0.001**	59.487/<0.001**
Nagelkerke's R^2	N/A	0.057	0.249	0.443	0.607
Class accur	70.6	71.4	73.0	81.0	83.4

Model 0: No predictor. Model 1: Demographic factors. Model 2: Demographic factors+gaming education program type (game coding education vs. game literacy education). Model 3: Demographic factors+gaming education program type+internet use. Model 4: Demographic factors+gaming education program type+internet use+psychological status. *p<0.05; **p<0.01. -2LL, -2 log likelihood; Class accur, classification accuracy; SNS, social network services; IGLS-Pos, Internet Game Literacy Scale-positive; IGLS-Neg, Internet Game Literacy Scale-negative; PHQ-9, Patient Health Questionnaire-9; K-ARS, Korean Attention Deficit Hyperactivity Disorder Rating Scale; KSPIN, Korean-Social Phobia Inventory; N/A, not available; OR, odd ratio

Table 3. Hierarchical logistic regression analysis (participants exhibiting problematic internet gaming)

Independent variables		Model 1			Model 2			Model 3			Model 4		
		B	Wald	OR	B	Wald	OR	B	Wald	OR	B	Wald	OR
Demographics	Gender	-1.461	5.125	0.232*	-2.283	7.086	0.102*	-3.211	4.767	0.040*	-4.780	2.610	0.008
	Age	1.897	2.870	6.667	2.306	3.321	10.034	2.254	1.704	9.522	7.448	3.891	21.765
	Education	-1.394	1.754	0.248	-1.526	1.770	0.217	-1.707	1.057	0.181	-4.241	0.484	0.014
Game education	Frequency				1.723	3.898	5.604*	2.858	2.927	17.424	3.859	3.564	29.383*
	Type				-2.185	5.320	0.113*	1.706	2.548	5.507	-4.461	3.448	0.032*
Internet use patterns	Time							-2.202	3.204	0.111	1.504	2.504	4.501
	Activity							-	3.019	-	-	3.680	-
	Game							-1.673	0.841	0.188	1.826	0.253	2.653
	Video							6.392	6.969	14.024	5.335	3.574	2.018
	Study							0.025	-4.114	0.016	-1.867	1.768	0.155
	SNS							-4.255	5.010	2552.2	-0.889	1.930	0.411
	IGLS-Pos							0.290	4.484	1.337*	0.227	1.461	1.254
	IGLS-Neg							0.070	0.570	1.073	0.477	4.052	1.611*
Psychological status	PHQ-9										-0.510	3.057	0.601*
	K-ARS										-0.087	0.497	0.917
	KSPIN										-0.128	1.509	0.880
	Self-esteem										0.488	4.040	1.654*

Indices	Model 0	Model 1	Model 2	Model 3	Model 4
-2LL	74.165	72.072	52.728	39.071	27.010
Step χ^2/p	N/A	1.959/0.581	19.344/<0.001**	13.657/0.034*	12.061/0.017*
Model χ^2/p	N/A	1.959/0.581	21.303/<0.001**	34.961/<0.001**	47.021/<0.001**
Nagelkerke's R^2	N/A	0.047	0.434	0.636	0.777
Class Accur	60.0	61.8	76.4	81.8	87.3

Model 0: No predictor. Model 1: Demographic factors. Model 2: Demographic factors+gaming education program type (game coding education vs. game literacy education). Model 3: Demographic factors+gaming education program type+internet use. Model 4: Demographic factors+gaming education program type+internet use+psychological status. *p<0.05; **p<0.01. -2LL, -2 log likelihood; Class accur, classification accuracy; SNS, social network services; IGLS-Pos, Internet Game Literacy Scale-positive; IGLS-Neg, Internet Game Literacy Scale-negative; PHQ-9, Patient Health Questionnaire-9; K-ARS, Korean Attention Deficit Hyperactivity Disorder Rating Scale; KSPIN, Korean-Social Phobia Inventory; N/A, not available; OR, odd ratio

Table 4. Repeated-measures ANOVA for changes in response to internet game education from baseline to follow-up (full sample)

	Baseline	Follow-up	Statistics
Internet use patterns			
YIAS (N=126)	39.5±15.6	35.4±12.4	t=3.89, p<0.01*
Coding (N=58)	40.3±14.7	36.1±12.1	t=3.42, p<0.01*
Literacy (N=68)	38.8±16.5	34.7±12.7	t=2.44, p=0.02
Int. use time (N=126)†	2.5±1.0	2.5±1.0	t=0.11, p=0.91
Coding (N=58)	2.6±1.2	2.4±1.0	t=1.75, p=0.09
Literacy (N=68)	2.5±1.0	2.6±1.0	t=-1.38, p=0.17
IGLS-Pos (N=126)	30.1±7.5	31.1±8.4	t=-1.57, p=0.12
Coding (N=58)	30.2±7.6	30.9±8.9	t=-0.79, p=0.43
Literacy (N=68)	30.0±7.4	31.2±7.9	t=-1.38, p=0.17
IGLS-Neg (N=126)	23.0±8.9	21.4±8.0	t=2.22, p=0.03
Coding (N=58)	21.6±8.2	19.6±6.5	t=2.53, p=0.01
Literacy (N=68)	24.2±9.3	23.0±8.8	t=1.06, p=0.29
Psychological variables			
KSPIN (N=126)	19.2±12.9	15.4±13.2	t=3.99, p<0.01*
Coding (N=58)	19.4±12.7	14.6±13.3	t=3.39, p<0.01*
Literacy (N=68)	19.0±13.1	16.0±13.2	t=2.31, p=0.02
PHQ-9 (N=126)‡	11.9±4.7	10.9±3.6	t=2.57, p=0.01
Coding (N=58)	12.7±5.2	10.8±11.8	t=3.75, p<0.01*
Literacy (N=68)	11.2±4.1	11.0±3.8	t=0.41, p=0.68
K-ARS (N=126)	8.5±10.5	7.3±7.9	t=1.49, p=0.14
Coding (N=58)	10.6±11.8	7.9±7.1	t=2.18, p=0.03
Literacy (N=68)	6.8±8.9	6.8±8.6	t=-0.08, p=0.94
Self-esteem (N=126)§	25.6±6.5	27.9±8.1	t=-2.50, p=0.01*
Coding (N=58)	25.6±5.4	30.0±7.5	t=-3.59, p<0.01
Literacy (N=68)	25.5±7.4	26.1±8.2	t=-0.43, p=0.67

Values are presented as mean±standard deviation. *statistically significant; †F=4.87, η^2=0.80, p=0.03; ‡F=4.68, η^2=0.790, p=0.03; §F=8.64, η^2=0.88, p<0.01. ANOVA, analysis of variance; YIAS, Young's Internet Addiction Scale; Int. use time, internet use time (h) per day; IGLS-Pos, Internet Game Literacy Scale-positive; IGLS-Neg, Internet Game Literacy Scale-negative; KSPIN, Korean-Social Phobia Inventory; PHQ-9, Patient Health Questionnaire-9; K-ARS, Korean Attention Deficit Hyperactivity Disorder Scale

DISCUSSION

In this study, more frequent education, coding education, stronger negative perceptions of internet gaming, and higher self-esteem predicted improvement of problematic internet gameplay among problematic gamers specifically. Additionally, only game coding education was significantly effective in decreasing internet use, lowering depressive symptoms, and improving self-esteem. Further, game coding (vs. literacy) education significantly decreased internet use and improved self-esteem among problematic gamers.

Coding education and self-esteem

Over the past two decades, a game construction-based curriculum in coding education has been thought to increase students' confidence, which is associated with self-esteem and computational skills.[34] It is surprisingly widely accepted that students in today's classrooms are all "digitally native" and are learning simply by playing internet games, but researchers are beginning to question this claim.[35] Game coding education, which enables students to directly design their own games, could be an important part of the contemporary curriculum, allowing students to apply new technological knowledge.[34] Similar to this study, previous studies have shown coding education to positively affect self-esteem and self-efficacy.[17,18] Such research has shown that self-esteem among adolescents who receive game coding education or robotic coding education could increase by improving their problem-solving, communication, and computational skills.[17,18]

Various interventions have been proposed to improve adolescents' self-esteem in other ways. Brinthaupt and Lipka[36] reported that the Adolescent Social Action Program, which is a structured-curriculum program to prevent alcohol and drug abuse, can reduce inner insecurities and improve self-esteem through coping appraisals by encouraging self-protective and socially responsible behavior. Sharma and Agarwala[37] reported that a behavioral intervention enhanced adolescents' self-esteem, and self-esteem can be improved by developing posi-

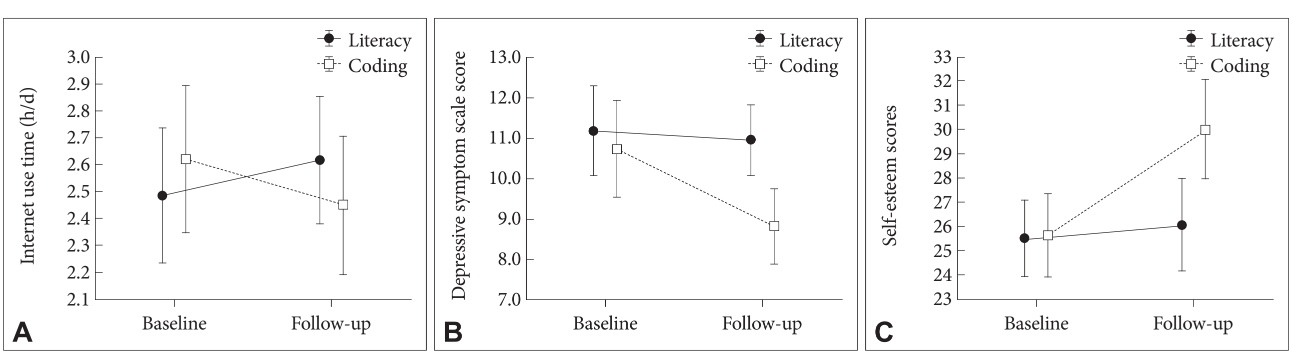

Figure 1. Comparison of changes in internet use time (A), PHQ-9 scores (B), and self-esteem (C) between game literacy and coding groups (full sample). A: F=4.87, p=0.03. B: F=4.68, p=0.03. C: F=8.64, p<0.01.

Table 5. Repeated-measures ANOVA for changes in response to internet game education from baseline to follow-up (participants exhibiting problematic gameplay)

	Baseline	Follow-up	Statistics
Internet use pattern			
YIAS (N=55)	54.9±9.7	44.4±9.4	t=6.24, p<0.01*
Coding (N=25)	54.6±9.5	46.4±9.9	t=3.39, p<0.01*
Literacy (N=30)	55.2±10.0	42.8±8.8	t=2.44, p=0.02
Int. use time (N=55)†	3.0±1.0	2.9±1.0	t=0.86, p=0.39
Coding (N=25)	3.0±1.1	2.6±1.0	t=2.31, p=0.09
Literacy (N=30)	2.9±1.0	3.1±1.0	t=-1.38, p=0.17
IGLS-Pos (N=55)	30.8±6.0	33.0±6.8	t=-2.45, p=0.02
Coding (N=25)	30.7±6.6	33.1±7.4	t=-2.03, p=0.05
Literacy (N=30)	30.8±5.5	32.8±6.4	t=-1.38, p=0.17
IGLS-Neg (N=55)	28.3±6.1	24.7±6.2	t=3.59, p=0.01
Coding (N=25)	26.6±6.0	23.3±5.6	t=2.73, p=0.01
Literacy (N=30)	29.7±5.9	25.9±6.6	t=2.47, p=0.02
Psychological variables			
KSPIN (N=55)	26.5±10.4	20.5±12.9	t=3.97, p<0.01*
Coding (N=25)	25.7±9.9	18.0±13.1	t=2.99, p<0.01*
Literacy (N=30)	27.1±10.9	22.5±12.6	t=2.61, p=0.01
PHQ-9 (N=55)	13.9±12.4	10.5±7.7	t=2.98, p<0.01*
Coding (N=25)	14.9±6.4	12.4±4.7	t=2.57, p=0.01
Literacy (N=30)	13.2±5.4	11.5±4.1	t=1.74, p=0.09
K-ARS (N=55)	13.7±12.4	10.5±7.7	t=2.15, p=0.04
Coding (N=25)	17.2±13.3	13.2±7.2	t=1.64, p=0.12
Literacy (N=30)	10.7±10.9	8.3±7.5	t=1.37, p=0.18
Self-esteem (N=55)‡	25.4±6.9	26.4±8.6	t=-0.69, p=0.49
Coding (N=25)	25.5±8.1	29.4±6.2	t=-3.63, p<0.01
Literacy (N=30)	25.5±5.0	24.1±9.5	t=0.33, p=0.85

Values are presented as mean±standard deviation. *statistically significant; †F=4.73, p=0.03; ‡F=4.48, p=0.03. ANOVA, analysis of variance; YIAS, Young's Internet Addiction Scale; Int. use time, internet use time (h) per day; IGLS-Pos, Internet Game Literacy Scale-positive; IGLS-Neg, Internet Game Literacy Scale-negative; KSPIN, Korean-Social Phobia Inventory; PHQ-9, Patient Health Questionnaire-9; K-ARS, Korean Attention Deficit Hyperactivity Disorder Scale

tive thinking and an awareness of one's strengths and weaknesses. Barrett et al.[38] also reported that specific skill development processes can positively affect self-esteem as well as other perceptions and cognitions related to the self. Additionally, improving adolescents' problem-solving skills can increase their self-esteem.[39] According to Huang et al.,[40] various psychosocial treatments for IGD, such as cognitive-behavioral therapy and reality therapy, can increase individuals' self-esteem and coping skills. Although cognitive-behavioral therapy is expected to increase self-awareness, promote emotion management, improve interpersonal communication, and improve coping skills, previous studies have yielded mixed results in terms of cognitive behavioral therapy's effects on IGD.[40]

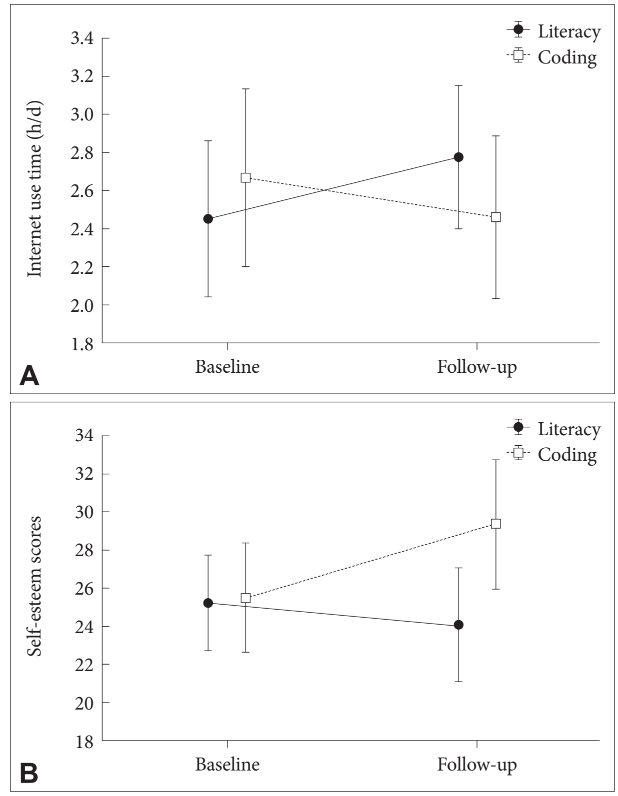

Figure 2. Comparison of changes in internet use time (A) and self-esteem (B) between game literacy and coding groups (participants with problematic gameplay only). A: F=4.73, p=0.03. B: F=4.48, p=0.03.

In this study, game coding education, which focused on adolescents' specific skills, may have made participants aware of their own abilities and improved their coping skills. Therefore, as confidence in one's abilities increases, self-esteem improves, and interventions fostering such abilities would be especially helpful.

Coding education, negative perceptions of internet gaming, and depressive symptoms

Interestingly, negative perceptions of internet gaming predicted improvement of problematic internet gameplay in the current study. Problematic internet gamers played extensively, but they perceived this behavior negatively. This paradoxical thinking might be associated with self-efficacy and depressive symptoms. As mentioned earlier, many adolescent gamers lack self-efficacy, using gaming as way to form their identity.[10] Bandura[11] reported that feelings of insecurity resulting from negative self-perceptions inhibit prosocial behavior, leading to social withdrawal. Adolescents with low self-esteem are more likely to have adjustment problems and are at higher risk for developing depression.[41] Additionally, adolescents exhibiting problematic internet gaming behavior may also exhibit withdrawal and loss of interest in other activities.[42]

Limitations

To our knowledge, our study was the first to directly compare the effects of game literacy education and game coding education on problematic internet gameplay. With little research precedent, our study confirmed game education's effects on various psychological outcomes, including depressive symptoms and self-esteem. However, there are several limitations. First, based on the collected questionnaires, it was difficult to obtain high-quality data, so the study's accuracy may have been compromised rather than evaluated by trained experts. Further, missing data may have affected the results' accuracy. Additionally, it was difficult to strictly randomly assign participants to each group (game coding education group vs. game literacy) and establish a placebo-control group in study process. Readers should be cautious in interpreting results considering the selection bias and confounding bias. Second, the results are based on a small sample, so it is difficult to generalize the conclusions. Third, because the questionnaire was conducted immediately after the education program ended, the short-term effects could be confirmed, but it was difficult to confirm the middle-long term effects.

Conclusions

In conclusion, our results provide evidence that game coding education may be more effective than other types of game education in improving problematic gaming behavior. As the effect increased with increasing education frequency, increasing the amount of game education time should be considered in the future. We found students' application of knowledge in creating their own games to be more effective than simply developing a conceptual understanding of games. Despite various limitations, this study confirms the beneficial effect of game coding education on problematic internet gaming, which could inform future research on and treatment of problematic internet gaming. Therefore, we contend that it is necessary to devise practical game education programs. In the future, game education programs tailored to students' psychological status could be beneficial.

Availability of Data and Material

The datasets analyzed in this study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: all authors. Data curation: Sungah Chung, Sol I Kim. Formal analysis: Hyunchan Hwang, Doug Hyun Han. Funding acquisition: Doug Hyun Han. Investigation: Sungah Chung, Sol I Kim. Methodology: Doug Hyun Han. Project administration: Doug Hyun Han. Resources: Hyunchan Hwang, Doug Hyun Han. Software: Doug Hyun Han. Supervision: Hyunchan Hwang, Doug Hyun Han. Validation: Hyunchan Hwang, Doug Hyun Han. Visualization: Sungah Chung. Writing—original draft: Sungah Chung. Writing—review & editing: Sol I Kim, Hyunchan Hwang, Doug Hyun Han.

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