

Research Article

Online Gaming Addiction and Quality of Life among Early Adolescents in Thailand: An Investigation from a SEM-Neural Network Approach

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Received 19 April 2022; Revised 25 May 2022; Accepted 20 April 2023; Published 8 May 2023

Academic Editor: Zheng Yan

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The popularity of gaming has greatly increased, especially among children and adolescents. As such, spending too much time playing games has become a serious issue and may have adverse effects on the quality of life of adolescents. This paper is aimed at identifying the factors and degree of influence that leads to gaming addiction and its impact on the quality of life of Thai adolescents. Data were collected from 2,044 adolescents in the form of a questionnaire from five major regions in Thailand, in both municipal and nonmunicipal areas. Structural equation modeling and the neural network model were used to analyze the data. The results indicate some differences between boys and girls as to what factors lead to gaming addiction. But gaming addiction was found to have a negative impact on the quality of life for both genders. Discussions comprising both academic and practical perspectives are also presented.

1. Introduction

After the economic bubble burst in the late 1990s, almost all Internet-related industries, with the exception of the computer game industry, online games, video games, and portable games, experienced a recession [1]. Since then, the Internet has greatly influenced people's daily lives—through email, instant messaging, blogs, Facebook, Twitter, and a plethora of similar applications. In some cases, people have even become addicted to playing online games, especially nowadays as more of them have access to high-speed Internet [2].

Along with browsing and instantaneous communication with friends, parents, and others, high-speed Internet has greatly increased the popularity of online gaming, which has become an important part of the lives of many young people [3]. Moreover, as the popularity of online gaming

continues to increase, concerns about excessive Internet usage has also increased, similar to concerns with regard to drug or alcohol addiction [4]. Indeed, game addicts show telltale signs of addiction by, for example, being obsessed with playing games all the time, isolating themselves from society in order to play games, and playing games to escape the real world pressures confronting them [5, 6]. For example, in the US, online gamers spend an average of 1-2 hours per day on their computers, more time at video game consoles, and between 6-10 hours per week on portable video game players. Therefore, it is evident that excessive game play can occur on many different platforms [7].

But it is not just online games that are popular with players around the world; the offline gaming industry is also growing rapidly. For example, Wii Sport, with worldwide sales of 82.65 million units, is an offline game played on Wii video game consoles, and offline games Minecraft and

Tetris have sold 122 million and 170 million units, respectively (as of June 2018). The largest seller of online games, on the other hand, is PUBG, with estimated sales of 27.8 million units for both mobile and tablet platforms. Other types of games on mobile and tablet platforms include arcade games (reaching 80.7 million gamers per month), adventure games (reaching 69.8 million gamers per month), and puzzle games (reaching 54.5 million users per month). It is also interesting to note that that 92 percent of mobile and tablet games are available for players to download and install for free [7].

Statistics in 2017 reveal that Thais use the Internet for an average of 6 hours and 30 minutes on work or school days and 6 hours and 48 minutes on weekends. On work or school days, 2 of these hours are spent playing online games, and for weekends it is 2 hours and 24 minutes. This is an increase of 1 hour per day or a 100 percent increase in online gaming time when compared to statistics from 2008 [8]. As such, spending so much time playing online games has become a serious issue and may have adverse effects on both physical and mental health, including fostering tendencies toward escapism and suicide and disrupting sleep patterns, resulting in insufficient rest, high blood pressure, and in some cases even death [9]. In the past decade, the topic of gaming has been given more importance. And in 2018, the World Health Organization (WHO) recognized gaming disorder as an official condition in its 11th Revision of the International Classification of Diseases (ICD-11).

The objectives of this research are the following:

- (1) To identify the factors that lead to gaming addiction among Thai adolescents
- (2) To identify the degree of influence each factor has on gaming addiction among Thai adolescents
- (3) To investigate the effect that gaming addiction has on the quality of life of Thai adolescents

A summary of previous studies that have been conducted on gaming addiction is presented in Table 1.

Indeed, the abovementioned studies have added to the body of knowledge of gaming addiction. However, the current study is aimed at closing gaps in the literature by the following:

- (1) Generating a comprehensive model that covers behavioral, entertainment, social, and quality of life factors
- (2) Employing a comprehensive sampling method that collects data for not only one city but for all five major regions in Thailand, as well as for schools in municipal and nonmunicipal areas
- (3) Defining an empirical view and insight for schools, parents, nonprofit organizations, state bodies, and policy makers so that methods can be developed to prevent or mitigate the negative effects of excessive gaming

2. Literature Review

2.1. Types of Games. As noted above, nowadays, games do not have to be played solely on a computer [16] but can also be played through a wide variety of electronic devices such as video game consoles, mobile phones, portable game consoles, and tablets [17]. Egenfeldt-Nielsen et al. [18] classify games into four main categories: arcade games, computer games, video game consoles, and games that can be played on mobile devices such as phones and tablets.

Arcade games are specifically designed for single game play. Most of them are housed in large cabinets with coin compartments where players have to pay to play. Even though they are designed for single play, some arcade games can be played simultaneously as well, (two or more people can play at the same time) but they cannot be played online. Currently, arcade games are not as popular as they were in the past. They can still be found in game centers and department stores, however [18].

Computer games refer to games that can be played on personal computers or notebooks, where outputs can be displayed through a monitor or television. Generally, computers are not designed for playing games, but there are also computers, known as gaming computers, that are specifically designed to play games. They are better equipped with hardware suitable for playing games and offer more flexibility than do regular computers, allowing players and game developers to modify and customize games. Computer games are designed to be played at the same time, whether on the same computer via local area networks or online via the Internet. Moreover, since 2000, playing games through web browsers and on social media has become very popular because these types of games are easy to play and do not need to be installed on the operating system [18].

Video game consoles are electronic devices designed to be connected to a television or a monitor but differ from computer games in that they are built by specific game companies. The PlayStation game consoles are manufactured by Sony, Nintendo Wii and Switch consoles by Nintendo, and the Xbox by Microsoft (a non-game-specific company). Video game consoles can be categorized into two types: home consoles (as discussed above) and portable video game consoles. In addition, portable video game consoles, such as Nintendo's Game Boy, are small in size, compact, and lightweight, and their performance is not as robust as on a computer or home console [18].

Games on mobile phones and tablets run on the two most dominant operating systems, Android and iOS. These types of games have become more advanced and sophisticated and playing games on mobile phones and tablets has become very popular. Mobile games are generally free to download with no installment costs. However, it is interesting to note that mobile games developers and game manufacturers can nonetheless generate revenue through micro transaction systems and get real money in the form of in-game purchases [18].

In addition, Esports, a competitive form of gaming has become very popular and is expected to grow more as evident by forecasted report. The report suggested that by

TABLE 1: Summary of previous studies on gaming addiction.

Authors	Topic	Population	Method
Apisitwasana et al. [10]	Gaming addiction situation among elementary school students in Bangkok, Thailand	295 grade 4-5 students studying in Bangkok	Cross-sectional study. Data was analyzed using descriptive statistics
Apisitwasana et al. [11]	Effectiveness of school- and family-based interventions to prevent gaming addiction among grades 4-5 students in Bangkok, Thailand	310 grade 4-5 students studying in Bangkok	An 8-week quasi-experimental study was conducted in two groups of students—ones with and ones without parental and teacher intervention
Qiaolei [12]	Internet addiction among young people in China: Internet connectedness, online gaming, and academic performance decrement	A group of 594 patients aged 10-24 who were treated for online game addiction in China	Quantitative study using questionnaires
Lopez-Fernandez [13]	Pathological video game playing in Spanish and British adolescents: towards the exploration of Internet gaming disorder symptomatology	2,356 adolescents aged 11-18 in Spain and the United Kingdom	Quantitative study using questionnaires
Chanchalor et al. [14]	Health effects of playing online game: vocational and technical students in Thailand	840 vocational and technical students in Thailand	Mixed method using questionnaires and experiments
Thomas and Martin [15]	Video-arcade game, computer game, and Internet activities of Australian students: participation habits and prevalence of addiction	1,326 middle school students from Tasmanian affiliated schools and 705 university students in Australia	Quantitative study using questionnaires

2023, there will be a total of 646 million Esports personnel and the industry will be worth US 1.56 billion [19].

2.2. Behavioral Factors. One reason that gamers spend their time playing games is that they can experience a variety of social experiences within a game, such as role playing, experiencing virtual professional careers, and enjoying membership in a virtual society. These experiences may not be available to them in the real world [20]. In addition, gamers who suffer from stress or depression use games as a means of escape from the real world [21]. This is also the case with people who lack self-esteem, who are also more likely to become addicted to games [22, 23]. Lack of confidence and social skills makes it even easier to become addicted to the Internet and games because doing so allows gamers to escape reality and, instead, to find happiness in the world of gaming.

Kuss and Griffiths [6] found another motivation for playing games, especially online games that have a large pool of players, namely, that this environment allowed players to compete and evaluate themselves within a game. Results of such competition come in the form of ranking and positions, leading to the increase in the reputation of the players, which in turn might allow them to earn a living via game-streaming platforms or as e-sport athletes. Therefore, the following hypotheses are proposed:

H1: Self-esteem posits a negative relationship towards gaming addiction

H2: Escapism posits a positive relationship towards gaming addiction

H3: Competition posits a positive relationship towards gaming addiction

2.3. Entertainment Factors. Excessive gaming may be the result of the gamer being absorbed in the state of flow of the game because of the enjoyment that they perceive. Games also make players want to experience the joy of finding new and different experiences inside the game [24]. of Wan and Chiou [25] study on continuous flow and psychological motivation found that there is a positive relationship between the state of flow and excessive gaming. Therefore, this relationship suggests that continuous flow is a factor in excessive gaming.

Cheng and Leung [26] concluded that people play games because doing so entertains them, helps pass the time, and allows them to enjoy the playfulness of games as well as feel relaxed because they are able to get away from the tensions of their daily life. Zanetta-Dauriat et al. [27] found that people, especially working people and students, play games because it relaxes them. But curiosity about new games is another factor that leads to increased game play. Playing games due to curiosity about new images and sounds generated by the game heightens the stimulation of players, making them want to play the game even more. Today's games are able to offer gamers both entertainment and novelty, be it role playing opportunities, the ability to virtually travel to various locations, the chance to experience novel sounds and effects, and to be virtually immersed in challenging situations. This relationship suggests that curiosity is a factor for excessive gaming [28]. Therefore, we propose the following hypotheses:

H4: Flow posits a positive relationship towards gaming addiction

H5: Playfulness posits a positive relationship towards gaming addiction

H6: Relaxation posits a positive relationship towards gaming addiction

H7: Curiosity posits a positive relationship towards gaming addiction

2.4. Social Factors. In-game social interaction creates a way for players to connect and create strong relationships with each other. It also serves as a communication channel to facilitate social interaction in the form of virtual communities, markets, and battlefields. Online games are also used as communication tools for gamers to meet and chat or message each other. Games that can facilitate good communication can promote social interaction among players [29]. The fact that games can create a world of virtual reality allows them to attract even more players because gamers are more likely to play games if their friends are also obsessed with playing games. It is interesting to note that gamers believe that games are a great way for them to get to know more people, develop social skills, and create relationships with one another [30]. Thus, gamers prefer to develop relationships with others through gaming channels rather than real life [31].

Another important factor is the social norm that arises when gamers acquire information from other gamers and strongly believe it. A social norm also arises when gamers adhere to the expectations of other gamers in the hope of receiving rewards or recognition and avoiding punishment. Therefore, when social gaming norms are established, gamers are influenced by other gamers as to the number of games they should play [1]. For example, in most massive multiplayer online role playing games (MMORPG), the game has a guild system where the gamer who is the head of the association has the right to form a policy or group rules. This helps increase communication channels in the game as well as the level and game time for other gamers. In light of the above, we propose the following hypotheses:

H8: Social norm posits a positive relationship towards gaming addiction

H9: Critical mass posits a positive relationship towards gaming addiction

H10: Relationships posit a positive relationship towards gaming addiction

2.5. Gaming Addiction and Quality of Life. Studies on quality of life in adolescents who are addicted to games or at risk of being addicted were assessed in the following related dimensions: physical health, learning, emotions, and social and behavioral changes since they started playing games [32]. According to the GAME-Q quality of life index, various studies have found that excessive game play is harmful in the short term, for example, gamers sleep late and miss school. But at some point, it can also have long-term adverse effects, such as visual or other physical problems [33] and emotional fluctuations caused by games that require excessive game play and exposure to virtual violence [34], as well as bad academic results [35]. Therefore, we propose the following hypothesis:

H11: Gaming addiction posits a negative relationship towards quality of life.

2.6. Gender Differences. In addition, past research has highlighted that male and female players have different levels of access to games. Male players were found to have significantly higher levels of access to games than did female players, and excessive gaming, apart from being a problem among adolescents and teenagers, it is especially problematic for men [36, 37]. However, Homer et al. [38] argue that the differences in the number of male and women gamers have continuously decreased over time. They also report that game production companies are no longer just focusing on males but are also trying to include female players as part of their game production demographics. The current situation indicates that female players have an important role in the gaming industry and that social networking platforms give women more access to games.

Nonetheless, the characters in video games portrayed by the media are mostly male characters, therefore giving the impression that male players dominate the video game space and ignoring how femininity is also represented in video games [39]. Based on the review of the literature, we propose the research model and hypotheses as shown in Figure 1, comparing gaming addiction and quality of life among male and female adolescents.

3. Research Methodology

3.1. Instrument Development. For each construct in the research model, multiple items were used for measurement. The items used in the measurement scale were adapted from previous studies, as shown below in Table 2 and translated into Thai for better understanding for the participants. The questionnaire was then approved by the Office of the Committee for Research Ethics, Faculty of Social Sciences and Humanities with the following approval number: 2019/291.0403. The Committee for Research Ethics is in full compliance with the International Guidelines of Human Research Protection such as Declaration of Helsinki, The Belmont Report, and CIOMS Guidelines.

Upon approval from the Ethics committee, pretesting was conducted among 100 school children to check for clarity of the language and understanding of the questions. The questions were then modified as suggested by the participants. Three experts, child psychiatrists from two major hospitals, provided their input and advice on the questionnaire as well as on the research framework.

3.2. Data Collection. In order to gain a comprehensive understanding of gaming addiction among Thai adolescents, data collection was broken into three levels as shown in Table 3 and explained below:

- (1) Level 1: Data were collected from schools in the five major regions in Thailand using proportionate sampling. The five regions are Bangkok and vicinity, central, northeast, south, and north altogether comprising all seventy-seven provinces. The province with the highest number of adolescents aged 11-15 from each region was selected, making up five provinces for this study

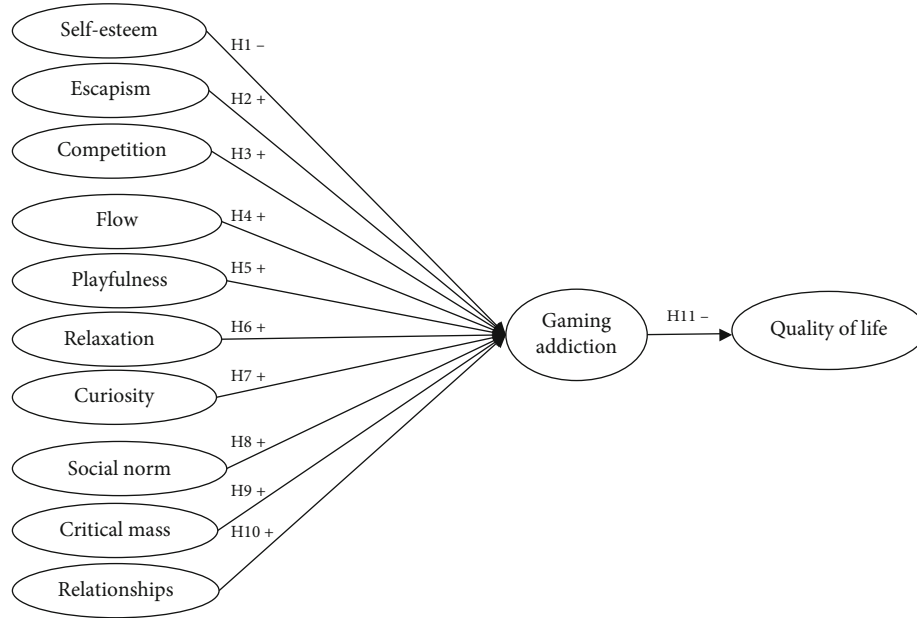


FIGURE 1: Proposed research model.

TABLE 2: Source for the measurement items.

Constructs	Source
Self-esteem	Rosenberg [40], Plumwongrot and Pholphirul [41]
Escapism	Charlton [42], Hussain and Griffiths [31]
Competition	Hussain and Griffiths [31], Lee and Schoenstedt [43]
Flow	Jackson and Marsh [44]
Playfulness	Choi and Kim [29], Hsu and Lu [1]
Relaxation	Crist et al. [45]
Curiosity	Hsu et al. [28]
Social norm	Hsu and Lu [1]
Critical mass	Hsu and Lu [1], Lee and Schoenstedt [43]
Relationships	Hussain and Griffiths [31], Lee and Schoenstedt [43]
Game addiction	Pornnoppadol et al. [46]
Quality of life	Pornnoppadol et al. [46]

- (2) Level 2: The schools in the provinces were then further divided into two areas: schools in the municipal areas and those in nonmunicipal areas; the proportion of sampling in municipal to nonmunicipal areas was 3 : 1
- (3) Level 3: Data were collected from students studying in grades 5-9 (age 11-15) for schools that fall under the Office of Basic Education, Office of the Higher Education Commission, and the Office of the Private Education Commission. This age range was selected because ETDA [8] found that the age range for stu-

dents who use the Internet to play games the most is below age fifteen as shown in Figure 2

Focusing on adolescents is very important, because compared to adults, adolescents tend to play games longer and are willing to sacrifice school and study time in order to play games [47]. A study done by Milford et al. [48] concluded that adolescents today use many mobile devices at home such as tablets, iPads, smartphones, and handheld gaming devices. In addition, children at this age are at a juncture of their lives when they can be easily tempted and develop risky behaviors that may cause problems in society [49]. Moreover, Apisitwasana et al. [11] suggest that adolescents under fifteen are considered to be high risk if not guided by their parents or teachers before they turn into adolescents. Once they become adolescents their behavior and attitude are more difficult to change.

Consistent with our predictions, results confirmed that many mobile media devices are used by adolescents in home, in particular tablets and iPads, and that often more than one device is being used, e.g., a tablet in combination with a smartphone and/or a handheld gaming device.

The breakdown of the population and sample size is shown in Table 4.

A total of 2,044 participants answered the questionnaire; the descriptive statistics are presented in Table 5.

4. Data Analysis and Results

Data were analyzed using the two-step approach recommended by Anderson and Gerbing [50], which includes analysis of measurement validity and the structural model in order to test the proposed model as well as the hypotheses.

TABLE 3: Levels of data collection breakdown.

Levels	Breakdown									
Level 1	Five regions: one province per region									
Level 2	Municipal schools					Nonmunicipal schools				
Level 3	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9	Grade 5	Grade 6	Grade 7	Grade 8	Grade 9

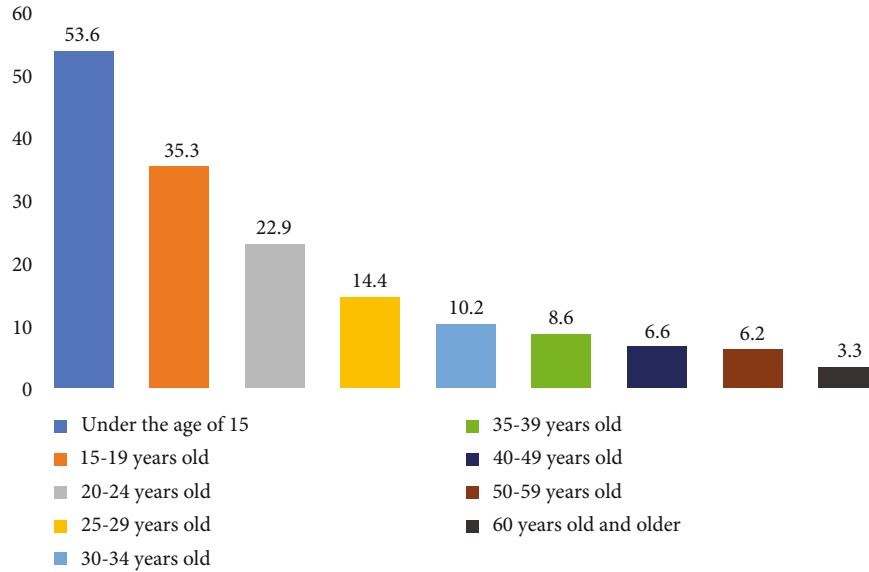


FIGURE 2: Online gaming percentage segmented by age groups.

TABLE 4: Population and sample size.

Region	Population		Total	Sample size	
				Municipal	Nonmunicipal
Bangkok and vicinity	644,108	16.24%	332	332	—
Central region	729,401	18.39%	380	287	93
Northeast	1,318,240	33.23%	675	504	171
South	625,953	15.78%	321	240	81
North	649,549	16.37%	336	253	83
Total	3,967,251	100.00%		2,044	

4.1. *Analysis of Measurement Validity.* The study conducted construct reliability and validity tests, using Cronbach’s alpha in order to test the reliability of the scales. Cronbach’s alphas for both genders were above the recommended threshold value of 0.70, indicating that the scales were reliable [51, 52]. Following this, confirmatory factor analysis was performed. The factor loadings were above 0.50, as suggested by Hair Jr. et al. [51], and the ones that were below 0.5 were removed because of low factor loading. Composite reliabilities (CR) and average variance extracted (AVE) for each construct (except male self-esteem and game addiction for both males and females) were above the recommended value of 0.5, suggesting good convergent validity [53]. Table 6 summarizes the confirmatory factor analysis CFA. Furthermore, the square root of the AVE and its correlation with

other constructs were compared to test for discriminant validity. The results in Tables 5, 7 and 8 demonstrate that the square root of the AVEs for almost all constructs is greater than the correlations between the constructs, thereby suggesting good discriminant validity [53].

4.2. *Model Testing Results.* Structural equation modeling (SEM) was run using the R language to test the path as well as the hypotheses proposed in the research model. SEM was preferred over traditional statistical tools like linear regression or ANOVA because SEM can simultaneously test the relationships between multiple independent and dependent variables (Anderson and Gerbing [50]). Table 9 shows the fit indices. Although the fit values do not exceed the threshold value of 0.9, they are still above 0.80. The justification for

TABLE 5: Demographic data of respondents.

	Option	Percentage ($n = 2,044$)	Length of game play (per day)
Gender	Male	45.60%	2 h 58 min
	Female	54.40%	1 h 49 min
Level of education	Grade 5	15.80%	2 h 34 min
	Grade 6	16.30%	2 h 29 min
	Grade 7	21.80%	2 h 31 min
	Grade 8	22.10%	2 h 10 min
	Grade 9	24.00%	2 h 5 min
Levels of problematic gaming behaviors	Not addicted	68.80%	1 h 59 min
	Probably addicted	21.00%	2 h 52 min
	Addicted	10.20%	3 h 30 min
Most types of games played	Action	79.10%	2 h 38 min
	Sport	9.10%	2 h 20 min
	Simulation	5.50%	2 h 21 min
	Adventure	3.20%	2 h 11 min
	Others	3.10%	2 h 12 min
Most played game consoles	Mobile or tablet	87.70%	2 h 27 min
	Computer	8.20%	3 h 1 min
	Others	4.10%	1 h 57 min
Marital status (parents)	Living together/married	67.20%	2 h 41 min
	Not living together, but not separated	6.20%	2 h 21 min
	Break up/divorced	21.50%	2 h 20 min
	Father or mother passed away	5.20%	2 h 15 min
Father's living status	Alive	91.80%	2 h 22 min
	Passed away	4.00%	2 h 1 min
	Do not know	4.30%	2 h 27 min
Father's highest level of education	Uneducated	2.60%	1 h 46 min
	Primary education	13.80%	2 h 9 min
	Junior high school	11.40%	2 h 7 min
	Senior high school/vocational certificate	18.00%	2 h 15 min
	Diploma	5.10%	2 h 47 min
	Bachelor's degree	11.20%	2 h 24 min
	Higher than bachelor's degree	4.20%	2 h 26 min
Do not know	33.20%	2 h 33 min	
Father's occupation	Government officer	10.10%	2 h 41 min
	Private employee	22.10%	2 h 25 min
	Own business	20.30%	2 h 12 min
	Help with family work	1.90%	2 h 14 min
	Farmer	12.40%	2 h 0 min
	Laborer	14.80%	2 h 24 min
	Taxi driver	6.40%	2 h 52 min
	Unemployed	3.00%	2 h 26 min
	Others	5.30%	2 h 29 min
Passed away	3.80%	2 h 0 min	

TABLE 5: Continued.

	Option	Percentage ($n = 2,044$)	Length of game play (per day)
Mother's living status	Alive	96.30%	2 h 21 min
	Passed away	1.80%	2 h 18 min
	Do not know	1.90%	2 h 48 min
Mother's highest level of education	Uneducated	3.60%	1 h 49 min
	Primary education	13.80%	2 h 16 min
	Junior high school	13.10%	2 h 1 min
	Senior high school/vocational certificate	18.10%	2 h 26 min
	Diploma	4.90%	2 h 26 min
	Bachelor's degree	15.70%	2 h 16 min
	Higher than bachelor's degree	4.50%	2 h 33 min
	Do not know	25.80%	2 h 38 min
Mother's occupation	Government officer	8.80%	2 h 28 min
	Private employee	22.30%	2 h 30 min
	Own business	27.30%	2 h 27 min
	Help with family work	5.80%	2 h 6 min
	Farmer	9.30%	1 h 54 min
	Laborer	13.60%	2 h 18 min
	Taxi driver	0.70%	1 h 54 min
	Unemployed	7.80%	2 h 22 min
	Others	2.90%	2 h 41 min
	Passed away	1.60%	2 h 12 min
Household income sufficiency	Sufficient and have savings	67.40%	2 h 25 min
	Sufficient but have no savings	14.90%	2 h 20 min
	Not sufficient	4.70%	2 h 13 min
	Do not know	13.00%	2 h 7 min
Average household income (monthly)	Less than 10,000 baht	14.90%	2 h 16 min
	10,000–19,999 baht	21.50%	2 h 12 min
	20,000–39,999 baht	19.30%	2 h 30 min
	40,000–59,999 baht	8.30%	2 h 46 min
	60,000–99,999 baht	4.10%	2 h 14 min
	100,000–199,999 baht	2.30%	2 h 56 min
	More than 200,000 baht	2.10%	2 h 51 min
	Do not know	27.60%	2 h 18 min
Average pocket money (per day)	Less than 100 baht	63.70%	2 h 20 min
	100-199 baht	32.60%	2 h 23 min
	200-299 baht	2.10%	2 h 27 min
	More than 300 baht	0.80%	2 h 33 min
Residential	Own house or condo	69.20%	2 h 26 min
	Rental	21.60%	2 h 13 min
	Dormitory	2.50%	2 h 10 min
	School dormitory	1.90%	2 h 9 min
	Others	4.70%	2 h 4 min

TABLE 5: Continued.

	Option	Percentage ($n = 2,044$)	Length of game play (per day)
Main person who takes care of child	Father and mother	63.90%	2 h 21 min
	Only father	7.40%	2 h 28 min
	Only mother	19.30%	2 h 16 min
	Grandparents	23.70%	2 h 40 min
	Relative	7.80%	2 h 22 min
	Nanny	2.60%	1 h 57 min
Parenting style	Caring	63.50%	2 h 16 min
	Controlling	30.30%	2 h 31 min
	Indulging	5.30%	2 h 25 min

this could be attributed to sample size ([54, 55] factor loading and model specification as these three factors are known to influence goodness fit values [55]. However, for this study, above 0.80 still meets the requirement suggested by Baumgartner and Homburg [56] and Doll et al. [57], while the RMSEA value is less than 0.08, also indicating a good fit [58]. Figures 3 and 4 show the direction as well as the strength and significance of the path coefficients classified by male and female, respectively. Only the significant paths are shown in the two figures.

5. Discussion and Implications

This study is aimed at investigating the factors and the degree of influence that lead to gaming addiction among Thai youth as well as its effect on their quality of life. A comprehensive model that covers behavioral, entertainment, social, and quality of life factors was proposed. Findings provide evidence to answer the research questions proposed and show that gaming addiction is influenced by a number of factors that differ by gender. A summary of the hypothesis testing is presented in Table 10.

As can be seen in the table, six out of the eleven hypotheses for males and seven out of eleven hypotheses for females were supported. We can see that there are some similarities between the two genders. For both genders, self-esteem had a negative relationship towards gaming addiction, which is consistent with the findings of Armstrong et al. [22] and Van Rooij et al. [23]. It can therefore be concluded that adolescents who lack confidence, have a negative attitude towards themselves as well as low self-esteem are more likely to be addicted to games. Escapism had a positive relationship for both males and females, consistent with the findings of [21]. This means that adolescents who are stressed and have problems in their day-to-day life find it important to escape these problems by playing games. By doing so, they are able to forget or at least lower their stress and are able to detach themselves from their problems. There was a positive relationship between competition and gaming addiction for males, but for females this was not supported. It can therefore be concluded that males play games because they have a strong competitive nature and want to prove to others that they are the most skillful and the fastest at the games they play, which gives them a sense of satisfaction.

Consistent with the findings of Wan and Chiou [25], for both genders flow had a positive relationship towards gaming addiction. This might be because once gamers start playing they become fully immersed in the game and lose track of time. While there was a positive relationship between playfulness and gaming addiction for females, this was not the case for males. Perhaps females play games because they believe simply that it is fun to do so. Inconsistent with the findings of Zanetta-Dauriat et al. [27], for both genders relaxation did not show a positive relationship with gaming addiction. This means that adolescents do not play games because they want to relax, feel refreshed, or enjoy a sense of calm after playing games. For females there was a positive relationship between curiosity and gaming addiction, but this was not found to be true for males. This could be because females are more satisfied playing games when doing so can satisfy their curiosity and when they feel that games can surprise them in a good way.

Inconsistent with the findings of Hsu and Lu [1], for neither gender did social norms show a positive relationship with gaming addiction. This is indeed surprising because according to Hofstede [59] cultural dimensions, Thailand is a highly collectivist country. This indicates that people are highly devoted to families, extended families, and friends and are involved in extended relationships, which means that they are greatly influenced by their social surroundings and value the opinions of others. But this study indicates that that adolescents are not influenced by the opinions of family or friends and do not play games to seek their approval. They are, however, influenced by critical mass as this had a positive relationship with gaming addiction for both genders. This is not surprising as the most popular games played by adolescents in this study are not single-but rather multi-player games and require a critical mass for playing to be enjoyable. These games require continued coordination among players, so playing games in groups or having a large critical mass is deemed important for the success of the game as well. Surprisingly, inconsistent with the findings of Ng and Wiemer-Hastings [30] and Hussain and Griffiths [31], for neither gender did such relationships show a positive relationship with gaming addiction. This means that young gamers do not play games because they want to necessarily spend time with others online and create personal relationships, implying that they still prefer the

TABLE 6: Assessment of construct reliability and validity.

Factor	Item	Male				Female			Cronbach's alpha
		Factor loading	AVE	CR	Cronbach's alpha	Factor loading	AVE	CR	
Self-esteem	self_est1	0.758	0.440	0.817	0.765	0.834	0.549	0.879	0.811
	self_est2	0.871				0.811			
	self_est3	0.738				0.684			
	self_est6	0.493				0.684			
	self_est8	0.457				0.635			
	self_est9	0.559				0.777			
Escapism	escap1	0.713	0.582	0.846	0.802	0.770	0.652	0.882	0.850
	escap2	0.731				0.861			
	escap3	0.702				0.800			
	escap4	0.890				0.795			
Competition	compe1	0.813	0.602	0.857	0.789	0.805	0.621	0.868	0.803
	compe2	0.706				0.771			
	compe3	0.729				0.777			
	compe4	0.846				0.799			
Flow	flow1	0.605	0.531	0.817	0.767	0.780	0.624	0.869	0.801
	flow2	0.689				0.723			
	flow3	0.814				0.846			
	flow4	0.789				0.805			
Playfulness	playful1	0.568	0.649	0.875	0.776	0.657	0.699	0.900	0.815
	playful2	0.970				0.964			
	playful3	0.967				0.971			
	playful4	0.630				0.701			
Relaxation	relax1	0.708	0.601	0.855	0.764	0.735	0.670	0.889	0.813
	relax2	0.879				0.911			
	relax3	0.867				0.881			
	relax4	0.616				0.730			
Curiosity	curios1	0.815	0.641	0.843	0.762	0.833	0.707	0.879	0.805
	curios2	0.764				0.831			
	curios3	0.822				0.858			
Social norm	soc_norm1	0.592	0.503	0.800	0.763	0.789	0.662	0.887	0.821
	soc_norm2	0.750				0.770			
	soc_norm3	0.690				0.848			
	soc_norm4	0.788				0.844			
Critical mass	cri_mass1	0.910	0.774	0.910	0.826	0.957	0.849	0.944	0.873
	cri_mass2	0.986				0.988			
	cri_mass3	0.722				0.809			
Relationship	relation1	0.806	0.575	0.842	0.768	0.826	0.670	0.890	0.826
	relation2	0.880				0.884			
	relation3	0.633				0.771			
	relation4	0.688				0.788			

TABLE 6: Continued.

Factor	Item	Male				Female			Cronbach's alpha
		Factor loading	AVE	CR	Cronbach's alpha	Factor loading	AVE	CR	
Game addiction	gast2	0.745	0.461	0.856	0.778	0.680	0.475	0.863	0.804
	gast6	0.683				0.724			
	gast8	0.576				0.649			
	gast9	0.767				0.779			
	gast10	0.590				0.629			
	gast12	0.701				0.746			
	gast14	0.668				0.599			
Quality of life	gameq1	0.704	0.602	0.882	0.818	0.731	0.622	0.891	0.833
	gameq2	0.717				0.784			
	gameq3	0.766				0.762			
	gameq4	0.928				0.889			
	gameq5	0.744				0.768			

TABLE 7: Correlation coefficient matrix and square root of AVEs (male).

Male		1	2	3	4	5	6	7	8	9	10	11	12
1	Self-esteem	0.44											
2	Escapism	-0.115	0.582										
3	Competition	0.034	0.544	0.602									
4	Flow	-0.045	0.528	0.675	0.531								
5	Playfulness	0.088	0.334	0.507	0.553	0.649							
6	Relaxation	0.037	0.444	0.486	0.525	0.576	0.601						
7	Curiosity	0.070	0.439	0.568	0.594	0.537	0.652	0.641					
8	Social norm	-0.079	0.416	0.413	0.353	0.254	0.298	0.345	0.503				
9	Critical mass	0.081	0.392	0.551	0.497	0.556	0.461	0.497	0.391	0.774			
10	Relationship	0.016	0.451	0.499	0.506	0.509	0.546	0.635	0.358	0.462	0.774		
11	Gaming addiction	-0.173	0.305	0.405	0.371	0.304	0.268	0.267	0.229	0.342	0.295	0.461	
12	Quality of life	0.275	-0.116	-0.097	-0.146	-0.047	-0.061	-0.068	-0.043	-0.081	-0.073	-0.232	0.602

TABLE 8: Correlation coefficient matrix and square root of AVEs (female).

Female		1	2	3	4	5	6	7	8	9	10	11	12
1	Self-esteem	0.549											
2	Escapism	-0.231	0.652										
3	Competition	-0.137	0.661	0.621									
4	Flow	-0.126	0.683	0.699	0.624								
5	Playfulness	0.016	0.473	0.552	0.587	0.699							
6	Relaxation	-0.099	0.553	0.552	0.604	0.600	0.670						
7	Curiosity	-0.038	0.532	0.600	0.623	0.616	0.709	0.707					
8	Social norm	-0.129	0.440	0.459	0.352	0.282	0.375	0.370	0.662				
9	Critical mass	-0.073	0.480	0.580	0.531	0.524	0.448	0.48	0.494	0.849			
10	Relationship	-0.064	0.538	0.558	0.586	0.529	0.637	0.698	0.412	0.473	0.670		
11	Gaming addiction	-0.223	0.404	0.393	0.445	0.424	0.352	0.314	0.215	0.375	0.296	0.475	
12	Quality of life	0.250	-0.203	-0.134	-0.173	-0.115	-0.113	-0.125	-0.111	-0.149	-0.061	-0.261	0.622

TABLE 9: Measures of the model fit.

Model	Chi-squares	df	p value	CMIN/df	NFI	GFI	IFI	CFI	SRMR	RMSEA
Male	2,079.85	483	0.0001	4.306	0.810	0.876	0.847	0.846	0.031	0.060
Female	3,346.40	580	0.0001	5.770	0.800	0.842	0.828	0.827	0.053	0.064

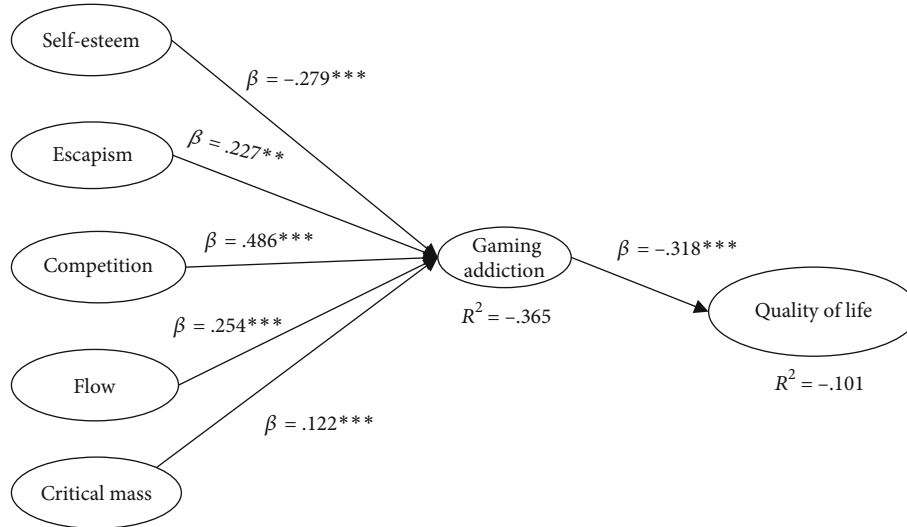


FIGURE 3: Path diagram and hypothesis testing results (male).

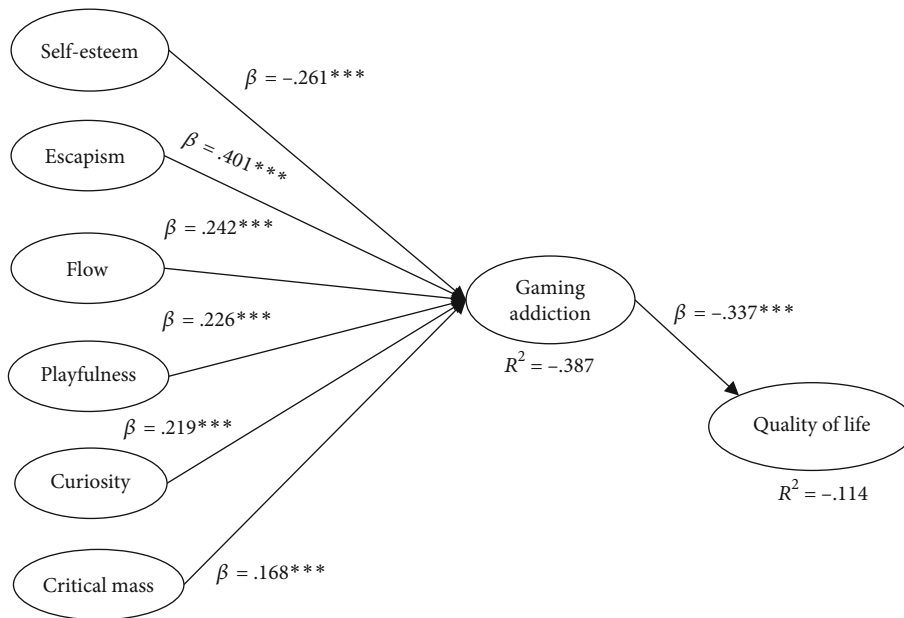


FIGURE 4: Path diagram and hypothesis testing results (female).

“offline,” real world method of creating and maintaining relationships. Finally, a negative relationship was found between gaming addiction and quality of life. This indicates that excessive gaming has a negative effect on physical health and mood as well as behavior. Youngsters’ academic performance in school also tends to decline as do their relationships with their family and friends.

This study also combined SEM and neural network analysis, which is one of the most important techniques used in artificial intelligence. The advantage of using the artificial neural network (ANN) model is that unlike multiple regression analysis and SEM, which can only detect linear relationships, it can detect nonlinear relationships [60]. In addition, according to Chan and Chong [61], ANNs are able to learn

TABLE 10: Summary of hypothesis tests.

Summary of hypothesis testing	Path coefficients	Results (male)	Path coefficients	Results (female)
H1: SE-GA	$\beta = -0.279^{***}$	Supported	$\beta = -0.261^{***}$	Supported
H2: ES-GA	$\beta = 0.227^{**}$	Supported	$\beta = 0.401^{***}$	Supported
H3: COM-GA	$\beta = 0.486^{***}$	Supported	—	Not supported
H4: FL-GA	$\beta = 0.254^{***}$	Supported	$\beta = 0.242^{***}$	Supported
H5: PLA-GA	—	Not supported	$\beta = 0.226^{***}$	Supported
H6: RX-GA	—	Not supported	—	Not supported
H7: CU-GA	—	Not supported	$\beta = 0.219^{***}$	Supported
H8: SN-GA	—	Not supported	—	Not supported
H9: CM-GA	$\beta = 0.122^{**}$	Supported	$\beta = 0.168^{***}$	Supported
H10: RE-GA	—	Not supported	—	Not supported
H11: GA-QL	$\beta = -0.318^{***}$	Supported	$\beta = -0.337^{***}$	Supported

TABLE 11: RMSE values for the neural networks.

Neural networks	RMSE			
	Male		Female	
	Training	Testing	Training	Testing
ANN1	0.0108	0.0105	0.0104	0.0101
ANN2	0.0106	0.0114	0.0101	0.0106
ANN3	0.0104	0.0102	0.0103	0.0103
ANN4	0.0104	0.0109	0.0103	0.0113
ANN5	0.0101	0.0108	0.0101	0.0097
ANN6	0.0107	0.0117	0.0097	0.0101
ANN7	0.0104	0.0120	0.0106	0.0108
ANN8	0.0102	0.0120	0.0103	0.0105
ANN9	0.0100	0.0114	0.0101	0.0110
ANN10	0.0097	0.0117	0.0106	0.0098
Mean	0.0103	0.0113	0.0103	0.0104
SD	0.0003	0.0006	0.0002	0.0005

TABLE 12: Normalized variable importance.

Predictors	Normalized importance	
	Male	Female
Self-esteem	100.00%	100.00%
Escapism	43.53%	28.37%
Competition	93.82%	n.s.
Flow	54.14%	67.68%
Playfulness	n.s.	86.83%
Curiosity	n.s.	14.42%
Critical mass	77.81%	51.11%

both complex linear and nonlinear relationships between predictors, are more robust, and are able to provide more complex accuracy with predictions [62]. This study uses multilayer perception (MLP) with nine independent variables—self-esteem, escapism, competition, flow, entertain-

ment, relaxation, curiosity, social norm, and critical mass—and relationships as the input layer while gaming addiction was used as the output layer. The study used a ten-fold cross validation, in which 90% of the data was used for training the network and the other 10% was used for testing. The root mean square error (RMSE) for both the training and the testing of data sets was set at ten neural networks in order to generate a predictive accuracy of the model [60]. The RMSE values for both the training and testing and the average and standard deviation for both genders are presented in Table 11. The average RMSE of the neural network model is relatively low 0.0103 for male training data and 0.0113 for male testing data, while for females it was 0.0103 for training data and 0.0104 for testing data), suggesting that it is quite an accurate prediction [60].

Table 12 presents the results of the sensitivity analysis, which show the normalized importance as the proportion of the importance of each of the predictors to the value that has the highest importance [60].

As shown in Table 12, based on the neural network analysis, self-esteem and competition are the most important predictors for gaming addiction among males whereas escapism and self-esteem are the most important predictors for females. One limitation of the neural network is that it does not identify the direction of the relationship of both the predictors and the outcomes. However, this limitation has already been addressed by SEM [60].

Our study provides both academic and managerial implications. In terms of academic implications, we propose a comprehensive framework that covers the behavioral and entertainment factors as well as social factors. Other researchers can perhaps use this as a guideline to conduct research on a similar context in their own countries, especially if they have similar social or gaming characteristics as Thailand. We have also found both contradictions and consistencies with previous studies on gaming addiction and have extended our perspective to measure how such addiction impacts young people's quality of life. We use neural network analysis in addition to the traditional approach of using SEM. In terms of practical contributions, solid empirical evidence indicate which factors lead to gaming addiction and how they affect the quality of life of Thai youngsters. This is especially important for parents to know so that they can understand why their adolescents become addicted to games and how this affects them. This is also important for schools and teachers so that they too can better understand the behavior of their students. In doing so, both parents and teachers can devise mechanisms that curb excessive gaming behaviors. It is also important for policy makers to devise nationwide policies that also restrict excessive gaming, similar to what governments in Australia, China, and France have done.

Even though meticulous attention was paid in the literature review process as well as to designing and carrying out the fieldwork, this study does have some limitations. First, this study was conducted only in Thailand, meaning that the results of the study might not be applicable in different countries with different cultures and settings. Secondly, the data were collected at one point in time (cross-sectional). Collecting data using the longitudinal approach might yield different results. Thirdly, although the proposed framework was comprehensive, it might have left out other factors that might better explain the factors that lead to gaming addiction. Further research could explore other factors that lead to gaming addiction.

Data Availability

Data supporting the results can be requested if needed.

Conflicts of Interest

No potential conflict of interest was reported by the authors.

Acknowledgments

This work was supported by the Thai Health Promotion Foundation.

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