

Correlation Study Between Online Game Playing Activities and Biology Cognitive Learning Outcomes Based on Gender

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ABSTRACT

Technological advancements have increased smartphone and internet use, including online gaming, which has become part of students' lifestyles. Findings at Muhammadiyah 1 Senior High School in Magelang indicate that some students play online games in their free time and during class, which is suspected to impact cognitive learning outcomes, especially in biology, which are considered difficult. This study aims to determine the relationship between online gaming activities and cognitive biology learning outcomes and the differences in these relationships based on gender. The method used is quantitative correlation with a population of all grade X students and a sample of 92 students through a simple random sampling technique. Data on online gaming activities were obtained through questionnaires, while cognitive biology learning outcomes were collected using a test instrument. The results showed a moderate negative correlation between online gaming activities and cognitive biology learning outcomes ($r = -0.515$). Based on gender, the correlation was higher in male students ($r = -0.592$) than in female students ($r = -0.357$). This indicates that the higher the online gaming activity, the lower the students' cognitive biology learning outcomes.

Keywords: cognitive learning outcomes, gender, online games playing activities

INTRODUCTION

The rapid development of technology certainly has an impact on various aspects of human life, especially in the world of education and entertainment. One real proof of the development of technology is the existence of various gadgets such as computers, laptops, tablets, cell phones, and smartphones. Gadgets are not only used to help with work and learning but are also used as entertainment media in the form of online games with the internet. Online games are not only played with people around them but can be played with many players from various locations to other parts of the world (Aprilia et al., 2022). Data on online game users in Indonesia reached 67% male and 59% female from all internet users (Irawan & Siska, 2021). Online game users are dominated by elementary, middle, high school, and college students. Therefore, online games have become a new lifestyle in the era of technological development.

On the other hand, the aspect of student learning achievement is influenced by cognitive abilities. According to Zainudin & Ubabuddin (2023), cognitive abilities include students' abilities in thinking, knowing, and solving problems. In biology, learning can provide real and meaningful learning experiences to students so that it aims to improve students' competence in understanding themselves and the environment (Banila et al., 2021). Therefore, a comprehensive understanding of foreign concepts and terms is needed. However, in biology learning, of course, there are obstacles in the form of both internal and external factors (Ndruru, 2024). The activity of playing online games in students can potentially be an internal factor because it interferes with the learning process due to weak student self-control and can potentially be an external factor due to the influence of the environment and peers (Sari et al., 2023).

Based on the results of observations, preliminary studies, and interviews at Muhammadiyah 1 Magelang High School in November 2025 with biology teachers, extracurricular games teachers, and several class X students, the researchers found that the school facilitates students' academic and non-academic development by providing various competitions and extracurricular activities such as dance, music, sports, and games. However, the duration of extracurricular game activities is only 1-2 hours per week, making students feel unsatisfied, so students increase the duration of online game-playing activities to 4-5 hours each day without being accompanied by teachers. As a result, when there are free hours and the learning process, sometimes students steal time to open online games even during exams, and sometimes students finish exam questions quickly just to play games earlier. Online game-playing activities done by students in class could also occur because of the less strict rules for using smartphones by subject teachers.

Students assume that biology is a difficult subject because there are many foreign terms and materials that are studied and memorized. Meanwhile, the learning methods used by teachers are less appropriate to the students' conditions, resulting in learning outcomes that are not yet complete or below the Criteria for Achieving Learning Objectives. Therefore, students sometimes choose to play online games to relieve boredom and as a medium of entertainment when they have difficulty understanding biology material. In addition, there were differences between male and female students in biology learning outcomes at SMA Muhammadiyah 1 Magelang based on the results of the Mid-Semester Exam, which show that female students had higher learning outcomes with an average score of 71.2 compared to male students who had average score of 70.3. Online games that are identical to men have the potential to be a factor that causes differences in learning outcomes between male and female students.

The current phenomenon of online gaming activities in students certainly has an impact on their physical, psychological, and social lives, even when these activities are carried out excessively, adolescents tend to ignore schoolwork and do not concentrate when following the learning process which causes a decrease in students' academic grades at school (Surbakti et al., 2022). The learning process that is disrupted due to excessive online gaming activities becomes a problem. The obligations and responsibilities of students who should be studying are disrupted

because their time is mostly used to play online games and the tendency for students' concentration to be disrupted when following the learning process.

Based on the background that has been explained, the purpose of this study is to determine the relationship between online gaming activities and students' cognitive biology learning outcomes at SMA Muhammadiyah 1 Magelang and to determine online gaming activities and cognitive biology learning outcomes based on student gender at SMA Muhammadiyah 1 Magelang.

METHOD

The type of research method used in this study is quantitative correlational with the aim of finding out how variables in a factor relate to other variables based on the correlation coefficient (Sugiyono, 2017). There is one predictor variable, namely online game-playing activity, and one criterion variable, namely cognitive biology learning outcomes. This study was conducted in class X of SMA Muhammadiyah 1 Magelang with a population of 125 students from 5 classes while the sample used was 92 students consisting of 46 male students and 46 female students. The sampling used a probability sampling technique of simple random sampling with the assumption that all members of the population are homogeneous or relatively homogeneous in online game-playing activities and cognitive biology learning outcomes. The data collection technique used an online game-playing activity questionnaire instrument and cognitive biology learning outcome test questions.

The online gaming activity questionnaire adopted the Game Addiction Scale for Adolescents which is based on the criteria of online gaming addiction consisting of salience, tolerance, mood modification, withdrawal, relapse, conflict, and problems (Griffiths, 2005). The questionnaire contains 21 favorable and unfavorable statements. Each statement item has alternative choices with a score of 1 to 5, namely never, rarely, sometimes, often, and very often. Cognitive learning outcomes were measured using a test instrument that had been developed in the form of 25 multiple-choice questions with cognitive levels C1 (Knowledge), C2 (Understanding), C3 (Application) and C4 (Analysis). The developed instrument was tested for validity based on the criteria for interpreting the feasibility of the instrument which can be seen in Table 1 below.

Table 1. Instrument eligibility interpretation criteria

Criteria	Validity Level
$80\% < X \leq 100\%$	Very Valid
$60\% < X \leq 80\%$	Valid
$40\% < X \leq 60\%$	Less Valid
$20\% < X \leq 40\%$	Not Valid
$X \leq 20\%$	Totally Invalid

Source: (Riduwan, 2009)

Based on Table 1, the online game-playing activity questionnaire has a validity score of 83% or very valid and the developed cognitive biology learning outcome instrument has a

validity score of 93% or very valid. Then a reliability test was carried out on both instruments, the reliability score on the online game-playing activity questionnaire was 0.80 while the reliability score on the cognitive learning outcome instrument was 0.86 so both instruments were declared reliable according to Asrul et al. (2014) and the instrument is declared reliable if it has a reliability score ≥ 0.70 .

Online gaming activities were analyzed based on the data category of online gaming addiction levels and the results of biological cognitive learning were analyzed based on test questions with the data category of biological cognitive learning results which can be seen in Table 2 and Table 3 below.

Table 2. Online game playing activity categorization

Criteria	Categorization
$65 < X \leq 105$	High Addiction
$65 < X \leq 84$	Moderate Addiction
$43 < X \leq 64$	Low Addiction
$21 < X \leq 42$	No Addiction

Source: (Başol & Kaya, 2018)

Table 3. Biology cognitive learning outcome categorization

Criteria	Categorization
$X \geq 80$	High Learning Outcome
$57 \leq X \leq 79$	Moderate Learning Outcomes
$X < 57$	Low Learning Outcomes

Source: (Azwar, 2020)

The data analysis technique uses descriptive analysis and inferential analysis to determine the level of the correlation coefficient between online game-playing activities and cognitive biology learning outcomes at SMA Muhammadiyah 1 Magelang in the form of Product moment correlation if it meets the normality test and linearity test and spearman rank if it does not meet the normality test and linearity test.

RESULT AND DISCUSSION

This study aims to determine the relationship between online game-playing activities and cognitive biology learning outcomes of students at SMA Muhammadiyah 1 Magelang and to determine the relationship between online game-playing activities and cognitive biology learning outcomes based on student gender at SMA Muhammadiyah 1 Magelang. The data obtained from this study are data on online game-playing activities, data on the duration of playing online games, and data on cognitive biology learning outcomes. Data on online game-playing activities can be seen in Figure 1 and data on cognitive biology learning outcomes can be seen in Figure 2.

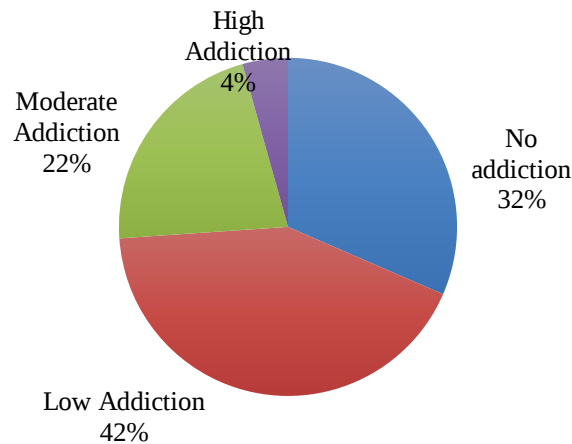


Figure 1. Online game playing activity categorization diagram

Based on Figure 1, shows that class X students of SMA Muhammadiyah 1 Magelang have a level of online game addiction that is dominated by low addiction, namely 42%, while the high addiction level has the lowest percentage, namely 4%.

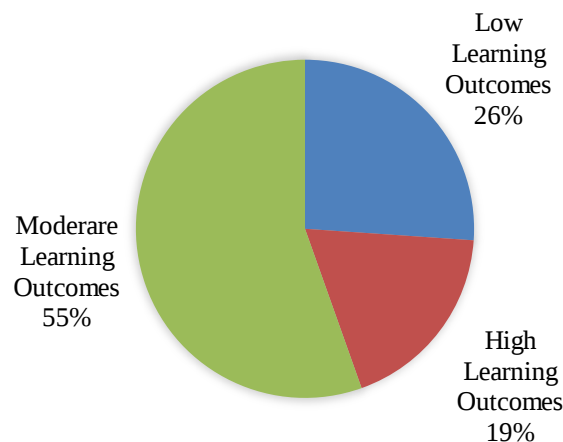


Figure 2. Biology cognitive learning outcome categorization diagram

Based on Figure 2, it shows that the cognitive learning outcomes of biology of class X students of SMA Muhammadiyah 1 Magelang are dominated by the moderate level, which is 55%, while the lowest percentage is the high level of cognitive learning outcomes of biology, which is 19%.

Then the data on online game playing activities based on student gender can be seen in Table 4 below.

Table 4. Online gaming activities based on gender

Measurement	Male Students	Female Students
Online Game Playing Activity Data Description		
Highest score	95	85
Lowest score	22	23
Mean	58.72	46.78
Median	54.50	43
Modus	47	29
Standard deviation	18.07	15.38
Online Gaming Activity Level		
No addiction	6.5% (N=6)	25% (N=23)
Low addiction	25% (N=23)	17.3% (N=16)
Moderate addiction	14.1% (N=13)	7.6% (N=7)
High addiction	4.3% (N=4)	0

Based on Table 4, it can be seen that male students dominate female students in online gaming activities with a mean or average value of 58.72 while female students are only 46.78. The level of online gaming activity is dominated by male students with the highest percentage being low addiction at 25% while female students only dominate at the level of not being addicted to online games at 25%.

Then the data on the duration of playing online games based on student gender can be seen in Table 5 below.

Table 5. Duration of online game playing activity based on gender

Measurement	Male Students	Female Students
Duration of Hours Per Day in Playing Online Games		
0-30 minute	5.4% (N=5)	11.9%(N=11)
> 30 minute-1 hour	7.6% (N=7)	11.9%(N=11)
> 1-2 hour	6.5% (N=6)	6.5% (N=6)
> 2-3 hour	5.4% (N=5)	0
> 3-4 hour	9.7% (N=9)	1% (N=1)
> 4-5 hour	5.4% (N=5)	2.2% (N=2)
> 5-6 hour	2.2% (N=2)	1% (N=1)
> 6-7 hour	0	0
> 7 hour	1% (N=1)	0
No answer	6.5% (N=6)	15.2% (N=14)
Duration of Days Per Week in Playing Online Games		
1 day/week	5.4% (N=5)	13% (N=12)
2-3 day/week	17.3% (N=16)	15.2% (N=14)
4-5 day/week	6.5% (N=6)	3.2% (N=3)
6-7 day/week	14.1% (N=13)	3.2% (N=3)
No answer	6.5% (N=6)	15.2% (N=14)

Based on Table 5, the duration of playing online games both per day and per hour is also dominated by male students with an average duration of 2-3 days/week and > 3-4 hours, while female students have a lower average duration of 2-3 days/week and > 30 minutes-1 hour.

Then the data on cognitive biology learning outcomes based on student gender can be seen in Table 6 below.

Table 6. Biology cognitive learning outcomes based on gender

Measurement	Male Students	Female Students
Description of Biology Cognitive Learning Outcome Data		
Highest score	92	96
Lowest score	44	32
Mean	66.34	69.56
Median	64	72
Modus	64	76
Standard deviation	12.77	12.37
Biology Cognitive Learning Outcome Level		
Low Learning Outcomes	16.3% (N=15)	9.7% (N=9)
Moderate Learning Outcomes	25% (N=23)	30% (N=28)
High Learning Outcomes	8.6% (N=8)	9.7% (N=9)

However, based on Table 6, in the cognitive learning outcomes of female biology students, the mean or average learning outcomes are higher than male students, which is 69.56, while for male students it is 66.34. Female students also dominate at the medium and high learning outcomes levels, which are 30% and 9.7%, while male students dominate the cognitive learning outcomes of biology at the low level, which is 16.3%.

Furthermore, prerequisite tests were carried out in the form of normality tests and linearity tests. The results of the Normality Test and Linearity Test can be seen in Table 7 and Table 8 below.

Table 7. Normality test results on students of Muhammadiyah 1 High School Magelang

Variable	Sig. Value	Conclusion
Online Game Playing Activities	0.200	Normal
Biology Cognitive Learning Outcomes	0.017	Not Normal
Online Game Playing Activities of Male Students	0.200	Normal
Biology Cognitive Learning Outcomes of Male Students	0.130	Normal
Online Game Playing Activities of Female Students	0.017	Not Normal
Biology Cognitive Learning Outcomes of Female Students	0.047	Not Normal

Based on Table 7, the data on online game-playing activities, online game-playing activity data of male students, and learning outcomes of male students are normally distributed or Sig. Value > 0.05, while the data on online game-playing activities of female students, cognitive biology learning outcomes, and learning outcomes of female students are not normally distributed or Sig. Value < 0.05.

Table 8. Linearity test results on students of Muhammadiyah 1 High School Magelang

Variable	Sig. Value	Conclusion
Online Game Playing Activities with Student Learning Outcomes	0.033	Not Linear
Online Game Playing Activity with Male Students' Learning Outcomes	0.354	Linear
Online Game Playing Activity with Female Students' Learning Outcomes	0.131	Linear

Based on Table 8, the data on online game-playing activities with cognitive biology learning outcomes do not have a linear relationship with a Sig. Value < 0.05 , while online game-playing activities with cognitive biology learning outcomes for both male and female students have a linear relationship with a Sig. Value > 0.05 .

Based on the results of the prerequisite test, online game-playing activities and cognitive biology learning outcomes in male students can be tested for product-moment correlation because they meet the prerequisite test which can be seen in Table 9 below.

Table 9. Product moment correlation test results on students of Muhammadiyah 1 High School Magelang

Variable	Correlation Coefficient	Sig. (2-tailed)
Male Students' Online Game Playing Activities with Male Students' Biology Cognitive Learning Outcomes	-0.592	0.000

Based on Table 9, the Sig. Value is 0.000 or < 0.05 with a correlation coefficient of -0.592 or moderate correlation so online game-playing activities and male students' cognitive biology learning outcomes have a significant relationship with a moderate correlation level.

Meanwhile, data on online game-playing activities and students' cognitive biology learning outcomes as well as data on online game-playing activities and female students' cognitive biology learning outcomes do not meet the prerequisite tests, namely the normality test and the linearity test, so a Spearman rank test is carried out which can be seen in Table 10 below.

Table 10. Spearman Rank test results on students of Muhammadiyah 1 High School Magelang

Variable	Correlation Coefficient	Sig. (2-tailed)
Students' Online Game Playing Activities with Students' Biology Cognitive Learning Outcomes	-0.515	0.000
Online Game Playing Activities of Female Students with Female Students' Cognitive Learning Outcomes in Biology	-0.357	0.015

Based on Table 10, the Sig. value is 0.000 or < 0.000 with a correlation coefficient of -0.515 or a moderate correlation so online game-playing activities and students' cognitive biology learning outcomes have a significant relationship with a moderate correlation level. Then the Sig. value is 0.015 or < 0.05 with a correlation coefficient value of -0.357 or a weak correlation so online game-playing activities and female students' cognitive biology learning outcomes have a significant relationship with a weak correlation level.

The results of this study indicate a relationship between online gaming activities and cognitive biology learning outcomes, both in male and female students at SMA Muhammadiyah 1 Magelang. Excessive online gaming activities can have negative impacts on physical, psychological, and health and have an impact on students' learning performance. According to Mak et al. (2012), excessive online gaming activities have the potential to disrupt sleep quality, cause insomnia, and are associated with poor academic achievement in students. Students who are not addicted to online games if they continue to play online games have the potential to become addicted. This can happen because of the inability of students to manage their time playing online games properly so they put aside other activities (Halawa, 2021). There are factors that influence excessive online gaming activities in students such as boring student activities, lack of opportunities for students to relax from a busy school schedule, students who find comfort when playing online games rather than the atmosphere of their residence, and invitations from peers to play online games continuously (Budhi & Indrawati, 2016).

Various studies have shown that excessive online gaming can trigger neurobiological changes similar to drug use. This excessive stimulation affects brain structure and volume, such as decreased gray matter and white matter density (Weinstein & Lejoyeux, 2020). This activity is also associated with disruption of the mesolimbic dopamine pathway and the involvement of other neurotransmitters such as serotonin, glutamate, GABA, adrenaline, acetylcholine, and opioids (Enoch, 2013). The impact is seen in brain areas such as the prefrontal, temporoparietal, frontolimbic, and subcortical (Schettler et al., 2022), including decreased volume in the ventromedial and dorsolateral prefrontal, anterior cingulate cortex, and premotor areas that regulate emotions, self-control, and decision-making (Yao et al., 2017). In addition, genetic factors also play a role, such as the CHRNA4 rs1044396 gene variant (Jeong et al., 2017), the CRHR1 gene (Park et al., 2018), and the Taq1A1 allele of the DRD2 gene associated with the risk of online game addiction (Han et al., 2007).

Based on the results of the hypothesis test, shows a negative relationship between online gaming activities and students' cognitive biology learning outcomes, so the higher the online gaming activity, the lower the students' cognitive learning outcomes and vice versa. However, online games not only have negative impacts but also positive impacts if they can be used properly and can manage time between studying and playing online games. According to Li et al. (2023), online games can strengthen relationships between players by discussing online gaming skills and sharing online gaming experiences. In addition, online games can feel happiness and relieve stress from pressure in the learning process (Ari et al., 2020; Pine et al., 2020). Online games also have the potential to increase student motivation and interest in

learning and increase student participation, creativity, and skills if they are able to integrate into the learning process (Clark et al., 2016).

The cognitive learning outcomes of biology students at SMA Muhammadiyah 1 Magelang which are classified as moderate are certainly not only caused by students' online gaming activities but are caused by other factors. According to (Faridah et al., 2020), low learning achievement is caused by students' habits of using smartphones, going out during class hours, and lack of interest in learning. In addition, psychological factors such as intelligence level, student talent for subjects, and low interest and motivation in learning. Therefore, students should be able to prepare themselves when taking part in the learning process by paying attention to the teacher's explanation and understanding themselves so that they are able to identify factors that can hinder the learning process. Not only that, schools and teachers must play an important role in educating students about the impact of playing online games on academic achievement, and mental and physical health.

The results of the correlation coefficient value between online gaming activities and cognitive biology learning outcomes differ based on student gender. Male students have a higher correlation coefficient value of -0.592 or at a moderate correlation level while female students have a weak correlation of -0.357. Male students also have a longer duration per day and week than female students with an average duration of 2-3 days/week and > 3-4 hours. This shows that male students have the potential to experience online game addiction which is related to low cognitive biology learning outcomes. According to Wittek et al. (2016), male adolescents are more susceptible to online game addiction than female adolescents. Online games that are currently developing contain elements of violence so interest in playing online games is more dominated by male adolescents than female adolescents (Sari et al., 2023). Meanwhile, women tend to be interested in online games with genres that are less aggressive or competitive than men (Lange et al., 2021). In addition, women tend to play online games to have relationships, show online gaming skills, have fun, and of course strengthen social relationships while men tend to play online games to achieve success and be competitive (Laconi et al., 2017; Martucci et al., 2023).

The results of the average value of cognitive learning outcomes in biology show that female students have higher cognitive learning outcomes than male students. According to Workman & Heyder (2020), female students have an advantage in academic grades, especially in language, science, and mathematics than male students. In addition, women generally show better grades than men when studying biology (Kessels et al., 2014). This is due to factors such as brain structure, character, learning style, and environment based on student gender. Women who have a thicker corpus than men make it easier for women to do many tasks than men (Newman, 2016), female students tend to care more about school so they work harder than men, but male students are more interested in technology than women so they have the habit of surfing the internet and video games (Khaleel, 2017). Male students feel happier in the learning process when learning something new or solving a challenging problem while female students feel happier in the learning process with a focus on communication such as studying together,

reading, discussions, presentations, lectures, and so on (Amin, 2018). Jackson & Dempster (2009) findings that low effort to learn shows masculinity and increases the popularity of male students among peers.

This provides evidence that the level of online game addiction in students can be related to differences in learning outcomes based on student gender. Therefore, the need for the use of diverse learning strategies, especially in biology learning, can increase students' interest and learning outcomes, especially in biology subjects by adjusting to student needs (Aldridge & Rowntree, 2022). In addition, teachers also need to know the condition of students in the learning process so that they can overcome if there are social norms that interfere with the learning process (Legewie & Diprete, 2012).

This study has several limitations. Online game-playing activities are measured based on addiction criteria and playing duration per day and hour. Addiction criteria emphasize aspects of excessive behavior, so they do not fully reflect normal playing activities. The study was also limited to one school, so the results cannot be generalized widely. In addition, other factors that influence learning outcomes, such as motivation, family environment, and learning quality, have not been analyzed. These limitations can be used as considerations for further research so that the results obtained are more comprehensive.

CONCLUSION

There is a negative correlation between online gaming activity and cognitive biology learning outcomes at SMA Muhammadiyah 1 Magelang with a correlation coefficient value of -0.515 or moderate correlation. In addition, a negative correlation is also found in the relationship between online gaming activity and cognitive biology learning outcomes based on student gender at SMA Muhammadiyah 1 Magelang. Male students have a higher correlation coefficient value of -0.592 or moderate correlation while female students have a correlation coefficient value of -0.357 or weak correlation. Therefore, the higher the online gaming activity, the lower the cognitive biology learning outcomes and vice versa. The results of this study contribute to schools, teachers, students, parents, and other researchers in understanding the influence of online gaming activity on cognitive biology learning outcomes, with practical implications in the form of regulating smartphone use, strengthening student self-control, parental support, and opportunities for developing further studies using more diverse approaches and indicators. These findings are expected to serve as a reference for teachers, schools, and parents in guiding students' online gaming habits to balance them with learning activities.

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