SEIRS model analysis for online game addiction problem of mathematics students

Azwan Anwar¹, Rahmat Syam², Muh. Isbar Pratama³ and Syafruddin Side²*

¹Student of Magister Mathematics Department, Universitas Negeri Makassar
²Department of Mathematics, Universitas Negeri Makassar
³*Corresponding author: Syafruddin@unm.ac.id

Abstract. The purposes of this research are to build a SEIRS model on the game online addiction problem, analyze the model and do a model simulation to predict the level of online game addiction of Makassar State University students. This research is a library research, population in this study is 655 undergraduate students in mathematics with a sample of 248 student. Data collection techniques using questionnaires. Analysis of the SEIRS model of online game addiction uses a generalization matrix, while the simulation model uses the MatLab Software. The results of this study are the SEIRS mathematical model of online game addiction which is a system of differential equations. Analysis of the model gives an addiction-free equilibrium value and a stable endemic equilibrium point. The results also found a baseline value of $R_0 = 0.033$ which showed that the level of online game addiction cases in mathematics students is not worrying, meaning that students addicted to online games did not cause other students to become addicted. The simulation results explained that 49 students were susceptible to online game addiction, 220 students began trying to play online games, 2 students were trying to get addicted to online games, and 13 students were released from online game addiction. Based on the results obtained from the number addicted to online games students the first four years increase, then reduced and constant on the eighth month.

1. Introduction

Online game is a type of game that uses electronic devices such as computers or special devices commonly used to play games. This game also uses the internet network, so that players around the world can play together at the same time [1]. Online gaming is increasing from day to day because of the rapid computer network that was once a small scale (small local network) into the internet and continues to grow until now [2]. Online games are currently facilitated a lot by social networks like Facebook and Line. The above conditions, in addition to bringing positive impacts, also bring negative impacts for adolescents. One of the negative effects caused by online games is the effect of pleasure for fans and can cause addiction [3].

Addiction is something fun that is done so excessive that it produces other things and makes people unable to control themselves [4]. If a player cannot control himself, the player forgets himself, forgets to learn, even when learning contradicts the game memory. Online games also have adverse effects on health [5].

Online game fans in Indonesia reach 6 million people and around 40% are teenagers who make negative contributions to them because they cannot be played. As many as 64.45% of adolescent boys and 47.85% of adolescent girls who enjoyed 12-22 years playing online games said they were addicted
to online games [6]. Playing excessive games can also cause death, some cases found people die because they sit too long in front of the computer after playing games for an excessive amount of time [5].

Research on online game addiction in Makassar has been conducted by several researchers including [7] who discuss the problem of online gaming in a social perspective but have not considered it from a mathematical point of view. Research on the mathematical model of SIR, SEIR, SIRS, and SEIRS has been carried out by [8-16], but the model is applied to cases of infectious diseases such as dengue fever, tuberculosis. The research has not applied the SEIRS model to social problems, especially the problem of online game addiction. This study discusses SEIRS mathematical modeling on the online game addiction problem, then conducts analyzes and simulations using data from students majoring in mathematics to find out and predict the number addicted to online games students. This study also provides an online game addiction status for students majoring in mathematics, Universitas Negeri Makassar (UNM), which is an alarming status, which means a student who is addicted to online games causes other students to complain or not cause other students to be addicted to online games.

2. Method

This study are literature study and applied methods, which examines theories related to online game problems and mathematical modeling, then applies the model to find out the number addicted to online games students today and predictions of the number of addictions of online games in the future. Mathematical models in online addiction are Suspect, Expected, Infected, Recovered, Suspended (SEIRS) models, the equilibrium analysis of the model using the Routh-Hurwitz [8] method, simulation models using Maple software, while the research data are 655 undergraduate students in mathematics department, Universitas Negeri Makassar. The sampling technique used in this study is probability sampling, that is proportionate stratified random sampling or proportional stratified random samples by simple random sampling [17].

3. Result and Discussion

3.1. SEIRS Model for Game Online Addiction.

Population changes in the problem of online game addiction with the SEIRS model can be interpreted in Figure 1:

![Figure 1. SEIRS Model Flow Chart of Online Game Addiction](image)

The total population of N is divided into four compartments, namely: Susceptible (S) stating groups of students who are susceptible to online gaming addiction, Exposed (E) stating groups of students who start playing online games but not including online game addicts, infected (I) stating groups of students who are addicted to online games, and recovered (R) states that groups of students are detached from online gaming addictions. While the model parameters are defined in Table 1:

| Symbol | Definition |
|--------|------------|
| $\alpha$ | The rate of students who are susceptible to online gaming (susceptible) to groups of students who start playing online games (exposed). |
| $\beta$ | The rate of students who start playing online games (exposed) to groups of students who are already addicted to online games (infected). |
| $\delta$ | The rate of students who are already addicted to online games (infections) to groups of students who are detached from online game addictions (recovered). |
| $\theta$ | The rate of students who are detached from online gaming addiction (recovered) to groups of students who are vulnerable to online gaming addiction (susceptible). |
| $\mu$ | The rate of students who leave or stop playing online games. |
Based on Figure 1, obtained the SEIRS mathematical model of online game addiction as in equation (1) - (4), namely:

\[
\begin{align*}
\frac{ds}{dt} &= \mu + \theta r - \alpha s - \mu s \\
\frac{de}{dt} &= \alpha s - \beta e - \mu e \\
\frac{di}{dt} &= \beta e - \delta i - \mu i \\
\frac{dr}{dt} &= \delta i - \theta r - \mu r
\end{align*}
\]

3.2. The Equilibrium point Analysis of the SEIRS model for online games addiction

3.2.1. The Equilibrium point for free addiction of online games

Addiction free of online games is assumed that no human being is addicted to online games. Determination of the online game addiction free equilibrium point is obtained by making the left side of equations (1) to (4) zero, then the online game addiction free equilibrium point occurs if \( i = 0 \). So the addiction-free equilibrium point is obtained namely:

\[
(s, e, i, r) = \left( \frac{\mu}{(\alpha + \mu)}, \frac{\alpha \mu}{\alpha \beta + \alpha \mu + \beta \mu + \mu^2}, 0, 0 \right)
\]

3.2.2. The Equilibrium point for online games addiction

Determination of the equilibrium point for online game addiction is obtained by making the left side of equations (1) to (4) be zero, then a solution is found in the form of the values of the variables \( s, e, i, r \). An endemic equilibrium point is obtained:

\[
(s, e, i, r) = \left( \begin{array}{c}
\alpha \beta \delta \mu + \alpha \beta \theta \mu + \alpha \beta \mu^2 + \alpha \delta \mu + \alpha \theta \mu^2 + \alpha \mu^2 + \alpha \mu^3 + \beta \delta \theta \mu + \beta \delta \mu^2 + \beta \theta \mu^2 + \beta \mu^2 + \delta \theta \mu^2 + \delta \mu^2 + \delta \mu^3 + \theta \mu^3 + \mu^3 \\
(\beta + \mu) (\delta + \mu) (\theta + \mu) \mu \\
\alpha \beta \delta \mu + \alpha \beta \theta \mu + \alpha \beta \mu^2 + \alpha \delta \mu + \alpha \theta \mu^2 + \alpha \mu^2 + \alpha \mu^3 + \beta \delta \theta \mu + \beta \delta \mu^2 + \beta \theta \mu^2 + \beta \mu^2 + \delta \theta \mu^2 + \delta \mu^2 + \delta \mu^3 + \theta \mu^3 + \mu^3 \\
(\delta + \mu) (\theta + \mu) \alpha \mu \\
\alpha \beta \delta \mu + \alpha \beta \theta \mu + \alpha \beta \mu^2 + \alpha \delta \mu + \alpha \theta \mu^2 + \alpha \mu^2 + \alpha \mu^3 + \beta \delta \theta \mu + \beta \delta \mu^2 + \beta \theta \mu^2 + \beta \mu^2 + \delta \theta \mu^2 + \delta \mu^2 + \delta \mu^3 + \theta \mu^3 + \mu^3 \\
\delta \beta \alpha \mu
\end{array} \right)
\]

3.3. Stability analysis of SEIRS model for online games addiction

Stability analysis from the equilibrium point of the SEIRS model is defined as a condition where if the equilibrium point is disturbed, it will return in an equilibrium state. The first step in the stability analysis of the equilibrium point is to determine the Jacobi matrix from equations (1) to (4), namely:

\[
\begin{bmatrix}
\lambda + \alpha + \mu & 0 & 0 & -\theta \\
-\alpha & \lambda + \beta + \mu & 0 & 0 \\
0 & -\beta & \lambda + \delta + \mu & 0 \\
0 & 0 & -\delta & \lambda + \theta + \mu
\end{bmatrix}
\]

(5)

then, obtained the characteristic equation:

\[
K(\lambda) = \lambda^4 + A \lambda^3 + B \lambda^2 + C \lambda + D = 0
\]

The Hurwitz stability test is used to determine the type of eigenvalue of the matrix, namely through the determinant of the M matrix called the Hurwitz matrix. In the general form matrix M is a matrix
3.4. The basic reproduction number $R_0$

The basic reproduction number ($R_0$) is the expected value of the number of secondary cases arising from a primary case in a vulnerable population. The number $R_0$ is a threshold condition to determine whether a population is endemic or not addicted. Basic reproduction numbers are obtained using the next generation matrix method. In this model the system of equation (3) which is a subpopulation of infected classes is:

\[
\frac{dS}{dt} = \beta e - \delta i - \mu i;
\]

According to [13], we obtained:

\[
F = \beta e, V = (\delta + \mu)i
\] (7)

Next, determine the differential from equation (7) obtained: $F = \beta, V = (\delta + \mu)$. (8)

then look for the value $V^{-1}$, obtained:

\[
V^{-1} = \frac{1}{\delta + \mu}
\] (9)

Equation (8) and Equation (9), obtained:

\[
K = F V^{-1} = \beta \left( \frac{1}{\delta + \mu} \right) = \frac{\beta}{\delta + \mu}
\]

so that equation (10) is obtained the basic reproduction number

\[
R_0 = \frac{\beta}{\delta + \mu}
\] (10)

3.5. Model SEIRS simulation for game online addiction cases

Model simulations use Maple software with parameter values and initial values based on research data. The data used in the simulation are primary data on the number of students majoring in mathematics in 2016, 2017, 2018 and 2019 who are vulnerable to online gaming addiction (S), starting to play online games (E), online gaming addiction (I), and apart from online gaming addiction (R) obtained by giving a questionnaire to students. Data collected into initial and parameters values are presented in Table 2.

| Parameter | Value     | Variable | Number of Population | Number of Proportion Sample |
|-----------|-----------|----------|----------------------|-----------------------------|
| $\mu$     | 0.181     | S        | 49                   | 0.17                        |
| $a$       | 0.331     | E        | 220                  | 0.78                        |
| $\beta$   | 0.036     | I        | 2                    | 0.007                       |
| $\delta$  | 0.895     | R        | 13                   | 0.04                        |
| $\theta$  | 0.351     | Total    | 284                  | 1                           |

Substitute the parameter values in Table 2 to equation (1) - (4) and equal to zero, an equilibrium point for online game addiction and eigenvalues is obtained: $(s, e, i, r) = (0.382, 0.584, 0.019, 0.033)$ and $\lambda_1 = -1.089, \lambda_2 = -0.180, \lambda_3 = -0.533, \lambda_4 = -0.533$. If the parameter values are substituted into equation (10), basic reproduction numbers are obtained: $R_0 = 0.0335 < 1$, this shown that the system solution to the point of equilibrium is free of addictions or students who are addicted to online games do not involve other students addicted, thus increasing the level of online gaming addiction in undergraduate students in Mathematics UNM.

The simulation of the SEIRS model for the problem of online game addiction in undergraduate mathematics Universitas Negeri Makassar students is presented in Figure 2.

Figure 2. The variable combination of SEIRS models for online game addiction in UNM Mathematics Department Students
Based on Figure 2 it is found that the number of students majoring in Mathematics UNM who are vulnerable to online game addiction continues to increase and is in a state of equilibrium in the eighth year. Based on Figure 2, it was found that the number of students majoring in Mathematics UNM who began playing online games continued to decline and was in a state of equilibrium after the eighth year. We also obtained the number of mathematics Universitas Negeri Makassar students who are addicted to online games continues to increase and reach a peak in the fourth year, then increase a level in the fourth year and the number of students majoring in Mathematics UNM who are free from online game addiction decreased in the first year and then increased until the fourth year and continued to increase until convergent. The combination of variables S, E, I, and R on the problem of online game addiction in undergraduate Mathematics Universitas Negeri Makassar students is presented in Figure 6:

The simulation model in Figure 6 shows that the number of students of UNM mathematics that is potentially addicted to online game has increased the first eight years and is in a state of loyalty after the eighth year of about 102 students. The number of students trying to play online games has decreased the first eight years and is in a state of loyalty after the eighth year of about 166 students. The number of students addicted to the first four-year online game experienced an increase and decreased in the fourth year to the eighth year. The number of UNM mathematics students who have been detached from online gaming addiction suffered a decline in the first year and then increased until the fourth year and re-increased in the tenth year which is about 9 students from the total sample.

Research on the case of online gaming addiction has been conducted by Mulyani [7] indicating that the lower the level of depression, the lower the level of addiction to online games on students and vice versa. In line with the results obtained by Mulyani [7], the results of the study explained that the level of addiction to online games on UNM mathematics students is not in an alarming condition. In addition, Syahran's research [18] suggests that students' dependence on online game is a case that needs to be addressed, as it is left negative for student learning and psychological. The results of this study explained that the addiction level of online games to UNM mathematics students is not in an alarming and predicted condition will continue to diminish if given a well-informed warning that online games have an unkind impact on psychological students. The results of the Side [8] research on SEIRS model by specializing in cholera, DBD and TB, shown that mathematical models of the stability analysis of infectious diseases provide a equilibrium point that is disease-free and endemic, as well as basic reproduction numbers. In line with the research of the Side [11], the results of this study provided the SEIRS mathematical models against online game addiction issues, an analysis of both the equilibrium point and the purity and simulation of the SEIRS model using Maple to predict the number of UNM mathematics students in the online games addiction. Then, the number of basic reproduction obtained less than one, which shown that UNM mathematics student is online game addicted does not lead to other students addicted.

4. Conclusion
Based on the results and research discussion, it can be concluded that: the social problems of online game addiction, can be explained by the SEIRS mathematics model; The SEIRS model analysis explains the stability and equilibrium point of online game addiction problems; and simulation results using software shown that the number of students addicted to the first four-year online game increased, then decreased until the eighth year and is in a state of loyalty after the eighth year which is about 6 students majoring in mathematics UNM.

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