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A Mathematical Approach Using the SDIR Model with Time Delay to Analyze Indonesian Students Interest in Government Organizations and Internship Programs: A Case Study at Universitas Negeri Makassar

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Abstract

This study is to build a time-delay SDIR model on the case of student interest in Organizations and Government Internship Programs, analyze the model and conduct a model simulation to predict the level of student interest cases in Organizations. This study is a theoretical and applied study. Analysis of the time-delay SDIR model of the case of student interest in Organizations, while the model simulation uses Maple Software. The population of the study was active students of FMIPA UNM, with a sample size of 1029 students obtained using the Sloving technique. The results of this study are a mathematical model of SDIR on the case of student interest in Organizations which is a system of differential equations. The model analysis provides a value of the free equilibrium point of the case of student interest in Organizations and a stable endemic equilibrium point. The results also found that the basic reproduction number value for cases without a solution would produce $\mathrm{R}_0 n = 9.912507841$, *which means that in social cases where one individual can influence 9-10 people in their environment to hesitate to participate in organizational activities or internship programs, but on the other hand if the case is given a solution, it will produce* $\mathrm{R}_0 s = 0.2737372211$, *which means that there is no psychological spread, where each individual does not influence other individuals .*

Keywords: *SDIR Model, Student Interest, Equilibrium Point, Basic Reproduction Number*

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1. Introduction

In the world of education, especially in higher education, there are various activities involving students, one of which is an organization. An organization is an entity formed by a group of people with the aim of achieving a common goal. Generally, organizations have a clear hierarchical structure, articles of association, and internal governance. Although organizations have many benefits, some organizations face the problem of lack of participation and attendance of members in organizational activities. Factors that can cause a lack of member participation in organizational activities include busyness, long distance, lack of support, and unclear organizational goals. According to Ayu [1], lack of member participation in an organization can reduce the effectiveness of the organization and hinder the achievement of organizational goals.

In addition, the lack of good organizational leaders and lack of motivation are also factors causing the lack of member participation in organizational activities. Hasanah [2] stated that good organizational leaders can increase member motivation and participation in organizational activities. Lack of support from organizational members can also worsen the situation. As mentioned by Putri. [3], member support is an important factor in ensuring the sustainability of the organization. Without member support, the organization can lose its appeal and become ineffective.

In addition to campus organizations, internship programs are also one of the activities involving students. Internship programs aim to introduce students to the world of work and provide opportunities to learn and practice directly in the work environment. In Indonesia, the government has launched an internship program as one of the strategies to reduce unemployment and improve the skills of graduates. However, although this internship program has great potential, there is still a lack of internship programs provided by the government. Zahra [4] stated that the lack of internship programs provided by the government can reduce students' opportunities to gain work experience and improve the skills needed in the world of work.

Internship programs provided by the government are also still limited to certain sectors, such as industry and manufacturing, although there are many other sectors that require skilled workers, such as the service and creative sectors. The lack of internship programs in the service and creative sectors can limit students' opportunities to gain work experience in these sectors. In addition, business actors and the government also need to pay attention to the legal aspects related to internship programs. Sugianto et al. [5] stated that there are still companies that do not meet the minimum standards for internship programs, such as providing compensation that is not in accordance with standards and imposing tasks that are not in accordance with students' abilities.

The long-term effects of students' disinterest in participating in government organizations and internship programs can significantly impact their practical experience and skills, ultimately influencing the overall quality of human resources. This study aims to address the issue of low student engagement in government-sponsored organizational activities and internship programs using a mathematical modeling approach. Previous research on government-sponsored organizational activities and internship programs primarily focused on conceptual and descriptive analysis [1-5], without employing mathematical models. In contrast, studies involving mathematical modeling and fuzzy parameters, such as those by Abdi and Annas [6-7], focused on disease modeling but did not explore this particular topic. Therefore, this study will utilize data collected from interviews with undergraduate students at the Faculty of Mathematics and Natural Sciences to examine and analyze the root causes of their lack of interest in these programs. The analysis will be conducted using a mathematical SDIR model, developed through the collaboration of previous studies, with the addition of time delay variables. Through mathematical modeling and simulations, the study aims to develop strategies that will enhance student involvement and participation in government organizations and programs, offering more effective solutions to the challenges faced.

2. Methods

This research is a hypothetical and applicative exploration, with the aim of testing the analysis and simulation of student interest behavior in organizational activities and internship programs, focusing on a case study of Mathematics students at the Faculty of Mathematics and Natural Sciences (FMIPA) Makassar State University (UNM). This research uses a Mathematical Modeling approach and is conducted in the city of Makassar, South Sulawesi.

The data used covers the entire population of South Sulawesi Province, which is around 80,965 individuals. The research process involves several important steps. First, the formulation of the time-delayed SDIR model is carried out to model the distribution of student interest in organizational activities and internships, especially among Mathematics students at FMIPA UNM. This stage involves measuring assumptions, identifying variables, and determining relevant parameters for the time-delayed SDIR model. Furthermore, the time-delayed SDIR model is analyzed by determining the equilibrium point, evaluating the type of stability based on eigenvalues, and calculating the basic reproduction number (R_0). In this context, a high R_0 value indicates a higher level of distribution, while a lower value indicates a lower level of distribution [6].

The final step is a simulation of the time-delay SDIR model to describe the distribution of student interest in organizational and internship activities, using Maple software, in the city of Makassar, South Sulawesi Province. This study provides an important contribution in understanding the impact of student interest on participation in organizational and internship activities, as well as its implications for the development of education among Mathematics students at UNM and the community in general.

3. Results and Discussion

3.1 Formation of SDIR Model of Students' Interest in Government Organizations and Internships Generation Delay Time

In this study, the population was divided into four classes: Susceptible Class (S), which consists of individuals who are susceptible to losing interest in organizational activities and government internship programs, with a total of 233 samples; Doubtful Class (D), which represents individuals who are starting to hesitate to participate in organizational activities and government internship programs due to the influence of their friendship environment, with a total of 180 samples; Isolated Class (I), which represents individuals who have no interest or do not participate in organizational activities and government internship programs, with a total of 484 samples; and Recover Class (R), which shows individuals who have regained interest in organizational activities and government internship programs, with a total of 132 samples. The total sample in this study was 1029, which was obtained through sampling using the Slovin formula against the number of students in the Faculty of Mathematics and Natural Sciences. In this study sample, 79.6% were female and 20.4% were male. Population changes in the context of social cases related to student interests are analyzed using the time-delayed SDIR model, which is illustrated in Figure 1, while the definitions of the variables and parameters of the time-delayed SDIR model are presented in Table 1.

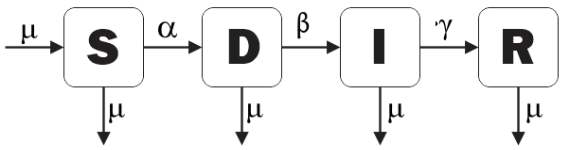


Figure 1. SDIR Model Scheme of student interest in organizational activities and internships.

Table 1. Parameters of the SDIR Model of the time delay of students' interest in organizational activities and internships.

Variable / Parameter	Definition
S(t)	The population is likely to lose interest in organizational activities and government internship programs.
D(t)	The number of population who are hesitant to participate in organizational activities and government internship programs.
I(t)	The number of population that does not have or participate in organizational activities and government internship programs
R(t)	The number of population who have a return interest in organizational activities and government internship programs
N	Total population
α	The rate of population that has doubts about interest in organizational activities and government internship programs.
β	The rate at which the population is losing interest in organizational activities and government internship programs.
γ	The rate at which the population is experiencing renewed interest in organizational activities and government internship programs.
μ	The population rate that enters as new students or transfer students or leaves campus as graduates or Drop Outs

$N = S + D + I + R$, where N is the total sample.

3.2 Data analysis

The data collection process has been previously conducted through the distribution of questionnaires or surveys, both online and offline. Once the data is gathered, an analysis is performed to transform it into quantitative results. This questionnaire-based data is considered annual data because it is collected, analyzed, and reported on a yearly basis, reflecting trends, performance, or changes that occur over the course of the year. The annual collection allows for comparisons across years, providing insights into patterns, progress, and areas for improvement over a 12-month period. After the data is collected, the analysis process is carried out so that it becomes quantitative as follows :

Table 2. Results of Data Analysis related to the SDIR Model Parameters of Social Cases of Organizational Activities and Government Internship Programs.

Parameter	Data	Source
α	0.1746	Online and Offline Questionnaire/Haunted
β	0.4706	
γ	0.598636	
μ	0.17	

3.3 SDIR Model Equilibrium Point Analysis

Based on Figure 1, the SDIR mathematical model is obtained. This can be seen in Equations (1) to (4):

$$\frac{dS}{dt} = \mu - \alpha SI(\tau - \mathrm{t}) - \mu S \tag{1}$$

$$\frac{dD}{dt} = \alpha SI(\tau - \mathrm{t}) - \beta D - \mu D \tag{2}$$

$$\frac{dI}{dt} = \beta D - \gamma \mathrm{I}(\tau - \mathrm{t}) - \mu I(\tau - \mathrm{t}) \tag{3}$$

$$\frac{dR}{dt} = \gamma \mathrm{I}(\tau - \mathrm{t}) - \mu R \tag{4}$$

with $N = S + D + I + R$

3.4 Determining the Equilibrium Point

Equations (1) to (4) have equilibrium points which are solutions to $\frac{dS}{dt}, \frac{dD}{dt}, \frac{dI}{dt}, \frac{dR}{dt} = (0,0,0,0)$. If the right side of the equation is equated to zero, then equations (5) to (8) are obtained, namely :

$$\frac{dS}{dt} = \mu - \alpha SI(\tau - \mathrm{t}) - \mu S = 0 \tag{5}$$

$$\frac{dD}{dt} = \alpha SI(\tau - \mathrm{t}) - \beta D - \mu D = 0 \tag{6}$$

$$\frac{dI}{dt} = \beta D - \gamma \mathrm{I}(\tau - \mathrm{t}) - \mu I(\tau - \mathrm{t}) = 0 \tag{7}$$

$$\frac{dR}{dt} = \gamma \mathrm{I}(\tau - \mathrm{t}) - \mu R = 0 \tag{8}$$

The equilibrium point in this SDIR model is formed by two equilibrium point conditions, namely the free equilibrium point and the equilibrium point.

3.4.1 Free Equilibrium Point

Free can be assumed that there is no population. The free equilibrium point occurs if $I = 0$. In this situation, equations (5) to (8) are used to represent the equilibrium as follows.

Trait 1

free equilibrium points of the SDIR model are given as:

$$(S, D, I, R) = \left(\frac{\mu}{\mu}, 0, 0,0\right)$$

So, based on the free equilibrium point for the SDIR model after the parameter values in table 1 are substituted, it is $(S, D, I, R) = (1, 0, 0, 0)$.

Proof:

By making $I = 0$ equation (7), we obtain equations (9) to (12):

$$I = 0 \tag{9}$$

$$\mu - \alpha SI(\tau - \mathrm{t}) - \mu S = 0$$

$$S = \frac{\mu}{\mu} = 1 \tag{10}$$

$$\alpha SI(\tau - \mathrm{t}) - \beta D - \mu D = 0$$

$$D = \frac{\alpha SI(\tau - \mathrm{t})}{\beta + \mu} = \frac{0}{\mu} = 0 \tag{11}$$

$$^{\gamma}\mathrm{I}(\tau - \mathrm{t}) - \mu R = 0$$

$$R = \frac{\gamma \mathrm{I}(\tau - \mathrm{t})}{\mu} = \frac{0}{\mu} = 0 \tag{12}$$

So, we get an equilibrium point which is symbolized by

$$(S, D, I, R) = \left(\frac{\mu}{\mu}, 0, 0,0\right) \tag{13}$$

3.4.2 Non-Free Equilibrium Point

Determining the non-free equilibrium point is obtained by making the left side of equations (1) to (4) have a value of zero, then looking for a solution in the form of the values of the variables S*, D*, I*, R*.

Trait 2

The endemic equilibrium point of the SDIR model is given as:

$$(S^*, D^*, I^*, R^*) = \left(\begin{array}{c} \dfrac{(\beta\gamma + \beta\mu + \gamma)\mu + \mu^2)}{(\alpha\beta)}, \\ , \dfrac{\mu(-\alpha\beta + \beta\gamma + \beta\mu + \gamma\mu + \mu^2)}{(\beta(\beta + \mu)\alpha)}, \\ \dfrac{\mu(-\alpha\beta + \beta\gamma + \beta\mu + \gamma\mu + \mu^2)}{(\alpha(\beta\gamma + \beta\mu + \gamma\mu + \mu^2))}, \\ \dfrac{\gamma(-\alpha\beta + \beta\gamma + \beta\mu + \gamma\mu + \mu^2)}{(\alpha(\beta\gamma + \beta\mu + \gamma\mu + \mu^2))} \end{array}\right)$$

Proof:

Making the simple algebraic operation equation from equations (2 & 3) to be zero, we obtain equations (14 & 15).

$$I1 = \frac{\beta D}{\gamma + \mu} \tag{14}$$

$$I2 = \frac{\beta D + \mu D}{\alpha S} \tag{15}$$

$$\frac{\beta D}{\gamma + \mu} = \frac{\beta D + \mu D}{\alpha SI(\tau - \mathrm{t})}$$

$$\gamma + \mu(\beta D + \mu D) = \alpha SI(\tau - \mathrm{t})(\beta D)$$

$$\gamma + \mu(\beta + \mu) = \alpha SI(\tau - \mathrm{t})(\beta)$$

$$S = \frac{\gamma + \mu(\beta + \mu)}{\alpha(\tau - \mathrm{t})(\beta)}$$

$$S = \frac{(\beta\gamma + \beta\mu + \gamma\mu + \mu^2)}{\alpha(\tau - \mathrm{t})(\beta)}$$

Then the value of s* $= \frac{(\beta\gamma + \beta\mu + \gamma\mu + \mu^2)}{\alpha(\tau - \mathrm{t})(\beta)}$ (16)

with equations (2 & 3) equated to zero, we obtain equation (17).
Substitute S* then,

$$D = \frac{\alpha SI(\tau-\mathrm{t})}{\beta+\mu} = \frac{\alpha I(\tau-\mathrm{t})\frac{(\beta\gamma+\beta\mu+\gamma\mu+\mu^2)}{(\alpha\beta)}}{\beta+\mu} = \frac{\alpha I(\tau-\mathrm{t})(\beta\gamma+\beta\mu+\gamma\mu+\mu^2)}{(\beta+\mu)(\alpha\beta)} = \frac{\mu(-\alpha\beta+\beta\gamma+\beta\mu+\gamma\mu+\mu^2)(\tau-\mathrm{t})}{(\beta(\beta+\mu)\alpha)} \quad (17)$$

Thus, the value $D^* = \frac{\mu(-\alpha\beta+\beta\gamma+\beta\mu+\gamma\mu+\mu^2)(\tau-\mathrm{t})}{(\beta(\beta+\mu)\alpha)}$ (18)

with equation (3) equated to zero, then equation (19) is obtained.
Substitute E* then,

$$I = \frac{\beta\left(\frac{\mu(-\alpha\beta+\beta\gamma(\tau-\mathrm{t})+\beta\mu+\gamma(\tau-\mathrm{t})\mu+\mu^2)}{(\beta(\beta+\mu)\alpha)}\right)}{\gamma+\mu} = \frac{\mu(-\alpha\beta+\beta\gamma(\tau-\mathrm{t})+\beta\mu+\gamma(\tau-\mathrm{t})\mu+\mu^2)}{(\alpha(\beta\gamma(\tau-\mathrm{t})+\beta\mu+\gamma(\tau-\mathrm{t})\mu+\mu^2))} \quad (19)$$

Thus, the value $I^* = \frac{\mu(-\alpha\beta+\beta\gamma+\beta\mu+\gamma\mu+\mu^2)}{(\alpha(\beta\gamma+\beta\mu+\gamma\mu+\mu^2))}$ (20)

with equation (4) equated to zero, then equation (21) is obtained.
Substitute L* then,

$$R = \frac{\gamma\left(\frac{\mu(-\alpha\beta+\beta\gamma+\beta\mu+\gamma\mu+\mu^2)}{(\alpha(\beta\gamma+\beta\mu+\gamma\mu+\mu^2))}\right)}{\mu} = \frac{\mu(-\alpha\beta+\beta\gamma+\beta\mu+\gamma\mu+\mu^2)}{(\alpha(\beta\gamma+\beta\mu+\gamma\mu+\mu^2))} \quad (21)$$

Thus, the value $R^* = \frac{\gamma(-\alpha\beta+\beta\gamma+\beta\mu+\gamma\mu+\mu^2)}{(\alpha(\beta\gamma+\beta\mu+\gamma\mu+\mu^2))}$ (22)

So, we obtain the non-free equilibrium points which are symbolized by (S*, D*, I*, R*) as follows:

$$(S^*, D^*, I^*, R^*) = \begin{pmatrix} \frac{(\beta\gamma+\beta\mu+\gamma\mu+\mu^2)}{(\alpha\beta)}, \\ , \frac{\mu(-\alpha\beta+\beta\gamma+\beta\mu+\gamma\mu+\mu^2)}{(\beta(\beta+\mu)\alpha)}, \\ \frac{\mu(-\alpha\beta+\beta\gamma+\beta\mu+\gamma\mu+\mu^2)}{(\alpha(\beta\gamma+\beta\mu+\gamma\mu+\mu^2))}, \\ \frac{\gamma(-\alpha\beta+\beta\gamma+\beta\mu+\gamma\mu+\mu^2)}{(\alpha(\beta\gamma+\beta\mu+\gamma\mu+\mu^2))} \end{pmatrix}$$

And then, the equilibrium point for the social bullying case after the parameter values in table 1. Substituted is (S*, D*, I*, R*) = (5.992266946, 1.324828880, 0.8111689710, 2.856269094). The Susceptible class (S*= 5.992266946) indicates that only a small number of students are susceptible to disengagement at equilibrium, suggesting that most students are influenced relatively quickly, either towards doubt or isolation. The Doubtful class (D* = 1.324828880) is similarly low, showing that few students remain in a prolonged state of hesitation due to peer or environmental factors. The Isolated class (I* = 0.8111689710) shows that fewer students persist in complete disengagement over time, indicating a natural or peer-influenced tendency for students to either remain open to engagement or regain interest eventually. The Recovered class (R* = 2.856269094) is relatively higher, which reflects that a significant portion of students return to active participation in organizational and internship activities at equilibrium. Overall, these equilibrium values suggest that students are generally inclined towards engagement, with most ultimately overcoming doubt or isolation, possibly due to effective social influences or motivational factors that encourage re-engagement over time.

3.5 Stability of SDIR Model

Based on equations (1) - (4), the Jacobian matrix (J) can be formed as follows::

$$J = \begin{bmatrix} -\alpha I(\tau - t) - \mu & 0 & -\alpha s & 0 \\ \alpha I(\tau - t) & -\beta - \mu & \alpha s & 0 \\ 0 & \beta & -\gamma - \mu & 0 \\ 0 & 0 & \gamma & -\mu \end{bmatrix} \quad (23)$$

Theorem

The equilibrium point in the SLER model is considered stable if the basic reproduction number (R0) is less than or equal to 1 ($R_0 \leq 1$), and is considered unstable if R_0 is greater than 1 ($R_0 > 1$) [7].

Proof:

The equilibrium points generally represent free and non-free equilibrium states, which are incorporated into the J matrix in equation (23),

$$J = \begin{bmatrix} -\alpha I(\tau - t) - \mu & 0 & -\alpha s & 0 \\ \alpha I & -\beta - \mu & \alpha s & 0 \\ 0 & \beta & -\gamma - \mu & 0 \\ 0 & 0 & \gamma & -\mu \end{bmatrix}$$

Then, the eigenvalues of the matrix in equation (23) are determined, with the following description:

$$|\lambda I - J| = 0$$

- $$|\lambda I - J| = \left| \left(\lambda \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} - \begin{bmatrix} -\alpha I(\tau - t) - \mu & 0 & -\alpha s & 0 \\ \alpha I(\tau - t) & -\beta - \mu & \alpha s & 0 \\ 0 & \beta & -\gamma - \mu & 0 \\ 0 & 0 & \gamma & -\mu \end{bmatrix} \right) \right| = 0$$

$$|\lambda I - J| = \left| \begin{bmatrix} -\alpha I\gamma - \mu - \lambda & 0 & -\alpha s & 0 \\ \alpha I(\tau - t) & -\beta - \mu - \lambda & \alpha s & 0 \\ 0 & \beta & -\gamma - \mu - \lambda & 0 \\ 0 & 0 & \gamma & -\mu - \lambda \end{bmatrix} \right| = 0 \quad (24)$$

Next, the determinant will be calculated, resulting in:

$$\alpha\beta\gamma I(\tau - t)\lambda + \alpha\beta\gamma I(\tau - t)\mu + \alpha\beta I(\tau - t)\lambda^2 + 2\alpha\beta I(\tau - t)\lambda\mu + \alpha\beta I(\tau - t)\mu^2 - \alpha\beta\lambda^2 s - 2\alpha\beta\lambda\mu s - \alpha\beta\mu^2 s + \alpha\gamma I(\tau - t)\lambda^2 + 2\alpha\gamma(\tau - t)I\lambda\mu + \alpha\gamma(\tau - t)I\mu^2 + \alpha I(\tau - t)\lambda^3 + 3\alpha I(\tau - t)\lambda^2\mu + 3\alpha I(\tau - t)\lambda\mu^2 + \alpha I(\tau - t)\mu^3 + \beta\gamma\lambda^2 + 2\beta\gamma\lambda\mu + \beta\gamma\mu^2 + \beta\lambda^3 + 3\beta\lambda^2\mu + 3\beta\lambda\mu^2 + \beta\mu^3 + \gamma\lambda^3 + 3\gamma(\tau - t)\lambda^2\mu + 3\gamma\mu^2 + \gamma\mu^3 + \lambda^4 + 4\lambda^3\mu + 6\lambda^2\mu^2 + 4\lambda\mu^3 + \mu^4 \quad (25)$$

Based on Descartes' sign rule, equation (25) will have roots that are all negative if all the signs in each are positive. Therefore, it can be concluded that the equilibrium point is considered stable when $R\,0 \leq 1$ and unstable when $R\,0 > 1$.

3.6 Eigenvalues

Based on equation (25), the eigenvalues obtained from the values (λ) obtained at the previous equilibrium point are real and negative numbers. Referring to the stability properties, the type of stability at this equilibrium point is asymptotically stable. So, the stability of the SDIR model of the social case related to organizational activities and government internship programs is (S,D,I,R) = $(-0.1700000000, -0.1700000000, -0.99830522640, -0.41089477360)$ and (S*, D*, I*, R*) = $(-1.3 \text{ x } 10^{-22}, -4.174249888\, x\, 10^{-11}, 9.260254038\, x\, 10^{-22}, -0.17)$. Therefore, the type of stability at both equilibrium points is asymptotic stability.

3.7 Basic Reproduction Number

The basic reproduction number (R_0) can be determined using the next generation matrix method. This matrix is formed by considering the positive and negative components of the transmission rate from the SDIR model. The formula for calculating the basic reproduction number can be found in equations (2 & 3):

$$R = F' \cdot (V')^{-1} \tag{26}$$

Based on the Equation

$$\frac{dD}{dt} = \alpha SI - \beta D - \mu D = 0 \tag{27}$$

$$\frac{dI}{dt} = \beta D - \gamma(\tau - t)I - \mu I = 0 \tag{28}$$

So that it is obtained

$$F = \begin{bmatrix} \alpha SI \\ 0 \end{bmatrix}, F' = \begin{bmatrix} 0 & \alpha S \\ 0 & 0 \end{bmatrix} \tag{29}$$

$$V = \begin{bmatrix} \beta D + \mu D \\ \gamma I(\tau - t) + \mu I(\tau - t) + \beta D \end{bmatrix}, V_h{}' = \begin{bmatrix} \beta + \mu & 0 \\ \beta & \gamma + \mu \end{bmatrix} \tag{30}$$

Then we get the inverse of the matrix equation (30), namely

$$(V')^{-1} = \begin{bmatrix} \frac{1}{\beta+\mu} & 0 \\ \frac{\beta}{(\beta+\mu)(\gamma+\mu)} & \frac{1}{\gamma+\mu} \end{bmatrix} \tag{28}$$

Next, the eigenvalues of the R matrix will be determined, based on Equation (26).

$$R = \begin{bmatrix} 0 & \alpha S \\ 0 & 0 \end{bmatrix} \begin{bmatrix} \frac{1}{\beta+\mu} & 0 \\ \frac{\beta}{(\beta+\mu)(\gamma+\mu)} & \frac{1}{\gamma+\mu} \end{bmatrix}$$

$$R = \begin{bmatrix} \frac{\alpha S\beta}{(\beta+\mu)(\gamma+\mu)} & \frac{\alpha S}{\gamma+\mu} \\ 0 & 0 \end{bmatrix} \tag{31}$$

After obtaining the matrix$R$ in equation (31), the eigenvalues will then be searched for using the formula $Det(\lambda I - R) = 0$, where I is the identity matrix. The basic reproduction number will be determined based on the largest eigenvalues (λ).

$$|\lambda I - R| = \left| \left(\lambda \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} - \begin{bmatrix} \frac{\alpha S\beta}{(\beta+\mu)(\gamma+\mu)} & \frac{\alpha S}{\gamma+\mu} \\ 0 & 0 \end{bmatrix} \right) \right| = 0 \tag{32}$$

So by using the matrix addition operation above, two lambda values are obtained which are eigenvalues based on equation (32), namely

$$\lambda_{1,2} = \left[\frac{\alpha S\beta}{(\beta+\mu)(\gamma+\mu)}, 0\right]$$

So the lambda value above is the largest eigenvalue, namely

$$\lambda = \left[\frac{\alpha S\beta}{(\beta+\mu)(\gamma+\mu)}\right]$$

with the largest lambda value compared to λ_2 the assumption of parameter rates and the presence of a population in the model. So based on the largest eigenvalue substituted for the free equilibrium point value, the basic reproduction number is obtained:

$$R_0 = \frac{\alpha\mu\beta}{(\beta+\mu)(\gamma+\mu)\mu} \tag{33}$$

The basic reproduction number for cases without intervention is $R_0 n = 9.9125$, which indicates that in social contexts, one individual can influence 9 to 10 people to hesitate or withdraw from participating in organizational activities or internship programs. However, when a solution is applied to the case, the basic reproduction number decreases to $R_0 s = 0.2737$, suggesting that there is no psychological spread, meaning individuals no longer influence each other in this case.

3.8 Simulation Results of the SDIR Model for the Potential Growth of Student Interest in Government Organizations and Internships with Time Delay

In this case, a simulation will be carried out based on the data that has been successfully collected as follows and displayed in the following graph:

The SDIR mathematical model simulation can be seen in Figures 2 & 3 as follows.

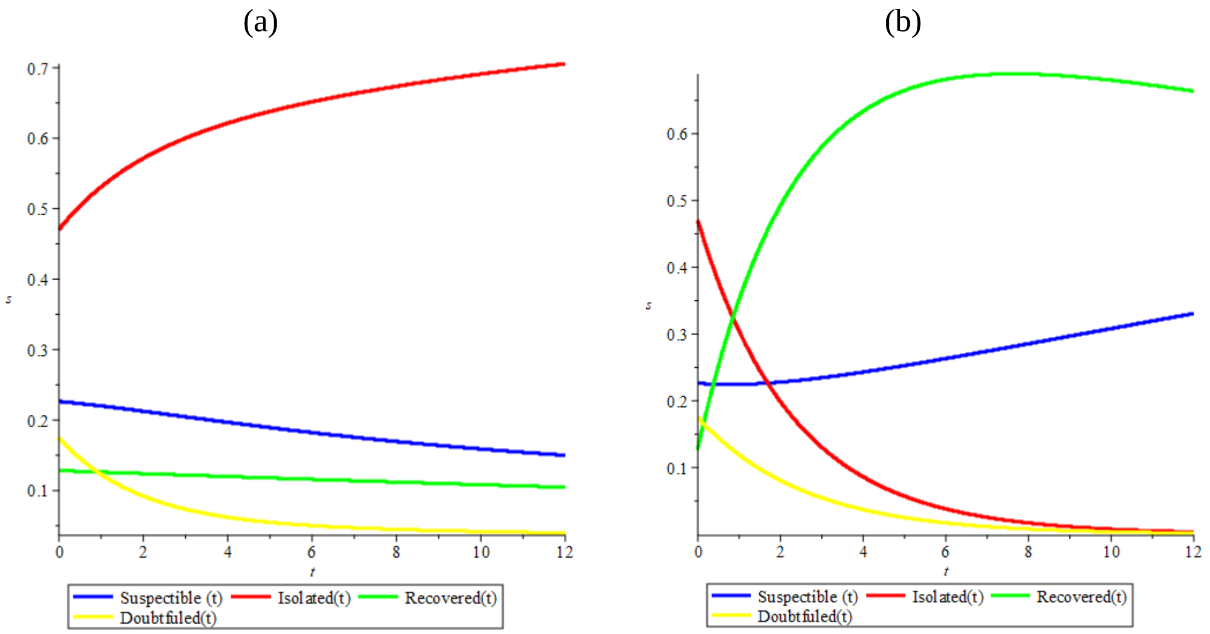
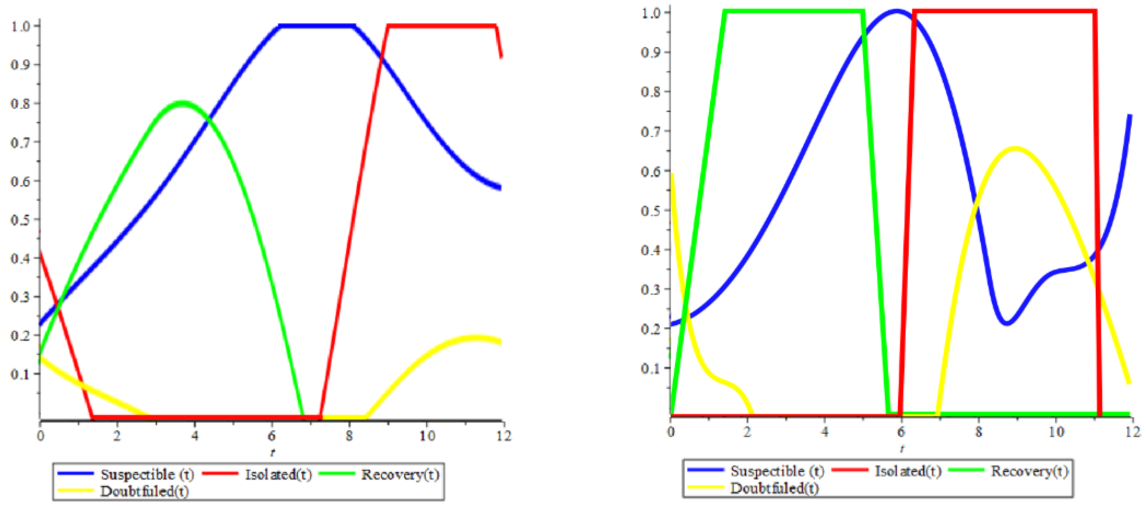


Figure 2. Plot of SDIR model with and without solution for the decreasing interest in organizational activities and government internship programs.



(a) (b)

Figure 3. Plot of SDIR model with and without solution with additional 3-month handling delay time against decreasing interest in organizational activities and government internship programs.

In Figure 2.a, it can be seen that the number of vulnerable samples decreased from the initial observation of 0.24 to 0.19 within 12 months. The sample of individuals influenced by friends and their environment also decreased from 0.19 to almost zero in the same period. Meanwhile, the sample that initially had doubts showed a significant increase from 0.48 to 0.7 within 12 months. Finally, for samples that were free from social cases, there was a definite decrease of 1% to 3%, which will continue constantly if no prevention is carried out within 12 months.

In Figure 2.b, it can be seen that the number of vulnerable samples increased from 0.23 to 0.29 in 12 months. The sample of individuals affected by the environment also decreased from 0.19 to almost zero in the same period. This also happened to individuals who experienced doubt, where it was initially at 0.48 and decreased to almost zero in 12 months. Furthermore, the individual experienced a very significant increase until the 7th month with a peak at 0.68 after receiving therapy, counseling, seminars, and others, although after the 7th month it decreased by about 5% until the 12th month.

In Figure 3.a, it can be seen that the number of susceptible samples increased from the initial observation of 0.24 to 1 in 6 months, then remained constant for 2 months before decreasing again in the following month. Samples of individuals influenced by friends and their environment also decreased from 0.19 to almost zero in the first month, remained constant for 5 months, and then increased again. Meanwhile, samples that initially had doubts showed a decrease in the first month to zero for 5 months, then increased significantly to 1 in 1 month, remained constant for almost 3 months, and finally decreased again. For samples that were free from this case, a stable increase of 0.6 was seen for 4 months, then decreased significantly to zero in 2 months, and this trend continued until the 12th month.

In Figure 3.b, it can be seen that the number of susceptible samples increased from 0.23 to 1 in 6 months, then decreased until the 8th month and increased again in the following month. The sample of individuals affected by the environment decreased from 0.19 to zero in 2 months, then increased again in the 7th month before decreasing again in the 9th month. A similar phenomenon is seen in individuals who experience doubt, where it was initially at 0.48, then decreased to almost zero in 1 month, then increased again in the 6th month, reached the entire population in 1 month, and remained constant for 5 months. Furthermore, these individuals experienced a very significant increase in 1 month, peaking in the entire population after receiving therapy, counseling, seminars, and others, although it decreased after the 5th month to zero and remained constant until the 12th month.

In general, the results of the SDIR mathematical model simulation in the FMIPA UNM environment can be seen through the basic reproduction number or R_0, which describes the potential for spread in a population. In the case without a solution, the basic reproduction number is obtained as $R_0 n = 9.91250784$, which means that in these social conditions, one individual can influence around 9-10 people around him to feel hesitant in participating in organizational activities or internship programs. Conversely, if a solution is given, $R_0 s = 0.273737221$ will be obtained, which indicates that there is no psychological spread, where each individual does not influence other individuals.

3.9 Discussion

The simulation results in this study show interesting developments related to the problems discussed. In Figure 2.a, which is the result of a simulation without a solution, it can be seen that the number of vulnerable samples decreased from the initial observation of 24% to 19% within 12 months. This indicates a decrease in the level of uncertainty or doubt in participating in organizational activities or internship programs among respondents. Furthermore, the sample of individuals influenced by friends and their environment also decreased from 19% to almost zero in the same period. This indicates a positive effect of a supportive environment in overcoming doubt or negative influence from friends.

However, the sample that initially had doubts showed a significant increase from 48% to 70% in 12 months. This could indicate that without intervention, doubts among these individuals increased, perhaps due to social pressure or ongoing uncertainty. On the other hand, for the sample that was free of social cases, there was a definite decrease of 1% to 3%, which would continue to be constant if no prevention was carried out in 12 months.

In Figure 2.b, which shows the simulation results with the solution, it can be seen that the number of vulnerable samples increased from 23% to 29% in 12 months, indicating that the implemented solution has helped increase the confidence or certainty of individuals in participating in organizational activities or internship programs. The sample of individuals who were initially affected by the environment also decreased from 19% to almost zero in the same period. This shows that solutions such as therapy, counseling guidance, and seminar programs have succeeded in reducing the negative influence of the environment.

Individuals who initially had doubts experienced a decline from 48% to almost zero in 12 months, but then experienced a very significant increase until the 7th month with a peak at 68% after receiving the solution, although after the 7th month it decreased by about 5% until the 12th month. This shows that the solution provided is able to stabilize the individual's condition, but needs to be continuously monitored and strengthened to prevent further decline.

In Figures 3.a and 3.b, with a case study of a 3-month delay in action, it can be seen that the number of vulnerable samples increased significantly from 24% and 23% to 100% in 6 months, before decreasing or stabilizing. Samples of individuals who were influenced by their friends and environment and who initially had doubts showed a fluctuating pattern, with a drastic decrease at the beginning, followed by an increase again in the following months. This indicates that a delay in implementing solutions can lead to increased doubts or negative influences from the environment, which ultimately require further intervention to overcome.

In general, the results of the SDIR mathematical model simulation in the FMIPA UNM environment reflect the impact of the solutions provided on existing problems. The calculated reproduction number R_0 has an important meaning. In the case without a solution, $R_0 n = 9,912507841$ indicates that one individual can influence about 9-10 other people in his environment to feel hesitant in participating in organizational activities or internship programs. However, with the application of the solution, $R_0 s = 0,2737372211$ indicates that there is no psychological spread, where each individual does not influence other individuals.

Compared with previous studies, this study offers a more integrated approach by using mathematical modeling to predict and simulate outcomes. The STIE Pancasetia study [8] and other studies [9] and [10] provided qualitative analysis without applying quantitative methods or mathematical modeling. They focused on literature review and descriptive analysis, while this study uses mathematical modeling to explore the dynamics of student interest. Previous mathematical modeling studies [6-7, 11-26] focused on the spread of disease, but none have applied mathematical models to student interest in organizational activities. By combining literature review with mathematical modeling methods, this study not only provides an in-depth understanding of the factors that influence student interest but also offers a simulation-based solution that can increase student participation in organizational activities and government internship programs.

So based on the discussion above, in the context of students' interest in government organizations and internship programs, this mathematical model has helped in analyzing the factors that influence these interests. The simulation results show that positive changes in students' interests can be achieved through solutions such as therapy, counseling guidance, and seminar programs. This is important in creating a young generation that is active and committed to national development through participation in government organizations and internship programs. In addition, this study also provides useful insights in the context of developing students' interests in various educational and community development contexts.

4. Conclusion

In this study, a 4-dimensional SDIR mathematical model was developed to analyze the dynamics of students' interest in organizational activities and government internship programs. This model includes two equilibrium points, namely free and dependent equilibrium, which show asymptotic stability. The analysis reveals that the basic reproduction number for the case without a solution yields $R_0 n = 9.91250784$, indicating that one individual can influence 9-10 others to hesitate in participating. Conversely, with interventions like psychological therapy, counseling, and seminars, the basic reproduction number decreases to $R_0 s = 0.273737221$, meaning there is no psychological spread, and individuals no longer influence others in their environment.

Additionally, the analysis suggests that time delay can amplify hesitation effects, as a delayed response to students' uncertainties may allow doubts to propagate more broadly. Thus, timely interventions are critical to mitigating these impacts. Overall, this model provides valuable insights into the importance of addressing hesitation through timely interventions, as well as through psychological therapy, counseling, and seminars. These solutions help individuals identify and resolve the causes of their doubts, fostering confidence and promoting engagement in organizational activities and internship programs. These findings underscore the need for well-timed and effective interventions to support students' interest in education and community development contexts.

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