Knowledgeable Research (An International Peer-Reviewed Multidisciplinary Journal) **ISSN 2583-6633**
Available Online: http://knowledgeableresearch.com/ Vol.03, No.1, August, 2024

Facts of Epidemic Mathematical Model for Slow Learners

[1]Rajeev Kishore, [2]Vinod Pal, [3]Kamlesh K Sharma and [4]Bhed Pal Gangwar
[1,2]Galgotias College of Engineering & Technology, Greater Noida, [3]IIMT University, Meerut,
[4]Government Polytechnic, Unnao, U.P.

****

Abstract

Learning disabilities, disorder or difficulty is a state of the brain that causes the difficulties to comprehend the messages or information is being transferred from one to another. Hence some people can be more accurate and precise to comprehend the topic. Similarly, this paper intensive over all difficulties has been noticed among the slow learners' leanings and in their behaviour in the classroom observation. Our efforts through the paper can bring the advanced improvements by using (SEIR) Mathematical model to improve the condition of slow learners' leaning and in their behaviours. It is universal proven that all living creatures adopt the social behaviour from the environment they exist in. The learners adopt the habits from their closes one such as family members, friends, society and institutions etc. and these play crucial role to shape the personality of the learner. Moreover, some cultural and curricular activities also may affect learners' academic developments. The reported study aims to explain the impact of learners' innovative teaching skills and behaviour on their academic achievement in the current scenario is slow learners' awareness, motivation, social interaction, sports, and academic interests. Similarly slow learners can successfully develop their innovative abilities and learning behaviours through the suggested model. This mathematical model can assist in identifying learners' innovative teaching skills and learning behaviours.

Key Points: *SEIR Model, Reproduction Number, Slow learners' learning and behaviour, Stability*

****

INTRODUCTION: Teaching skills and behavior of a teacher will also encourage the slow learners' lives for the continuous development in society. There are numbers of problems in learners' learning skills and behavior skills which affects their daily routine of life such as family environment, friends' environment, social environment and working place etc. Here Mathematical models are positively going to boost the interest of the slow learners with Mathematical model and this also does the critical study of the issues surrounding of the slow learners like pollution, infections, and rumors of society. The SEIR model, analogizing learning behavior with infectious diseases, helps to understand learners' problems which affects their learning and helps to develop slow learners' innovative learning skills and behavior. This model aims to simplify mathematical understanding, model construction, organize problems, interpret solutions, and validate. It helps to detect the diffusion of learners' learning behavior in real-world and learner's performance academic and universal both. It is greatly influencing the family members and its circumstances. Negative educational conditions, social disruptions, and ineffective instruction can all contribute to sluggish learning. Learners those possess intelligence below the average are known as slow learners in comparison to their peers. Slow

learners' motivation is a central element in the teaching process that influences theirs target to set career.

The SEIR model diagnoses the prominence of motivation in learning behavior and also discovers motivational teaching pedagogy and learning methods in order to assess academic achievements. Academic performance influences learners' behavior and support to enhance their social skills. Motivation is a crucial part of the education system and an essential component of a nation's growth. Teacher is only the source to make a learner proud in academic field and bring out the children's inner talents out. Slow learners get developed their learning skills with the support of this suggested SEIR model and happy when eligible teacher comes in their contact and start his/her teaching pedagogy with the experiments to apprehend the reasons and circumstances behind. The teacher identify the issues of a slow learner and make available them positive reinforcement to think more deeply about their studies. If it does not happen, the learner can lose his/her confidence and noted as illiterate. One of the most crucial factors in the teaching-learning process is academic success. Teachers need to understand learning options and create more study tactics to evaluate academic chances with the assistance of academic counselors for their learner's and parents need to cooperate with the teachers and help them by their regular support. Similarly, teachers and parents support may get the good results in their wards' results and help them to become successful learners to raise their literacy. These educational opportunities in the future may help the learners a nation creator respectively. Hence, they are important for the nation development. In the present study, Denny Beatriz Moreira-Morales and María Inés García-Loor [1] have studied the role of motivation in academic performance. The academic performance and motivation in medical learners have been discussed by Khalid A. Bin Abdulrahman et al. [2]. One of the most crucial principles of motivation and learning was proposed by Al-Osaimi and Fawaz [3]. A mathematical model incorporating the effects of learning motivation and learner social interaction has been presented by Mutiawati, J. Rahmah, et al. [4]. In the literature, several analysts have utilized the epidemic model to demonstrate that some curricular activities affect learners' academic achievement as well as overall development in a direct or indirect manner. This model offered a more standard classical model for learner learning behavior, based on the biological or computer epidemic model [5, 6] as well as the SEIR epidemic model.

In Mathematical Modeling for Slow Learners, F. Setyawan et al. [7] discussed about the need for rigorous thought. Slow learners will be happier in the classroom if the teacher can bring out the inherent talents of the learners through the use of various situations, according to Appaji Korikana. [8]. The effects of academic desire and metacognitive awareness on academic accomplishment are discussed by Abdelrahman, R. M. [9]. Meta-cognitive behavior and mathematical modeling skills were examined by Hidayat, R., et al. [10]. The assessment procedures for mathematics learners who are the slow learners have been examined by Khaira, U., et al. [11]. Those who were slow learners are mostly just ordinary learners who have little interest in learning within the confines of an established educational framework. A slow learning process could be caused by a plethora of reasons [12, 13, 14, and 15]. The use of mathematical models in population biology and epidemiology was examined by Brauer, F. et al. [17] in 2010. In terms of education, there are four categories under which the study of slow learners is defined: the slow learners who are not actually slow learners but engaged in some abnormal behavior and activities, slow learners who actively participate in academic pursuits and

Knowledgeable Research (An International Peer-Reviewed Multidisciplinary Journal) **ISSN 2583-6633**
Available Online: http://knowledgeableresearch.com/ Vol.03, No.1, August, 2024

engage in social interactions, and slow learners, which represent learners who have improved themselves through activities. The study uses a computational mathematical model and a qualitative method to understand the learning behavior and Innovative teaching skills for slow learners. The SEIR mathematical model and a qualitative approach are used in this study to describe the critical thinking of slow learners. As per our slow learners' classroom observation if a learner interacts with peers of the same age group it boosts the learner's self-esteem. Right now, one of the finest strategies for parents and teachers of learners who are slow learners are to encourage them to study in groups. Hence the Mathematical model will help to support the development of learners' extrovert and introvert innovative teaching skills and behaviors. This mathematical model can be used to track the dissemination of learners' creative learning methods to change the slow learners' real-world behavior. For slow learners, increasing awareness, motivation, social connection, athletics, and academic interests might be an effective way to boost their innovative talents.

2. Model Construction:

In this model, A represents learners who are slow learners, B represents learners who are not slow learners but engage in abnormal behavior, C represents learners who actively participate in non-academic pursuits and social interactions, and D stands for those learners who have improved themselves through academic activities and teacher motivation at time t. The mathematical paradigm for slow learners is shown schematically below.

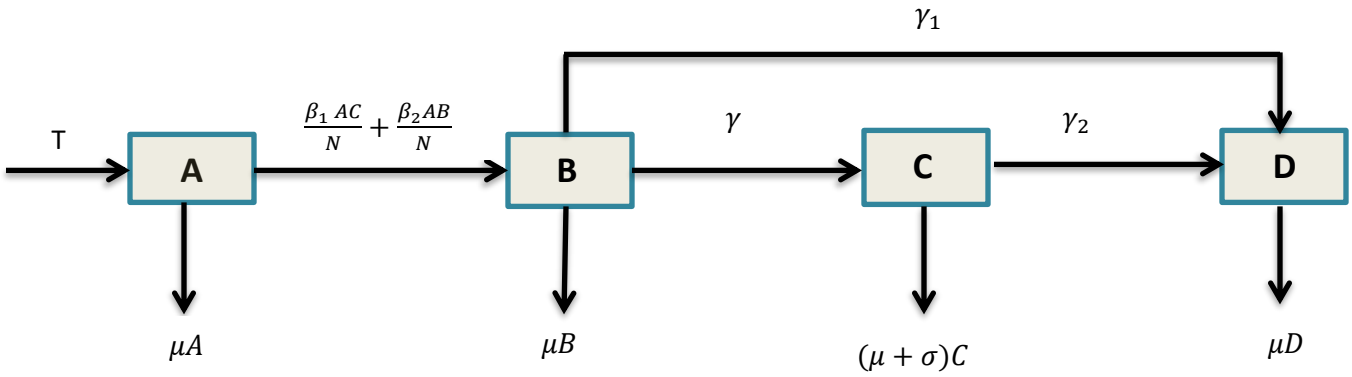


Figure-1 Mathematical flowchart of slow learners

According to our assumption regarding slow learners, the following nonlinear differential equation represents the above mathematical computational epidemic model.

$$\left.\begin{aligned}
\frac{dA}{dt} &= T - \frac{\beta_1 AC}{N} - \frac{\beta_2 AB}{N} - \mu A \\
\frac{dB}{dt} &= \frac{\beta_1 AC}{N} + \frac{\beta_2 AB}{N} - \gamma B - \gamma_1 B - \mu B \\
\frac{dC}{dt} &= \gamma B - \sigma C - \gamma_2 C - \mu C \\
\frac{dD}{dt} &= \gamma_1 B - \gamma_2 C - \mu D
\end{aligned}\right] \qquad (2)$$

Knowledgeable Research (An International Peer-Reviewed Multidisciplinary Journal) **ISSN 2583-6633**
Available Online: http://knowledgeableresearch.com/ Vol.03, No.1, August, 2024

As of right now, the system (1)'s feasible area is described as $\varphi = \{(A, B, C, D)\epsilon R^4: A > 0, B \geq 0, C \geq 0, D \geq 0, A + B + C + D \leq 1\}$. In relation to system (2), this feasible area φ is positively invariant. As a result, model is presented both mathematically and epidemiologically.

Table 1: The mathematical model's epidemiological coefficients

Symbol	Description
A	Represent learners who are slow learners
B	Learners who are not slow learners but engage in abnormal behavior
C	Represent learners who actively participate in non-academic pursuits and social interactions.
D	Stands for learners who, during academic activities and motivation at time t, have improved themselves.
T	Constant admitted learners
β_1	Transmission rate between individuals A and C
β_2	Transmission rate between individuals A and B
γ	Rate at which the individuals B join the other individuals C
γ_1	Improvement rate of individuals B
γ_2	Improvement rate of individuals C
σ	Quit rate slow learners through slow learning process
μ	Natural quit rate of learning process
N	Total strength

3. Basic Reproductive Number R_0 :

The Next Generation Method is the most popular technique for calculating reproduction number. The value of reproduction number R_0 determines whether a model succeeds or fails. The model is stable in a feasible area if and only if $R_0 \leq 1$, and unstable in a feasible region φ if and only if $R_0 > 1$. The fundamental reproduction number of system (1) is as follows:

To determine R_0 from the mathematical model of individual class B and C

$$\frac{dB}{dt} = \frac{\beta_1 AC}{N} + \frac{\beta_2 AB}{N} - \gamma B - \gamma_1 B - \mu B$$

$$\frac{dC}{dt} = \gamma B - \sigma C - \gamma_2 C - \mu C$$

With the help of infectious individual class B and C, we get Transmission matrix F and Transition matrix V

$$F = \begin{bmatrix} \beta_2 & \beta_1 \\ 0 & 0 \end{bmatrix} \quad \text{and} \quad V = \begin{bmatrix} \gamma + \gamma_1 + \mu & 0 \\ -\gamma & \sigma + \gamma_2 + \mu \end{bmatrix}$$

Determine V^{-1}

Now $$V^{-1} = \frac{1}{(\gamma+\gamma_1+\mu)(\sigma+\gamma_2+\mu)}\begin{bmatrix}\sigma+\gamma_2+\mu & 0\\ \gamma & \gamma+\gamma_1+\mu\end{bmatrix}$$

Determine FV^{-1}

$$FV^{-1} = \frac{1}{(\gamma+\gamma_1+\mu)(\sigma+\gamma_2+\mu)}\begin{bmatrix}\beta_2 & \beta_1\\ 0 & 0\end{bmatrix}.\begin{bmatrix}\sigma+\gamma_2+\mu & 0\\ \gamma & \gamma+\gamma_1+\mu\end{bmatrix}$$

$$FV^{-1} = \frac{1}{(\gamma+\gamma_1+\mu)(\sigma+\gamma_2+\mu)}\begin{bmatrix}\beta_2(\sigma+\gamma_2+\mu)+\beta_1\gamma & \beta_1(\gamma+\gamma_1+\mu)\\ 0 & 0\end{bmatrix}$$

The greatest Eigen value of the matrix FV^{-1} is basic reproduction number R_0

Now basic reproduction number R_0 is expressed as

$$R_0 = \frac{\beta_2(\gamma_2+\sigma+\mu)+\beta_1\gamma}{(\gamma_2+\sigma+\mu)(\gamma+\gamma_1+\mu)}$$

$$R_0 = \frac{\beta_2}{(\gamma+\gamma_1+\mu)} + \frac{\beta_1\gamma}{(\gamma_2+\sigma+\mu)(\gamma+\gamma_1+\mu)}$$

4. Stability Analysis of Equilibrium:

We shall ascertain the equilibrium points of the system (2) and investigate their stability in this section. Now equilibrium points will be obtain by using the following equations.

$$T - \frac{\beta_1 AC}{N} - \frac{\beta_2 AB}{N} - \mu A = 0$$

$$\frac{\beta_1 AC}{N} + \frac{\beta_2 AB}{N} - \gamma B - \gamma_1 B - \mu B = 0$$

$$\gamma B - \sigma C - \gamma_2 C - \mu C = 0$$

$$\gamma_1 B - \gamma_2 C - \mu D = 0$$

1. **Equilibrium points free from abnormal learning behavior** $E_0(A_0, B_0, C_0, D_0) = (\frac{T}{\mu}, 0,0,0)$

   The equilibrium point is unaffected by learning behaviors when there are no abnormal learning behaviors among the learners.

2. **Point of endemic equilibrium (abnormal learning behavior consistently exists yet has a specific range)** $E^*(A_0, B_0, C_0, D_0) = (A^*, B^*, C^*, D^*)$

   When a learner begins to display abnormal learning behaviors or when a class of learners is "influenced" but not completely by learning behaviors. Point of Endemic Equilibrium investigates

Knowledgeable Research (An International Peer-Reviewed Multidisciplinary Journal) **ISSN 2583-6633**
Available Online: http://knowledgeableresearch.com/ Vol.03, No.1, August, 2024

the social connections and motivating effect in the study of slow learners. The endemic equilibrium point is now equal to $E^*(A_0, B_0, C_0, D_0) = (A^*, B^*, C^*, D^*)$

Where $A^* = \frac{T\{\beta_1\alpha+\beta_2 k_2\}-\{T\beta_1\alpha+T\beta_2 k_2-N\mu k_1 k_2\}}{\mu(\beta_1\alpha+\beta_2 k_2)}$

$$B^* = \frac{T}{k_1}\left[\frac{T\beta_1\alpha+T\beta_2 k_2-N\mu k_1 k_2)}{\beta_1\alpha+\beta_2 k_2}\right]$$

$$C^* = \frac{\alpha T}{k_1 k_2}\left[\frac{T\beta_1\alpha+T\beta_2 k_2-N\mu k_1 k_2)}{\beta_1\alpha+\beta_2 k_2}\right]$$

$$D^* = \frac{T}{k_1\mu}\left[\gamma_1+\frac{\gamma_2\alpha}{k_2}\right]\left[\frac{T\beta_1\alpha+T\beta_2 k_2-N\mu k_1 k_2)}{\beta_1\alpha+\beta_2 k_2}\right]$$

Where $k_1 = \gamma + \gamma_1 + \mu$ & $k_2 = \sigma + \gamma_2 + \mu$

4.1 Equilibrium point free from abnormal learning behavior of learners and its stability

Lemma1.The equilibrium point free from learners' abnormal learning behavior if $R_0 \leq 1$ and it is locally asymptotically stable in a feasible region and the abnormal behavior of the learners does not affect the other learners. Conversely, if $R_0 > 1$, equilibrium point is unstable and learning behavior does not propagate.

Proof: The jacobian matrix of system (2) can be expressed as

$$J = \begin{bmatrix} -\frac{\beta_1 C}{N} - \frac{\beta_2 B}{N} - \mu & \frac{-\beta_2 A}{N} & \frac{-\beta_1 A}{N} & 0 \\ \frac{\beta_1 C}{N} + \frac{\beta_2 B}{N} & -(\gamma+\gamma_1+\mu) & \frac{\beta_1 A}{N} & 0 \\ 0 & \gamma & -(\sigma+\gamma_2+\mu) & -\mu \\ 0 & \gamma_1 & \gamma_2 & \end{bmatrix}$$

The characteristic equation of system (2) at free equilibrium $E_0 = (\frac{T}{\mu}, 0,0,0)$ is

$$J = \begin{bmatrix} -\mu & \frac{-\beta_2}{N}\cdot\frac{T}{\mu} & \frac{-\beta_1}{N}\cdot\frac{T}{\mu} & 0 \\ 0 & -(\gamma+\gamma_1+\mu) & \frac{\beta_1}{N}\cdot\frac{T}{\mu} & 0 \\ 0 & \gamma & -(\sigma+\gamma_2+\mu) & -\mu \\ 0 & \gamma_1 & \gamma_2 & \end{bmatrix}$$

Since all the Eigen values of the above jacobian matrix are negative when $R_0 < 1$.

Here $\lambda_1 = -\mu$, $\lambda_2 = -(\gamma+\gamma_1+\mu)$, $\lambda_3 = -(\sigma+\gamma_2+\mu) + \frac{\gamma}{\gamma+\gamma_1+\mu}\frac{\beta_1 T}{N\mu}$

$\lambda_4 == -\mu$

Now put $A = \frac{T}{\mu}$

$\lambda_4 = \beta\frac{T}{\mu}(e^{-\mu\delta_1} + e^{-\mu\delta_2}) - (\mu + \gamma + \eta)$ negative if $\mu(\mu + \gamma_2 + \eta) > \beta T(e^{-\mu\delta_1} + e^{-\mu\delta_2})$

Hence the equilibrium point free from abnormal learning behavior $E_0 = (\frac{T}{\mu}, 0,0,0)$ is locally asymptotical stable in φ if $R_0 \leq 1$ and if $\mu(\mu + \gamma_2 + \eta) < \beta T(e^{-\mu\delta_1} + e^{-\mu\delta_2})$ then fourth Eigen value are positive and the equilibrium point free from abnormal learning behavior $E_0 = (\frac{T}{\mu}, 0,0,0)$ becomes unstable hence it is proved that E_0 is locally asymptotical stable if $R_0 \leq 1$ is unstable if $R_0 > 1$.

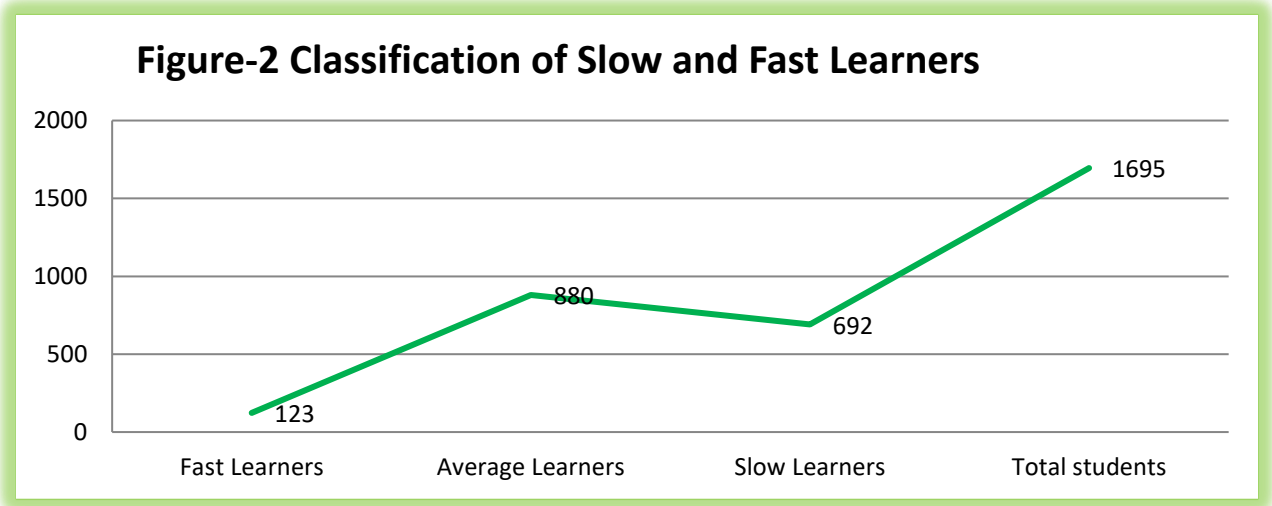
4.2 Endemic equilibrium points and its stability

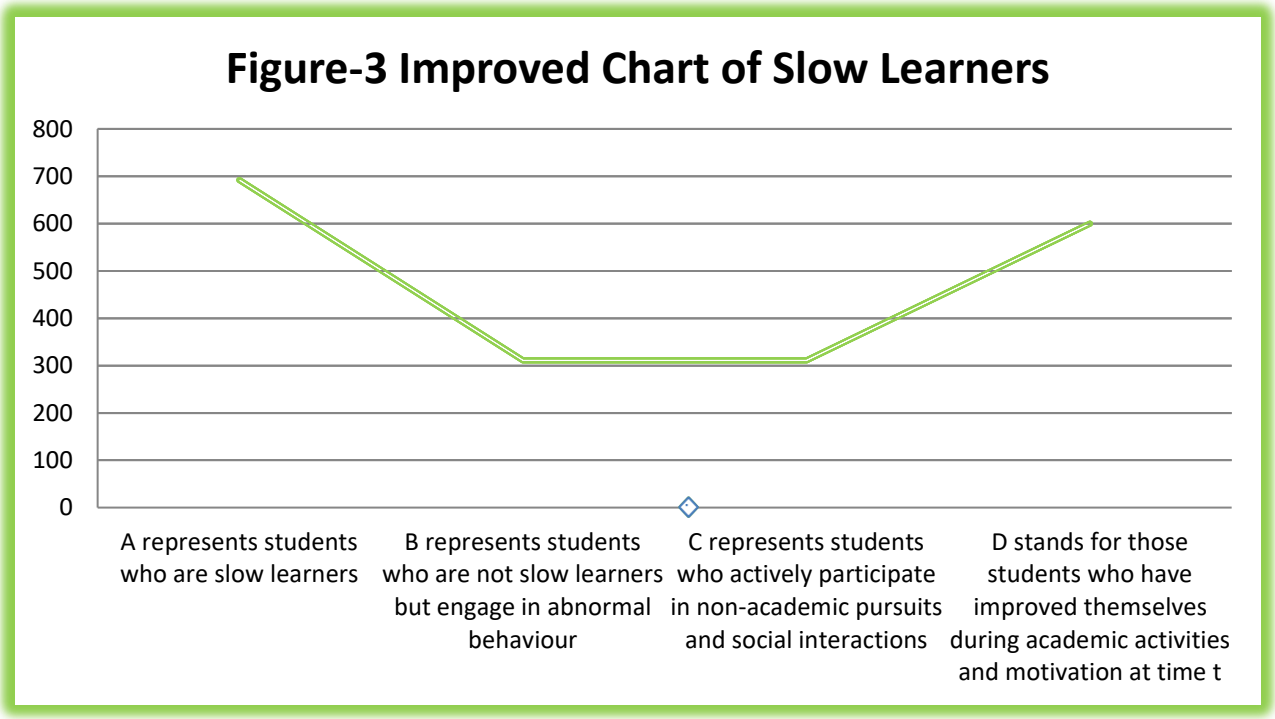
Lemma2. The unique endemic equilibrium points $E^*(A_0, B_0, C_0, D_0) = (A^*, B^*, C^*, D^*)$ is locally asymptotical stable in φ if $R_0 > 1$ and unstable if $R_0 < 1$.

Proof: The characteristic equation of system (2) at unique endemic equilibrium points $E^*(A_0, B_0, C_0, D_0) = (A^*, B^*, C^*, D^*)$ is

$$J = \begin{bmatrix} -\mu + \beta D^* & 0 & 0 & -\beta A^* + \varepsilon e^{-\mu\delta_3} \\ \beta D^*(P - e^{-\mu\delta_1}) & -\mu & 0 & \beta A^*(P - e^{-\mu\delta_1}) \\ \beta D^*(1 - P - e^{-\mu\delta_2}) & 0 & -\mu & \beta A^*(1 - P - e^{-\mu\delta_2}) \\ \beta D^*(e^{-\mu\delta_1} + e^{-\mu\delta_2}) & 0 & O & \beta A^*(e^{-\mu\delta_1} + e^{-\mu\delta_2}) - (\mu + \gamma + \eta) \end{bmatrix}$$

Since the Eigen value $\lambda_2 = -\mu, \lambda_3 = -\mu$ of the above Jacobian matrix is negative and other two roots are also negative if $R_0 > 1$. Hence therefore it is proved that endemic equilibrium points $E^*(A_0, B_0, C_0, D_0) = (A^*, B^*, C^*, D^*)$ is locally asymptotical stable in φ if $R_0 > 1$.





In the above study we examined the learning behavior of 1695 engineering learners and divided them into four groups, as shown in figure-2. A represents slow learners, B represents slow learners who are engaged in abnormal behavior, C represents slow learners who actively participate in non-academic pursuits and social interactions, and D stands for those learners who have improved themselves through academic activities and teacher motivation at time t. Figure-3 shows that slow learners are capable of improving their academic performance through academic activities, social interaction with academician awareness, motivation, and sports. 85% of slow learners can enhance their innovative teaching techniques and learning behaviours by the end of the semester with the help of this computational mathematical model.

Conclusion:

The study about the slow learners' behavior with the help of a mathematical model based on epidemic theory used a qualitative approach to describe slow learners' critical thinking. This epidemic model is capable of improving the academic performance of slow learners through academic activities and social interaction. In this paper, learners can improve their learning behavior and their advanced skills through a computational mathematical model. Here we have designed the various equilibrium points and explored the conditions of equilibrium points and analyzed their local stability. Thus, over time, the abnormal behavior of the learners dies out, and the number of slow learners who actively participate in academic activities converts into the category of improved learners. In the future, we shall discuss the effects of different parameters on some constraints.

Acknowledgment: Rajeev Kishore and Vinod Pal are thankful to the Chairman of Galgotias Group of Institutions, Greater Noida, for providing the necessary infrastructure. K.K. Sharma is also grateful

to the Hon'ble Chancellor, IIMT University, Meerut and Bhedpal Gangwar is appreciative to the Principal, Government Polytechnic, Unnao, U.P, for promoting the research facilities.

References:

[1] Denny Beatriz Moreira-Morales & María Inés García-Loor, Motivation in Academic Performance ,International Research Journal of Management, IT & Social Sciences (2024),Vol.11(1)2024,pp.30-38, ISSN: 2395-7492.DOI:10.21744/irjmis.v11n1.2403

[2] Khalid A Bin Abdulrahman et al., the relationship between Motivation and Academic Performance among Medical Learners in Riyadhin, cureus part of springer nature group, Oct, 2023, vol-15(10): e46815. doi: 10.7759/cureus.46815.

[3] Al-Osaimi, D. N., & Fawaz, M. (2022). Nursing learners' perceptions on motivation strategies to enhance academic achievement through blended learning: Aqualitativestudy.Heliyon,8(7),2022,e09818. https://doi.org/10.1016/j.heliyon.2022.e09818

[4] Mutiawati, Rahmah Johar , Marwan Ramli & Mailizar, Mathematical model of learner learning behavior with the effect of learning motivation and learner social interaction, Journal on Mathematics Education, Vol-13(3), 2022, pp. 415-436. https://doi.org/10.22342/jme.v13i3.pp415-436

[5] Rajeev Kishore, Indu Tyagi, Yerra Shankar Rao, Deepak Kumar, Epidemic model on rumor propagation in e-commerce, Materials Today: Proceedings, Vol-57(5), 2022,pp.2056-2060,ISSN 2214-7853. https://doi.org/10.1016/j.matpr.2021.11.263.

[6]. R. Kishore, I. Tyagi, D. Kumar and Y. S. Rao, "Control of Rumor Spreading in Online Social Network Through an Epidemic Model," 4th International Conference on Advances in Computing, Communication Control and Networking (ICAC3N), Greater Noida, India, 2022, pp. 2036-2043.https://doi:10.1109/ICAC3N56670.2022.10074270.

[7] F Setyawan , Andriyani, Tri Kinasih Handayani, Koesoemo Ratih, Anam Sutopo, Tri Indah Rusli & Nur Rizky Alfiany, Rigorous Thinking in Mathematics Modelling for Slow Learners, Journal of Physics: Conference Series 1720,(2021),012005 IOP Publishing doi:10.1088/1742-6596/1720/1/012005

[8] Korikana, A. "Slow Learners- A Universal Problem and Providing Educational Opportunities to Them to Be a Successful Learner". PEOPLE: International Journal of Social Sciences, 6(1), 2020, pp.29-42. DOI:10.20319/pijss.2020.61.2942

[9] Abdelrahman, R. M., Metacognitive awareness and academic motivation and their impact on academic achievement of Ajman University learners. *Heliyon*, *6*(9), 2020, e04192. https://doi.org/10.1016/j.heliyon.2020.e04192.

[10] Hidayat, R., Syed Zamri, S. N. A. , Zulnaidi, H., & Yuanita, P.,Meta-cognitive behaviour and mathematical modelling competency: mediating effect of performance goals. *Heliyon*, 6(4), 2020. https://doi.org/10.1016/j.heliyon.2020.e03800

[11] Khaira, U., & Herman, T.,Assessment processes for slow learners in mathematics learning. Journal of Physics: Conference Series, (Vol. 1521(3), 2020, p.032097. IOP Publishing. https://doi.org/10.1088/1742-6596/1521/3/032097

[12] Fithriyana, E.,Game Therapy Based on Local Wisdom in Cognitive Development of Slow Learner Children,Vol. 4,2019, Presented at the Annual Conference on Islamic Early Childhood Education, Yogyakarta.

[13] Jebaseelan, A.U.S. & T. M. Amirtha, Learner Learning Behavior and Academic Achievement - Unraveling its relationship, Indian journal of applied research, Vol-4(12), 2016, pp. 57-59. https://www.researchgate.net/publication/307964442

[14] Dasaradhi, K., Rajeswari, S.R., & Badarinath, S. (2016). 30 Methods to Improve Learning Capability in Slow Learners. Vol-4(2), 2016, pp. 556-570. http://ijellh.com/wp content/uploads/2016/03/60.Dasardhi-paper-final.pdf

[15] Varachanon, P., Study of Learning Behaviors of Nursing Learner at the Royal Thai Navy College of Nursing. Procedia Social and Behavioral Sciences, 197 (2015), pp.1043–1047. https://doi.org/10.1016/j.sbspro.2015.07.313

[16] Brauer, F.; Castillo-Chávez, C. Mathematical Models in Population Biology and Epidemiology; Springer: New York, NY, USA, 2010.pp.1-522.

Corresponding Author: Rajeev Kishore
E-mail: dr.rajeevkishorepandey@gmail.com
Received 3 August 2024; Accepted 22 August 2024. Available online: 30 August, 2024
Published by SAFE. (Society for Academic Facilitation and Extension)