



DEVELOPMENT OF AN EVALUATION MODEL TO ASSESS THE EFFECTIVENESS OF PEER LEARNING COMPARED TO TRADITIONAL LEARNING

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ABSTRACT

This study presents the development of a mathematical evaluation model aimed at evaluating the effectiveness of peer learning compared to traditional learning methods. The newly developed model is called Traditional versus Peer Learning evaluation model (TPL model). It is structured into four compartments: Skilled from Traditional Learning (S_T), Unskilled from Traditional Learning (U_T), Skilled from Peer Learning (S_P) and Unskilled from Peer Learning (U_P). A key feature of the model is the inclusion of a parameter called the basic reproductive ratio, which determines the effectiveness of peer learning. In the case where peer learning is ineffective, we also introduced another parameter, the specific threshold (S_P), which calculates the number of knowledgeable students required to make peer learning impactful. Lastly, the study outlines the application procedure for the TPL model, offering a systematic approach for evaluating and optimizing peer learning strategies in educational settings.

KEYWORDS: *Peer learning, traditional learning, threshold, model and compartment*

1. INTRODUCTION

The traditional learning approach, which involves students attending physical classrooms to learn from teachers or lecturers, has been identified in recent years as having several notable disadvantages. According to Hu [1], the traditional learning approach presents several drawbacks, including a one-size-fits-all teaching method, limited connection to real-world applications, inadequate focus on developing perceptual skills, and a lack of emphasis on actively engaging students in the learning process. Another study indicated that not long ago, it was observed that universities are increasingly exploring alternative approaches to education to supplement traditional classroom learning. This shift was driven by budget cuts and a growing student population in many institutions [2]. To address the various challenges associated with traditional learning, one study proposed the adoption of peer learning as a potential solution [3]. The study found significantly higher performance scores among students in the peer learning groups. Moreover, the study revealed that the majority of students in peer learning groups reported increased interaction and collaboration with their peers. They found it easier to communicate openly with their peers compared to their instructors and felt more comfortable seeking help from their peers than approaching their instructors. Overall, the study validates the positive impact of peer learning methods within the academic environment. On the other hand, it is undeniable that some researchers have found traditional learning to be effective and capable of producing satisfactory results [4]. In this context, what if peer learning works well for some but not for others? This suggests that there is no universal teaching method; effectiveness varies across institutions. Therefore, learning institutions should implement suitable evaluation tools to determine which teaching methods are most beneficial for their unique needs.

Therefore, the current study aims to develop a mathematical model to assess the effectiveness of peer learning compared to traditional learning for a given institution. Our model seeks to answer the following two questions: i) Is the peer learning method effective enough for the institution? and ii) If it is not effective, what percentage of students must be knowledgeable for peer learning to become effective?

2. LITERATURE REVIEW

2.1. Evaluation of Two Teaching and Learning Methods

In 2016, Sabaq et al. [5] evaluated the effectiveness of peer teaching compared to traditional teaching methods on the performance of nursing students in pediatric cardiopulmonary resuscitation. The study found that the knowledge and performance scores of nursing students who learned through the peer teaching method were significantly higher than those of students who learned through traditional teaching methods. Participants in the peer teaching group highlighted numerous benefits of this approach, both as teachers and learners. The study recommended incorporating peer teaching methods into undergraduate nursing curricula to enhance students' knowledge acquisition and performance in clinical skills. It also suggested conducting similar studies with larger sample sizes across multiple universities to provide stronger evidence for generalizing the findings.

Another study critically reviewed the literature on mathematics and engineering education by comparing traditional and non-traditional teaching methods [6]. The study revealed that non-traditional teaching methods are generally more popular than traditional classroom teaching. However, it also highlighted that many studies report only marginal improvements or no significant differences in outcomes between the two methods.

Ishchenko and Verkhovtsova [7] summarized arguments supporting the adoption of peer feedback practices over traditional teaching methods in English language classrooms. Their discussion was based on an analysis of the most effective forms of feedback, with a particular focus on peer feedback. They concluded that the feedback process should primarily emphasize: i) Behaviors, tasks, or events, rather than personal attributes; ii) Observation rather than inference; iii) Description rather than judgment; iv) Taking responsibility for providing feedback and its outcomes; v) Anticipating the effect of feedback on the recipient.

Wang [8], evaluated and analyzed the advantages and disadvantages of modern and traditional educational methods by synthesizing existing literature. The results indicate that, from a broader perspective, modern educational methods offer greater advantages. However, the

authors emphasize that teachers should carefully evaluate and select the most appropriate teaching method based on the students' needs, teaching objectives, and potential challenges.

2.2 Evaluation Model

The concept of evaluation is not a modern invention; it dates back as early as 2200 B.C. During that time, public officials serving Chinese emperors were required to demonstrate their proficiency through formal tests, a practice that represents an early form of evaluation [9]. While the concept remains relevant today, it was between 1970 and 1980 that the field of education witnessed the development of several well-known evaluation models.

In 1971, Daniel Stufflebeam developed a model that highlighted the importance of generating evaluative data to support decision-making processes [10]. This model, known as the CIPP model, organizes evaluation into four key stages: context evaluation, input evaluation, process evaluation, and product evaluation [10]. More recently, in 2018, the Stufflebeam model was applied across various branches of the Welfare School System in Rawalpindi. The evaluation revealed that learning experiences were generally satisfactory. However, it was noted that teachers placed a greater emphasis on theoretical work and rote learning, which negatively impacted students. This approach exerted undue pressure on students and constrained the development of their intellectual abilities [11].

A year after Stufflebeam's model, Michael Scriven introduced his goal-free model in 1972 [12]. Scriven was the first to challenge the significance of goals or objectives in the evaluation process. His model focuses primarily on the effects of the program rather than its goals and objectives, which is why it is referred to as Scriven's goal-free model. He explicitly stated that his model does not replace goal-based models but rather complements them. Therefore, when used alone, it may not provide sufficient information for decision-making [12]. Scriven's contribution was widely recognized, and the concept of "goal-free evaluation" was so highly regarded by some scholars that they applied it to their own work [13 - 15].

Halfway through the decade, another evaluation model, known as Stake's responsive model, was introduced. This model emphasizes that the concerns of those being evaluated should take priority [16]. It remains one of the most recognized models, even to this day. Wood [17], demonstrated the effectiveness of Stake's model when it was applied to evaluate an environmental

education professional development course. The model was successfully implemented through the examination of both qualitative and quantitative data during all phases of the course. However, Dewantara [18] found that the model was not suitable for small sample sizes (e.g., 315 participants). He suggested using a larger sample size to obtain a clearer and more reliable evaluation.

Just before the end of the decade, the connoisseurship model was introduced in the field of curriculum studies, with "connoisseurship" referring to the art of appreciation [19]. The evaluation approach of this model focuses on raising awareness of the qualities that define a process or object and understanding their significance. The model is based on two interconnected concepts: connoisseurship and criticism. It introduced a new perspective that contrasted with the approaches commonly known at the time.

Additionally, many other valuable contributions were made during the 1970 - 1980 period that are not discussed in this study [20 - 24]. We acknowledge and appreciate the work of these researchers and their contributions to the field of curriculum studies.

3. METHODOLOGY

3.1. Model Development

In 1927, Kermack and McKendrick [25], introduced a pandemic model known as the susceptible-infected-recovered (SIR) model. This model categorizes the population into three compartments based on their disease status: susceptible (S), infected (I), and recovered (R). The model is governed by two key parameters: β , the transmission rate, and γ , the recovery rate, as depicted in Figure 1. Here is a short description of each compartment in the SIR model,

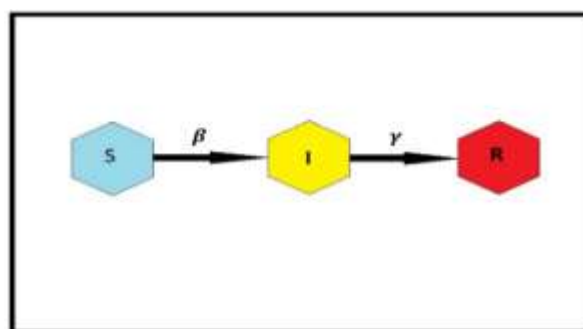


Figure 1: Susceptible, Infected and Recovered Model (SIR Model).

- Susceptible: Refers to individuals who have never been infected and are at risk of catching the disease. Once infected, they move into the *Infected* compartment.

- **Infected:** Refers to individuals who currently have the disease and can spread it to susceptible individuals. They remain in this compartment for the duration of their infectious period, after which they transition to the *Recovered* compartment.
- **Recovered:** Refers to individuals who have recovered from the disease and are assumed to have lifelong immunity, preventing them from becoming susceptible again.

The SIR model is formulated using ordinary differential equations (ODEs), making it a deterministic model. Drawing an analogy from reaction kinetics, the model assumes that interactions between susceptible and infected individuals occur at a rate proportional to their respective numbers in the population. The equations of the SIR model are expressed as follows [25].

$$\left. \begin{aligned} \frac{dS}{dt} &= -\beta SI \\ \frac{dI}{dt} &= \beta SI - \gamma I \\ \frac{dR}{dt} &= \gamma I \end{aligned} \right\} \quad (1)$$

Earlier in 2024, Mazibuko and Maharaj [26] adopted the concept of the SIR model to evaluate the effectiveness of the curriculum in equipping students with higher-order thinking skills (HOTS). Their model included five compartments: susceptible $S(t)$, vaccinated $V(t)$, healthy $H(t)$, infected $I(t)$, and recovered $R(t)$. As a result, the model is referred to as the SVHIR model. They described the SVHIR model using ordinary differential equations (ODEs) as follows:

$$\left. \begin{aligned} \frac{dS}{dt} &= -\mu S(t), \\ \frac{dV}{dt} &= \mu S(t) - \theta H(t) - \beta V(t), \\ \frac{dH}{dt} &= \theta V(t), \\ \frac{dI}{dt} &= \beta V(t) - \gamma I(t), \\ \frac{dR}{dt} &= \gamma I(t). \end{aligned} \right\} \quad (2)$$

Later in 2024, Mazibuko and Maharaj [27] extended the concept of the SVHIR model to encompass a broader range of curricula and skills, rather than focusing solely on higher-order thinking skills (HOTS). This expansion resulted in the development of a new model called the RCUSP model. Again, they described the RCUSP model using ordinary differential equations (ODEs) as follows:

$$\left. \begin{aligned} \frac{dR}{dt} &= -\mu R(t), \\ \frac{dU}{dt} &= \beta C(t), \\ \frac{dS}{dt} &= \gamma C(t), \\ \frac{dP}{dt} &= \alpha C(t). \end{aligned} \right\} \quad (3)$$

In the current study, we intend to adopt the same idea as the SIR, SVHIR, and RCUSP models to evaluate the effectiveness of peer learning compared to traditional learning for a given institution. This is achieved by dividing the students into four compartments. We begin by assuming that, in a given class, a portion of the students primarily relies on traditional learning, while the other portion depends mostly on peer learning. Within the traditional learning group, a portion of the students will be skilled in achieving the curriculum objectives, while the remainder will be unskilled. The same applies to the peer learning group. This model is applicable under the following conditions:

- The model is applicable only during the period before the completion of the curriculum.
- Students who do not rely on either traditional learning or peer learning are excluded from the analysis.
- On the first day, all students are assumed to be unskilled.
- On the first day, all students are assumed to rely on traditional learning methods.

3.2. Specific Threshold

One of the most critical parameters of the SIR model is the basic reproductive ratio, R_0 . It is defined as the average number of secondary cases generated by a single infected individual in a fully susceptible population. The value of R_0 determines the progression of the disease as follows,

Case 1: If $R_0 < 1$, the infected individuals will recover (or die), and the pandemic will eventually stop.

Case 2: If $R_0 > 1$, the infected number of individuals will increase, and the pandemic will occur or continue.

The basic reproductive ratio is expressed mathematically as [28 and 29]:

$$R_0 = \frac{\beta}{\gamma}. \quad (4)$$

where β is the transmission rate, and γ is the recovery rate.

Further on, from the basic reproductive ratio emerges another important parameter called herd immunity threshold (HIT). The herd immunity threshold is the proportion of a population that needs to be immune to an infectious disease through vaccination or prior infection to prevent the disease from spreading widely. When this threshold is reached, even individuals who are not immune are indirectly protected because the spread of the disease is significantly slowed or stopped [30, 31, 32 and 33]. The herd immunity threshold applies only in Case 2 and is expressed as follows [33]:

$$HIT = 1 - \frac{1}{R_0} \quad (5)$$

The current study also incorporates the concepts of the reproductive ratio and the herd immunity threshold to address the second research question, if necessary. The second research question is: If peer learning is not effective, what percentage of students needs to be knowledgeable for peer learning to become effective? This study aims to answer the question by developing a specific threshold (SH) based on the adoption of the concepts of reproductive ratio and herd immunity threshold.

4. RESULTS AND DISCUSSION OF THE RESEARCH

4.1. Development of the Peer-Learning Evaluation Model

This section presents the development of a new model called the Traditional versus Peer Learning (TPL) evaluation model, illustrated in Figure 2. As outlined in Section Three, the TPL model assumes that all students in a given class are engaged in learning the curriculum, placing the total number of students in the curriculum compartment. Within the curriculum compartment, some students primarily use peer learning methods, while others rely predominantly on traditional learning approaches. Furthermore, within both groups, a subset of students will be skilled with the predefined curriculum objectives, while the rest will remain unskilled. Consequently, the model is divided into four compartments, as detailed below,

- Skilled from Traditional Learning (S_T): Students who achieve skill proficiency through traditional teaching methods, such as lectures, textbooks, and instructor-led activities.

- Unskilled from Traditional Learning (U_T): Students who remain unskilled despite exposure to traditional teaching methods.
- Skilled from Peer Learning (S_P): Students who acquire skills through peer interaction, collaboration, and shared learning experiences.
- Unskilled from Peer Learning (U_P): Students who do not gain skills effectively through peer learning mechanisms.

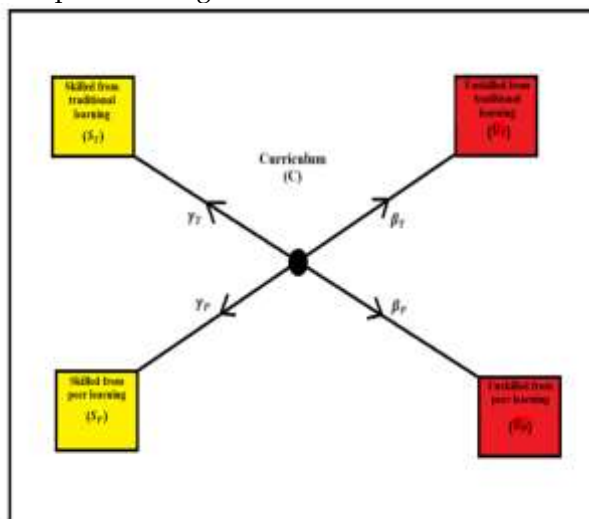


Figure 2: TPL model

When examining Figure 2, it becomes apparent that there are five compartments rather than the four mentioned above. This discrepancy arises because the model is designed to apply only while the curriculum is ongoing. As such, the four compartments described above are technically subsets of the curriculum compartment. Consequently, the curriculum compartment $C(t)$ is not explicitly counted, as it is inherently defined by the four above mentioned compartments.

Furthermore, each compartment is linked to its respective transition rates, which represent the movement of students within the curriculum compartment based on their learning progress or method preferences,

- Skilled Transition in Traditional Learning (γ_T): This rate represents the proportion of students in the traditional learning group who become skilled over time within the curriculum.
- Skilled Transition in Peer Learning (γ_P): This rate indicates the proportion of students in the peer learning group who acquire skills through interactions with their peers within the curriculum.
- Unskilled Transition in Traditional Learning (β_T): This rate describes the proportion of students in the traditional learning group

who fail to gain or retain skills, effectively becoming unskilled within the curriculum.

- Unskilled Transition in Peer Learning (β_P): This rate represents the proportion of students in the peer learning group who remain unskilled within the curriculum.

The TPL model is applicable under the following conditions:

- The model is applicable only during the period before the completion of the curriculum.
- Students who do not rely on either traditional learning or peer learning are excluded from the analysis.
- On the first day, all students are assumed to be unskilled.
- On the first day, all students are assumed to rely on traditional learning methods.

We described the TPL model using ordinary differential equations (ODEs) as follows

$$\left. \begin{aligned} \frac{dS_T}{dt} &= \gamma_T C(t), & (a) \\ \frac{dS_P}{dt} &= \gamma_P C(t), & (b) \\ \frac{dU_T}{dt} &= \beta_T C(t), & (c) \\ \frac{dU_P}{dt} &= \beta_P C(t), & (d) \end{aligned} \right\} (6)$$

As mentioned that all four mentioned compartments technically fall under the umbrella of the curriculum ($C(t)$); then that means the number of students in the curriculum will always remain constant (C) and equal to the total number of students (N). Consequently, equation (6) simplifies to

$$\left. \begin{aligned} \frac{dS_T}{dt} &= \gamma_T C, & (a) \\ \frac{dS_P}{dt} &= \gamma_P C, & (b) \\ \frac{dU_T}{dt} &= \beta_T C, & (c) \\ \frac{dU_P}{dt} &= \beta_P C, & (d) \\ S_T(t) + S_P(t) + U_T(t) + U_P(t) &= C & (e) \\ C &= N & (f) \end{aligned} \right\} (7)$$

From (7)(a) we get,

$$dS_T = \gamma_T C dt \quad (8)$$

By introducing indefinite integrals both sides in (8) we get,

$$\int dS_T = \gamma_T C \int dt$$

$$S_T(t) = \gamma_T C t + c_1 \quad (9)$$

By substituting (9) into (7)(e) we get

$$\gamma_T C t + c_1 + S_P(t) + U_T(t) + U_P(t) = C$$

$$c_1 = C - (\gamma_T C t + S_P(t) + U_T(t) + U_P(t)) \quad (10)$$

Where $\gamma_T, C, t, S_P(t), U_T(t), U_P(t) \geq 0$.

When analyzing (10), c_1 will always be less than C or equal to C . Mathematically, this is expressed as,

$$c_1 \leq C \quad (11)$$

Therefore, (9) becomes,

$$S_T(t) = \gamma_T C t + c_1; \quad c_1 \leq C \quad (12)$$

The same procedure demonstrated from (8) - (12), when applied to (7)(b), (7)(c), and (7)(d), yields the following results,

$$\left. \begin{aligned} S_T(t) &= \gamma_T C t + c_1; \quad c_1 \leq C & (a) \\ S_P(t) &= \gamma_P C t + c_2; \quad c_2 \leq C & (b) \\ U_T(t) &= \beta_T C t + c_3; \quad c_3 \leq C & (c) \\ U_P(t) &= \beta_P C t + c_4; \quad c_4 \leq C & (d) \end{aligned} \right\} (13)$$

To determine the transition rates according to the compartments, we apply definite integrals into the four equations in (7). From (7)(a) we get,

$$dS_T = \gamma_T C dt \quad (14)$$

By introducing definite integrals both sides in (14) we get,

$$\int_{S_T(t_0)}^{S_T(t_f)} dS_T = \gamma_T C \int_{t_0}^{t_f} dt \quad (15)$$

$$S_T(t_f) - S_T(t_0) = \gamma_T (t_f - t_0)$$

$$\gamma_T = \frac{S_T(t_f) - S_T(t_0)}{C(t_f - t_0)} \quad (16)$$

The same procedure demonstrated from (14) - (16), when applied to (7)(b), (7)(c), and (7)(d), yields the following results,

$$\left. \begin{aligned} \gamma_T &= \frac{S_T(t_f) - S_T(t_0)}{C(t_f - t_0)} & (a) \\ \gamma_P &= \frac{S_P(t_f) - S_P(t_0)}{C(t_f - t_0)} & (b) \\ \beta_T &= \frac{U_T(t_f) - U_T(t_0)}{C(t_f - t_0)} & (c) \\ \beta_P &= \frac{U_P(t_f) - U_P(t_0)}{C(t_f - t_0)} & (d) \end{aligned} \right\} \quad (17)$$

The initial compartment conditions outlined in (17) can be determined by following the instructions provided in Table 1. Conversely, the final conditions can be derived from the collected data

Table 1: Explanation of the TPL model initial values

Parameter Description	Initial value	Reason
Time	$t_0 = 1$	This study adopted the notion that when counting days, weeks, and months, we typically start at one, not zero.
Unskilled from Traditional Learning	$U_T(t_0) = C$	According to conditions (iv) and (v) of the TPL model, on the first day, all students technically belong to this compartment. Consequently, all other compartments are initially empty.
Skilled from Traditional Learning	$S_T(t_0) = 0$	According to conditions (iv) and (v) of the TPL model.
Unskilled from Peer Learning	$U_P(t_0) = 0$	According to conditions (iv) and (v) of the TPL model.
Skilled from Peer Learning	$S_P(t_0) = 0$	According to conditions (iv) and (v) of the TPL model.

4.2. Development of the Basic Reproductive Ratio and Specific Threshold

When examining sub-section 3.2 above, it is evidently that the SIR reproductive ratio is all about evaluation of the infected against recovery compartment. Hence, the two cases of R_0 are all about what will happen to the infected compartment. Furthermore, the formula for R_0 represents the transition rate of the compartment being evaluated divided by the transition rate of the compartment it is being evaluated against. Therefore, since the current study focuses on evaluating the effectiveness of peer learning against traditional learning, the primary focus is on effectiveness, specifically examining the skilled compartments. Consequently, as the evaluation is on peer learning against traditional learning, the skilled transition rate in peer learning will appear in the numerator, while the skilled transition rate in traditional learning will appear in the denominator. Hence, the basic reproductive ratio of the PTL model is expressed mathematically as:

$$R_0 = \frac{\gamma_P}{\gamma_T} \quad (18)$$

Case 1: If $R_0 < 1$, this indicates that peer learning plays a significant role in equipping students with the predetermined skills outlined in the curriculum objectives.

Case 2: If $R_0 > 1$, Peer learning is currently insignificant; a specific threshold of knowledgeable students is required for it to become impactful.

When applying the TPL model and arriving at case 2, the key question becomes: "How many knowledgeable students are required in the system to make peer learning impactful?". The current study adopted the idea of herd immunity threshold [30, 31, 32 and 33], to produce the formula for specific threshold (ST) expressed as:

$$ST = \left(1 - \frac{1}{R_0}\right) \times 100\% \quad (19)$$

The specific threshold (ST) formula determines the actual percentage of knowledgeable students required in the system to make peer learning impactful.

4.3. TPL Model Application

At this stage, the TPL model can be applied by following these steps,

Step 1: Data collection

To execute data collection, one needs to design a data collection instrument in the form of questionnaires. The first set of questions should aim to assess the predetermined curriculum skills of the students. The second set of questions

should assess the students' preferred learning approach, whether peer learning or traditional learning. Furthermore, the evaluator should ensure the reliability and accuracy of the data collection instrument. Various methods can be employed for validation, depending on the variation of the data collection instrument. Hence, each evaluator should adopt suitable validation methods tailored to their specific data collection instrument.

Step 2: Validation of the model

The TPL model is designed to address data in a general context and does not automatically apply to specific datasets. Therefore, it is essential to align the model with your current data and validate it before drawing any conclusions based on the model. This process involves using Table 1 and the collected data to compute Equations in (17). Following this, Equation (13) is computed, which yields the predictions for each compartment. If the difference between the actual and predicted compartment values is insignificant, then the model can be considered valid. There are various methods that can be adopted to determine whether the difference is significant or not. Therefore, this decision is left to the discretion of the evaluator.

Step 3: Computation of the basic reproductive ratio and specific threshold

The basic reproductive ratio and specific threshold is determined through (18) and (19) respectively.

Step 4: Conclusion

If Case 1 of the reproductive ratio is observed in Step 3, it indicates that peer learning is effective and should be continued. Consequently, the learning institution under investigation should promote it by providing the necessary resources to ensure the smooth implementation and operation of peer learning.

If Case 2 results, it means that peer learning should not be the priority. The institution should invest in other learning methods. However, if the institution is committed to promoting peer learning, it can calculate the number of knowledgeable students required in the system to make peer learning impactful using the specific

threshold formula. If the required number of students is low, the institution may need to explore alternative strategies to reach the necessary threshold.

5. CONCLUSIONS

The current study emphasizes the effectiveness of the newly developed Traditional versus Peer Learning (TPL) evaluation model in evaluating peer learning compared to traditional methods. The TPL model is structured into distinct compartments, which includes skilled and unskilled learners from both traditional and peer learning methods. The model is ready for application across various fields of study. With its comprehensive structure and inclusion of critical parameters such as the basic reproductive ratio and the specific threshold (SP), the model provides a flexible and systematic tool that can be used to assess and optimize peer learning strategies in diverse educational contexts. Its versatility allows for wide applicability, making it a valuable resource for improving learning outcomes in a variety of disciplines. At this stage, no notable weaknesses have been identified in the model. However, the authors acknowledge that further insights and refinements will emerge during the next phase of research, which will focus on the practical application of the model. This future application study will help uncover potential areas for improvement and provide a deeper understanding of the model's effectiveness in real-world educational settings.

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7. DECLARATION OF INTEREST

In the current study, ChatGPT was utilized for grammar correction purposes.

REFERENCES

1. Hu, J. (2024). The challenge of traditional teaching approach: A study on the path to improve classroom teaching effectiveness based on secondary school students' psychology. *Lecture Notes in Education Psychology and Public Media*, 50(1), 213–219. <https://doi.org/10.54254/2753-7048/50/20240945>
2. Colvin, J. W., & Ashman, M. (2010). Roles, risks, and benefits of peer mentoring relationships in higher education. *Mentoring & Tutoring: Partnership in Learning*, 18(2), 121–134.
3. Ahmad, I. M., & Mohamed, H. E. (2018). The effect of peer learning vs. traditional learning on knowledge and clinical performance of critical care nursing students. *Journal of Education and Practice*, 9(8), 139–142.
4. Schwerdt, G., & Wuppermann, A. C. (2011). Is traditional teaching really all that bad? A within-student between-subject approach. *Economics of Education Review*, 30(2), 365–379. <https://doi.org/10.1016/j.econedurev.2010.11.005>

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5. Sabaq, A., Farouk, M., & Ismail, S. (2016). Effect of peer teaching versus traditional teaching method on nursing students' performance regarding pediatric cardiopulmonary resuscitation. *Tanta Scientific Nursing Journal*, 10(1), 6–25. <https://doi.org/10.21608/tsnj.2016.69231>
6. Tularam, G. A. (2016). Traditional vs non-traditional teaching and learning strategies – The case of e-learning! In *International Conference on Engineering Education and Research* (pp. 1–8). Sydney, Australia.
7. Ishchenko, O., & Verkhovtsova, O. (2019). Peer feedback versus traditional teaching. *Journal of English Teaching*, 5(2), 115. <https://doi.org/10.33541/jet.v5i2.1065>
8. Wang, Y. (2022). A comparative study on the effectiveness of traditional and modern teaching methods. In A. Holl et al. (Eds.), *ICHESS 2022* (pp. 270–277).
9. Guba, E. G., & Lincoln, Y. S. (1981). *Effective evaluation: Improving the usefulness of evaluation results through responsive and naturalistic approaches*. Jossey-Bass.
10. Stufflebeam, D. L. (1971). *Educational evaluation and decision making*. Phi Delta Kappa.
11. Aziz, S., Mahmood, M., & Rehman, Z. (2018). Implementation of CIPP model for quality evaluation at school level: A case study. *Journal of Education and Educational Development*, 5(1), 189–203.
12. Scriven, M. (1972). Pros and cons about goal-free evaluation. *Journal of Educational Evaluation*, 3(4), 1–7.
13. Worthen, B. R. (1990). Program evaluation: Goal-free evaluation. In *The international encyclopaedia of educational evaluation* (pp. 42–47). Pergamon Press.
14. Youker, B. W. (2013). Goal-free evaluation: Potential model for the evaluation of social work programs. *Social Work Research*, 37(4), 432–438.
15. Zurqoni, Z., Retnawati, H., Apino, E., & Anazifa, R. (2018). Impact of character education implementation: A goal-free evaluation. *Problems of Education in the 21st Century*, 76(6).
16. Stake, R. E. (1975). *Evaluating the arts in education: A responsive approach*. Charles E. Merrill.
17. Wood, B. B. (2001). Stake's countenance model: Evaluating an environmental education professional development course. *The Journal of Environmental Education*, 32(2).
18. Dewantara, I. P. M. (2017). Stake evaluation model (countenance model) in learning process Bahasa Indonesia at Ganesha University of Educational. *International Journal of Language and Literature*, 1(1). <https://doi.org/10.23887/ijll.v1i1.9615>
19. Eisner, E. W. (1979). *The educational imagination: On the design and evaluation of school programs*. Macmillan.
20. Lewy, A. (1973). The practice of curriculum evaluation. *Curriculum Theory Network*, 11, 6–33.
21. Walker, D., & Schaffarzick, J. (1974). Comparing curricula. *Review of Educational Research*, 44(1), 83–111.
22. Parlett, M., & Hamilton, D. (1977). Evaluation as illumination: A new approach to the study of innovatory programs. *Occasional Paper 9, Centre for Research in the Educational Sciences*, University of Edinburgh.
23. Sage, M. (1978). Utilization-focused evaluation. In *Kluwer International Handbook of Education* (Vol. 9, pp. 223–242).
24. Apple, M. W. (1980). Analysing determiners: Understanding and evaluating the production of social outcomes in school. *Curriculum Inquiry*, 55–76.
25. Kermack, W. O., & McKendrick, A. G. (1927). A contribution to the mathematical theory of epidemics. *Proceedings of the Royal Society*, 115, 700–721.
26. Mazibuko, G. N., & Maharaj, A. (2024). Explorative study of developing a mathematical model for evaluating HOTS in the mathematics curriculum operating in the KZN TVET colleges. *Education Sciences*, 14, 2–21.
27. Mazibuko, G. N., & Maharaj, A. (2024). Development of the RCUSP model for the purpose of improving the curriculum evaluation. *Educational Administration: Theory and Practice*, 462–474. <https://doi.org/10.53555/kuey.v30i9.7779>
28. Rodrigues, H. S. (2016). Application of SIR epidemiological model: New trends. *International Journal of Applied Mathematics and Informatics*, 10, 92–97.
29. Mohamed, L., & Dilip, K. B. (2020). Estimation of SIR model's parameters of COVID-19 in Algeria. *Bulletin of the National Research Centre*, 1–6. <https://doi.org/10.1186/s42269-020-00434-5>
30. Topley, G. S., & Wilson, S. G. (1923). The spread of bacterial infection: The problem of herd-immunity. *Journal of Hygiene*, 243–249.
31. Anderson, R. M., & May, R. M. (1985). Vaccination and herd immunity to infectious diseases. *Nature*, 318, 323–329.
32. Anderson, R. M. (1992). The concept of herd immunity and the design of community-based immunization programmes. *Vaccine*, 10, 928–935.
33. Smith, P. G. (2010). Concepts of herd protection and immunity. *Procedia in Vaccinology*, 2(2), 134–139. <https://doi.org/10.1016/j.provac.2010.07.005>