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# Implementing the Integrated GREEN Model for Social Natural Science Project (IPAS) to Enhance Understanding of Sustainable Biodiversity Concepts in Schools

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**Abstract:** This research implements the Garden Resources, Education, and Environment Nexus (GREEN) Model as an innovative learning strategy to enhance the sustainable understanding of biodiversity concepts through Project-Based Learning (PjBL) Science and Social Science (IPAS) subject in schools. This PjBL model aims to integrate the GREEN Model into PjBL IPAS to enhance students' understanding of biodiversity concepts at the Indonesian School in Kota Kinabalu, Sabah, Malaysia. The research employs an experimental method with a ODGE using PjBL in IPAS subjects, the sample 34 students 10th. Research instruments and data collected included a 14-item short-answer pretest-posttest, a 8-item Likert Scale questionnaires, and interview guidelines and analyzed using descriptive statistical methods. The research results indicate that the implementation of the integrated GREEN Model in PjBL IPAS can improve students' understanding of biodiversity concepts, increasing the average score from 64.85 to 83.41 with a sig (2- tailed = 0.034) < (0.05). Based on statistical analysis, the integrated GREEN Model with PiBL in subject IPAS significantly enhance students' understanding concepts of biodiversity knowledge. According to the survey and interview data processing, most students also responded positively to the learning process, finding the GREEN Model engaging and easy to understand when integrated with PjBL IPAS.

**Keywords:** Biodiversity; Garden; GREEN Model; PjBL; Understanding of concepts

## Introduction

Quality biology education is influenced by five key domains: conceptual understanding, process skills, creativity, attitude development, and the practical application of concepts in daily life (Yunanda et al., 2019). To achieve these five domains, a strategy is needed to make the learning process more closely aligned with everyday life. Especially when it comes to understanding the concept of biodiversity, before reaching the stage of comprehension, students will first form a conceptual framework. According to Gabel, conceptual mastery is the ability that enables someone to accomplish something (Yunanda et al., 2019). Based on a series of studies conducted on tenth-grade students in various high schools in Indonesia, such as SMAN 1 Pontianak (Septian et al., 2018), SMA East Java (Yunanda et al., 2019), and SMAN 5 Banda Aceh (Nurmaliah et al., 2020), there appears to be a pattern indicating a high level of misconceptions and a lack of understanding among students regarding the concept of biodiversity. The research results also indicate that instructional models such as Problem Based Learning (PBL) (Erwanto, 2020) and Project-Based Learning (PjBL) (Pratiwi et al., 2020; Mulyani et al., 2023) have a significant impact on students' critical thinking,

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creativity, and science process skills in understanding the concept of biodiversity. Therefore, this study aims to further explore the potential implementation of the PjBL model to enhance students' understanding, critical thinking skills, creativity, and science process skills in biodiversity education within the Indonesian educational environment.

According to the research conducted by Yunanda (2019) on the identification of biodiversity and protist material concepts among 10th-grade students in East Java high schools, it was found that 28% of students were not familiar with the concept of biodiversity. Concepts related to the differences in biodiversity at the genetic, species, and ecosystem levels were not well-understood by the students. The highest misconceptions were found in the concept of genetic-level biodiversity, reaching 97.7%. In this concept, many students had misconceptions about the understanding of genetic-level biodiversity (Yunanda et al., 2019).

In the effort to enhance understanding of biodiversity concepts, it is important to consider the crucial role of school gardens as valuable learning resources, in line with recent research findings. Research conducted by Ohly et al. (2016) and Kohlstedt (2008) has emphasized that school gardens have significant potential as effective learning mediums. Recent studies on school gardens have also provided valuable insights into the biodiversity-related benefits, including increased food production, improved nutritional knowledge, enhanced interest in consuming fruits and vegetables, and positive psychosocial attitudes such as a sense of responsibility and food preferences (Langellotto & Gupta, 2012; Ratcliffe et al., 2011). Furthermore, other benefits include improved physical health, better academic outcomes, a positive environmental attitude, and the development of strong social relationships among students and the school community. The utilization of the school environment as a learning resource with guided inquiry models has an influence on students' learning outcomes in the biodiversity concept of class X at SMA Negeri 4 Palembang (Febrianti et al., 2019). Additionally, the use of the school garden as a learning resource designed within the instructional organization can improve the quality of the student learning process and outcomes related to plant classification, structure, and function (Nurwidodo et al., 2022). Furthermore, the understanding of biodiversity conservation among Adiwiyata school teachers received a 'Very Good' response of 80%, primarily due to the more common use of green open spaces as a learning medium by teachers at Adiwiyata schools (Rahayu et al., 2021).

In this context Ozer (2007) provides a crucial framework for understanding the factors influencing the effectiveness of well-integrated school gardens. Ozer's framework identifies three main categories as the foundation, namely garden location, formal curriculum, and the involvement of parents and the community in garden management. Furthermore, the preliminary research titled "The Establishment of GREEN Integrated Model as a Promotion of Media Biodiversity, Food and Nutrition Sustainable for Students of Kota Kinabalu Indonesian School" highlights the importance of creating an integrated GREEN Model (Garden Resources, Education, and Environment Nexus) that involves garden concepts, project-based learning planning, resource preparation, and active participation of the school community throughout the implementation process (Hanif et al., 2021). This study was conducted on a small scale involving students who are members of the SIKK Farm extracurricular program.

Based on the findings of the preliminary research, there is a need for the implementation of the GREEN Model as an innovative learning strategy to enhance sustainable understanding of biodiversity concepts through Science and Social Science Project-Based Learning (IPAS) in schools. In the subsequent sections, it is essential to further explore the benefits of this implementation and its integration into learning management, such as strengthening the Pancasila Student Profile strengthening project (P5) and the potential to empower students as agents of change in preserving environmental sustainability. The research results are also important in reinforcing the implementation of Problem-Based Learning (PjBL) models to improve students' understanding of biodiversity concepts.

Therefore, this research aims to enhance the understanding of biodiversity concepts by implementing the integrated GREEN Model through Science and Social Science Project-Based Learning (IPAS) in schools. The research results are expected to yield innovative learning strategies in the form of the integrated GREEN Model within IPAS Project-Based Learning. It is anticipated that this integrated GREEN Model can enhance the comprehension of biodiversity concepts. This research holds significant value as it provides new insights into the application of the school garden based on the GREEN Model developed by Ozer (2007). Through the implementation of this model, it is hoped that a more sustainable education and a deeper understanding of biodiversity issues among students can be achieved.

## Method

This study is a quasi-experimental research with a One-Group Pretest and Posttest Design (Ningrum et al., 2022). The research phase begins with an analysis of the understanding of biodiversity concepts through literature review and initial observations. It is then followed by administering a pretest and evaluating it to assess the initial conceptual understanding. Subsequently, the treatment is provided through learning using the integrated GREEN Model within IPAS Project-Based Learning. The final stage involves administering a post-test and evaluating it to determine the effectiveness of the learning in enhancing conceptual understanding. The research design is presented in Table 1.

**Table 1.** One Group Pretest Posttest Design (Sugiyono, 2007 at Ningrum et al., 2022)

| Pretest | Treatment | Posttest |
|---|---|---|
| $O_1$ | X | $O_2$ |

Information:

$O_1$ = Initial conception understanding test (pretest) before students receive learning.

X = Treatment, namely the GREEN Model integrated with PjBL IPAS.

$O_2$ = Final conception understanding test (posttest) after students receive learning with GREEN Model integrated with PjBL IPAS.

This research was conducted at the Indonesian School in Kota Kinabalu, Sabah, Malaysia, from July to September 2023, utilizing the GREEN Model-based school garden. The study focused on a sample of 34 $10^{th}$-grade students, representing various majors at the Vocational High School, including Culinary, Hospitality, and Aircraft Technology programs. The research instruments included a pretest-posttest exam and non-test instruments in the form of questionnaires and interview guidelines. Data were collected through Likert Scale questionnaires (Somerset & Markwell, 2009), interviews (Lile & Richards, 2018), and pretest-posttest (OGDE) (Alexander et al., 2016).

Changes in conceptual understanding are analyzed descriptively and statistically. Descriptive analysis is conducted to observe changes in students' conceptual understanding. Statistical analysis uses the T-test to determine the significance of differences in conceptual understanding before and after learning using the GREEN Model integrated with IPAS Project learning. The T-test is performed using the Microsoft Excel 2010 software application. If the value of $p <$ sig ($\alpha$=0.05), then $H_0$ is rejected. This means there is a significant difference between the pre-test and post-test averages. The hypothesis is as follows: $H_0$: There is no difference in conceptual understanding between before and after learning using the integrated GREEN Model within IPAS Project-Based Learning; Ha: There is a difference in conceptual understanding between before and after learning using the integrated GREEN Model within IPAS Project-Based Learning.

## Result and Discussion

The initial steps of this research involve problem formulation and school garden planning. It begins with a comprehensive literature review on school gardens, aligning with the school garden domains established by Ozer (2007). Additionally, content standards for biodiversity at the vocational school level are analyzed during the planning phase. Following that, the preparation phase for utilizing the school garden according to the GREEN Model integrated with IPAS Project learning is carried out. The concept of the GREEN Model integrates three main categories: the location and garden activities used in learning, the formal curriculum as a reference, and community or parental involvement. The process of creating the garden location can be seen in Figure 1.

**Figure 1**. Establishing the garden location and school staff and employee activities

For the implementation of the garden location and activities used in learning according to the GREEN Model integrated with IPAS Project learning, it can involve groups of students, teachers, staff, and employees. Through the SEAMEO BIOTROP program titled "The Establishment of GREEN Integrated Model as a Promotion of Media Biodiversity, Food and Nutrition Sustainable for Students of Kota Kinabalu Indonesian School," the GREEN model can be effectively realized (Hanif et al., 2021). The results of creating the school garden can be seen in Figure 2.

The learning for biodiversity material is derived from an analysis of high school biodiversity material that refers to learning outcomes. By the end of Phase E, students should have the ability to generate solutions to problems based on local, national, or global issues related to understanding biodiversity and its roles. Meanwhile, in the vocational school (SMK) IPAS learning outcomes, by the end of Phase E, students are expected to explain the phenomena occurring in their surroundings from various aspects, including living organisms and their environment.

**Figure 2.** GREEN model-based garden for learning

**Figure 3.** Learning about genetic, species, and ecosystem biodiversity through the GREEN model

**Figure 4.** Labeling the classification system on plants

According to Zulhamsyah Imran (Susanti, 2022), changing the curriculum is a lengthy process. Therefore, biodiversity material for vocational schools can be included as an extracurricular activity. This activity nurtures the future generation's love for Indonesia's natural wealth, which needs to be restored and well-preserved in the future (Susanti, 2022). In order to enhance the understanding of biodiversity concepts in vocational schools, biodiversity material is continuously delivered through integrated Science and Social Science Project-Based Learning (IPAS) within the school. Refer to Figure 3 and Figure 4 for activities and the implementation of learning using the GREEN model within IPAS Project-Based Learning. The achievements of the Integrated GREEN Model components can be seen in Table 2.

**Table 2.** Main Category Ozer & Achievement of its Components

| Main Category | Observed Components |
|---|---|
| Garden logistics | 1. Garden care and upkeep |
| | 2. Planning & establishing the physical space |
| | 3. Characteristics of the physical space |
| | 4. Crop vitality and diversity |
| | 5. Budget and funding |
| | 6. Networks and outside organizations |
| Student experience | 1. Connection with curriculum |
| | 2. Time spent in the garden |
| | 3. Activities |
| | 4. Engagement |
| | 5. Tasting opportunities |
| | 6. Additional learning opportunities |
| School culture | 1. Administrative support |
| | 2. Organizational staff structure |
| | 3. Volunteer and parent involvement |
| | 4. Social events and activities |
| | 5. Food environment and policies |
| | 6. Evaluation and feedback |

Source; The school garden domains created from Ozer's three domain categories and composed of 18 components described in the literature.

To assess the achievement of the implementation of the GREEN Model as an innovative learning strategy, it can be evaluated based on self-assessment components following the main categories developed by Ozer (2007). Here are the achievements of the school garden that have been developed to measure the attainment of the Integrated GREEN Model. When the Integrated GREEN Model has been achieved, the next step is to carry out sustainable biodiversity material learning. Analysis in this research is conducted through two methods, namely qualitative and quantitative analysis. Qualitative data analysis is used to assess the improvement of learning activities using project-based learning (PjBL) in the school garden and the learning process as a form of action taken. The syntax for Project-Based Learning used can be seen in Table 3.

Meanwhile, quantitative data analysis is used to assess the improvement in student learning outcomes as a result of each action taken. The quantitative data analyzed include pretest and posttest data. A conceptual understanding test was designed to obtain data on the improvement of students' conceptual understanding before and after the treatment was conducted. The test sheet consists of 14 short-answer questions. This test is structured based on the concept understanding indicators by Anderson, which include aspects of explaining, making inferences, interpreting, comparing, and classifying. Based on the results of the pre-test and post-test, the data on students' conceptual understanding analysis are obtained in Figure 5.

**Table 3**. Project Based Learning Syntax (Nurhidayah et al., 2021)

| Syntax | Activities |
|---|---|
| Reflection | Reflection Students are led into the context of the material and relate what is known to what needs to be learned. Then students are given a problem around. |
| Research | Research Students collect relevant sources of information to solve problems. Each group is directed to joint discussion |
| Discovery | Discovery Each group designs an experiment |
| Application | Application Each group will test the results of the experiments that have been designed. |
| Communication | Communication Each group reports the results of their research, and draws conclusions together |

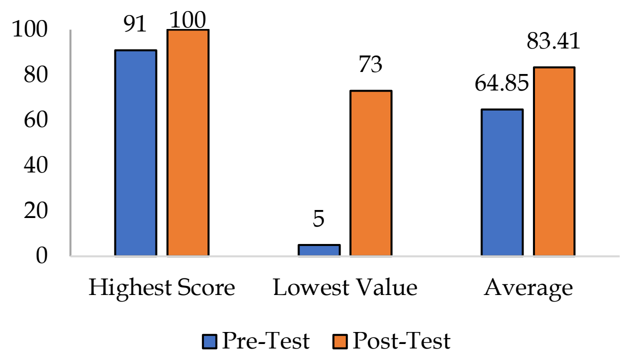


**Figure 5.** Comparison of pre-test and post-test Student's Understanding of Concepts

Based on Figure 5, the average score of the pre-test results obtained is quite high, which is 64.85. This indicates that the presence of a GREEN Model-based garden in the school environment can have an impact on the learning process indirectly through the formation of concepts themselves. Students acquire concepts in two ways: concept formation and concept assimilation (Dahar, 2012). Concept formation can be obtained by students before entering school, while concept assimilation is obtained during and after school. Meanwhile, the average post-test score obtained has increased to 83.41, meaning that the contribution of concept assimilation in the learning activities conducted by the teacher has only increased by approximately 18.56.

To date, there has been a notable deficiency in conceptual understanding regarding biodiversity topics, encompassing genetic biodiversity comprehension, illustrations of genetic biodiversity, levels of biodiversity comprehension, factors contributing to biodiversity in Indonesia, indigenous fauna within Indonesia, regional fauna type zones based on geographical distribution, and the distinctiveness of Indonesian tropical rainforests (Septian, 2018; Biggs, 2008).

To test whether there is a significant impact in implementing the GREEN Model integrated with IPAS Project learning, a t-test was conducted using the Microsoft Excel 2010 software application. If the value of p < sig (α=0.05), then H0 is rejected. This means there is a significant difference between the pre-test and post-test averages through the Two-Sample Assuming Equal Variances, as shown in Table 4.

**Table 4.** T-test: Two-Sample Assuming Equal Variances

| Statistical Description | Pre | Post |
|---|---|---|
| Mean | 64.85 | 83.41 |
| Variance | 755.40 | 276.67 |
| Observations | 34.00 | 34.00 |
| Pooled Variance | 516.03 | |
| Hypothesized Mean Difference | 0.00 | |
| df | 66.00 | |
| t Stat | -2.16 | |
| P(T<=t) one-tail | 0.02 | |
| t Critical one-tail | 1.67 | |
| P(T<=t) two-tail | 0.03 | |
| t Critical two-tail | 1.99 | |

Based on the data in Table 4, the results of the significance test for the difference in conceptual understanding before and after learning by implementing the GREEN Model integrated with IPAS Project learning in the two-tailed T-test with a sig (2-tailed = 0.034) < (0.05). Therefore, H0 is rejected. This indicates a significant difference in conceptual understanding before and after learning through the application of the GREEN Model integrated with IPAS Project learning. Based on these results, it reinforces the statement that learning through the application of the GREEN Model integrated with IPAS Project learning is effective in enhancing students' understanding of biodiversity material. Good conceptual understanding is one of the outcomes of concept formation and concept assimilation, as evident from the analysis of the effectiveness of improving students' conceptual understanding through the application of the GREEN Model integrated with IPAS Project learning in biodiversity material. The research results indicate that the project-based learning model has a high overall effect. This is consistent with a study by Melina et al. (2023), which shows that the project-based learning model can be used as an effective alternative in biology education. Furthermore, the research findings from Almulla (2020), also demonstrate that the project-based learning model enhances student engagement through knowledge sharing, information, and discussions. Therefore, the project-based learning model is highly recommended for educational use. Another finding from the research Rumahlatu et al. (2019), shows that the implementation of the project-based learning strategy has a significant effect on concept understanding.

The findings of this study are in line with the research results of Wara et al. (2015), which also demonstrate that the use of outdoor learning methods has a positive impact on student learning achievement. Dillon et al. (2006) claimed that outdoor learning experiences are much more effective in enhancing students' cognitive capacity compared to classroom-centered learning. This is because outdoor learning provides opportunities for students to construct their knowledge based on the natural environment (Hastutiningsih et al., 2016). The improved understanding of students' concepts is not solely due to the project-based learning model, but also due to the integration of the school environment as a learning resource. Taking students to the school environment provides ease in obtaining information about biodiversity directly, enabling students to learn how to discover facts, concepts, and principles through direct experience, thus allowing the knowledge gained to be deeply rooted in students' long-term memory and mind (Febrianti et al., 2019). This aligns with the view that the school environment is one of the learning resources that can be used to achieve quality learning processes and outcomes for learners (Aprilla et al., 2021). The implementation of the GREEN Model (Garden Resources, Education, and Environment Nexus), which utilizes the school garden as a learning resource, aligns with the research findings Nurwidodo et al. (2022), through steps of socialization, observation, potential identification, action planning, and implementation. The main categories developed Ozer (2007) align with the steps of utilizing the school garden in the Indonesian School Kota Kinabalu, meeting six criteria to be used as a learning resource, including clarity of potential, goals, targets, provided information, exploration guidelines, and acquisition (Nurwidodo et al., 2022).

Furthermore, qualitative data in this research were obtained from interviews and questionnaires. A total of 34 students provided responses to 8 questions related to their learning experiences using the Project-Based Learning model, which included activities such as reflection, research, discovery, application, and communication as shown in Figure 6. Overall student participation in all stages of Project Based Learning activities, starting from Reflection, Research, Discovery, Application, to Communication, received a positive response, which is above 50% or categorized as good

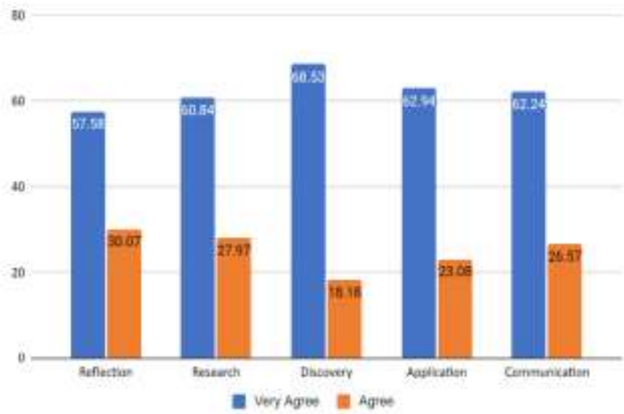


**Figure 6.** Student activity responses in PjBL

In detail, derivatives of the five indicators of student learning activities derived from the syntax of the Project Based Learning model have been developed into 8 statements.

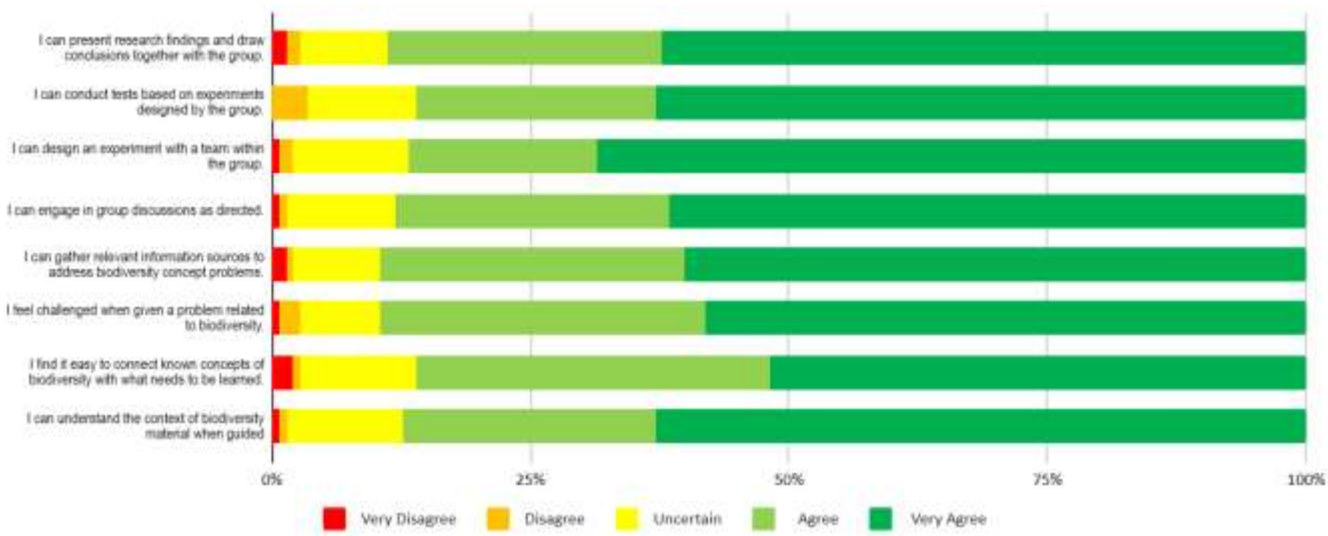


**Figure 7.** Diagram of questionnaire results

Overall, based on the distributed questionnaire Figure 7, it was found that students can understand the context of biodiversity material when guided and easily connect known concepts of biodiversity with what needs to be learned. They also feel challenged when given a problem related to biodiversity. Furthermore, students are capable of gathering relevant sources of information to address biodiversity concept issues, engaging in discussions within assigned groups, designing experiments as a team, conducting tests based on the experiments designed by their group, and presenting research results and drawing conclusions together as a group.

These findings were confirmed through interviews with three students about their experiences during learning using the GREEN Model integrated with IPAS Project learning, which enhanced their learning activities and improved their understanding of biodiversity concepts. This conclusion aligns with the literature review by Nurhidayah et al. (2019), who concluded that PjBL learning has a positive impact on student learning in schools. PjBL can enhance students' problem-solving abilities, subsequently improving their learning outcomes. Furthermore, PjBL learning can make students more active when participating in classroom learning.

## Conclusion

The research findings suggest that implementing the GREEN Model integrated with IPAS Project learning has a significant positive impact on students' understanding of biodiversity concepts. The pre-test scores, with an average of 64.85, indicate that the presence of a GREEN Model-based garden in the school environment indirectly influences the learning process through concept formation and assimilation. Concept formation may occur before students enter school, while concept assimilation happens during and after school. The average post-test score, which increased to 83.41, signifies that the contribution of concept assimilation in teacher-led learning activities improved by approximately 18.56. This demonstrates a notable difference in conceptual understanding before and after learning through the application of the GREEN Model integrated with IPAS Project learning. These results support the effectiveness of the GREEN Model integrated with IPAS Project learning in enhancing students' comprehension of biodiversity material. Strong conceptual understanding is an outcome of both concept formation and assimilation, as evidenced by the analysis of the effectiveness of this approach in improving students' conceptual understanding in biodiversity material.

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**Author Contributions**

All authors in this article play an active role, conceptualization, N.H. and E.R.; methodology, E.R.; software, N.H.; validation, N.H., S.F. and E.R.; formal analysis, S.F.; investigation, N.H.; resources, N.H.; data curation, N.H.; writing—original draft preparation, N.H.; writing—review and editing, E.R.; visualization, S.F.; supervision, E.R.; project administration, S.F.; funding acquisition, N.H.

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**Conflicts of Interest**

Research has no interest to anyone; research is purely a form of scientific writing for the world of education.

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