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The Influence of Experimental Learning Models on Cognitive Learning Outcomes in Energy Transformation Material in the Independent Curriculum

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Abstract: This study aims to test the effect of experimental learning models on the cognitive learning outcomes of 4th grade elementary school students on the material of energy transformation in the Independent Curriculum. Quantitative methods with quasi-experimental designs were used, involving all 4th grade elementary school students in Tugu District, Semarang City, divided into experimental and control classes. The experimental class was taught using an experimental learning model, while the control class used the lecture method. Cognitive learning outcomes were measured using tests that included indicators of essential competency achievement in the material of energy transformation. Data were analyzed using normality tests, homogeneity tests, t tests, N-Gain tests, and hypothesis tests to compare the average post-test scores between the two groups. The results showed a significant difference between students' cognitive learning outcomes in the two groups. The data obtained in the t stat column or t_{count} was 4.005, and the Critical two-tail or t_{table} was 1.972. The $t_{count} > t_{table}$ = 4.005 > 1.972 was obtained based on this. So, it can be concluded that, with a significance level of 5%, Ha is accepted and H0 is rejected. This study concludes that the experimental learning model positively affects students' cognitive learning outcomes on energy transformation material in the Independent Curriculum and can be an effective alternative to improve cognitive learning outcomes.

Keywords: Cognitive learning outcomes; Energy transformation; Experimental learning

Introduction

Education will influence human life in the future. Everyone needs education to improve their knowledge and skills and become quality human resources. Akareem & Hossain (2016) added, building quality human beings can be done through education. In line with this opinion, education is a conscious and planned effort to develop self-potential to explore intelligence and skills. Quality education will create a generation that is intelligent and has good ethics. According to Yusuf (2018), education is a learning process to develop knowledge gained through learning that has been done. Learning is the interaction between students and teachers in a place of learning (Ong & Quek, 2023; Sun et al., 2023). Learning is a process of interaction between teachers and students, both direct interactions such as face-to-face and indirect interactions or through learning media (Amrullah, 2021; Khalida & Astawan, 2021; Kalangi & Zakwandi, 2023). Learning is a teacher's effort that aims to build student understanding by organizing students, providing motivation so that it can provide good changes in students (Pinasthika & Kaltsum, 2022). Pamorti et al. (2024) added that learning is an activity of conveying knowledge, skills, and teaching good attitudes by teachers.

Teachers are the main factor that determines the quality of education (Mulyati, 2020). In line with the

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opinion of Loilatu et al. (2021) teachers are not just conveyors of material, but teachers play an important role in learning activities (Monteiro et al., 2021; Nadeem et al., 2023). Creating conducive learning activities in order to get maximum learning outcomes is the task of a teacher. So, it can be concluded that teachers greatly influence the world of education. However, the results of the PISA 2022 science literacy scores show that it is a significant challenge for the education system in Indonesia, especially in the cognitive aspect. The cognitive aspect is one of the domains in Taxonomy Theory (Andryannisa, 2023). In fact, in 2018 Indonesia's score was 396. While in 2022, it dropped to 383 points, far below the OECD average of 485 points. Of the 50 countries, Indonesia is ranked eighth from the bottom and has the second lowest score in ASEAN (OECD, 2022).

The low scores reflect the weak scientific thinking skills of students. Many students have difficulty answering questions that refer to scientific thinking skills. Daily and end-of-semester test scores also show low results (Mursyid et al., 2024). Low thinking skills are one of the factors that cause low science literacy scores. Superior cognitive abilities, especially in the field of critical thinking, are still in the low category, where during the teaching and learning process, students memorize more facts, principles, and theories, especially in the field of science. Science learning is not enough just by explaining and listening. Students must better understand the concepts taught by carrying out activities to discover them (Fitriani et al., 2024; Widiastuti et al., 2024). Therefore, as an important role holder, teachers must help overcome cognitive barriers or difficulties experienced by students during learning activities. These difficulties also include students' mental attitudes, self-control, distrust, anxiety, lack of knowledge, and conceptual misunderstandings (Chew & Cerbin, 2021).

In addition, there are also internal and external factors that affect student learning outcomes. Internal factors include interest and motivation, while external factors include monotonous learning activities (Efendi & Putri, 2022; Rahmah & Harahap, 2024). This problem is also increasingly complex due to teacher-centered learning, monotonous learning methods, and the lack of varied learning models. As a result, students tend only to memorize facts without being invited to think deeply, so their science learning outcomes are low (Nurmayani et al., 2018).

Science is an important subject and is always present at the elementary and secondary levels. In the independent curriculum, at the elementary school level, science (natural science) is combined with social science (IPS) to become natural and social science (IPAS) (Dauly et al., 2024). Suhelayanti et al. (2023) added that IPAS is a discipline that studies the interactions between living and non-living things in the universe as well as individual and social aspects of human life, by examining individual and community aspects of human life and how they interact with their environment. IPAS helps students develop a sense of curiosity about the phenomena around them (Nuryani et al., 2023).

Based on the results of interviews and observations conducted with grade IV elementary school teachers in Tugu District, Semarang City, it was found that student learning outcomes were still low, especially in the subject of science, energy transformation material. This can be seen from the daily scores that have not reached the specified Learning Objective Achievement Criteria. This is because teachers do not use a variety of learning models. Teachers tend to use the lecture method when explaining a material so that students feel bored and cannot understand the material optimally. Of course, this problem needs to be overcome so that student learning outcomes can achieve the set learning objectives. The role and skills of teachers when teaching are needed to overcome the problem of low learning outcomes (Hanifah et al., 2022; Permatasari & Ramadan, 2024; Zakharov et al., 2020). Teachers can make efforts to increase student interest and learning achievement with learning methods and models that need to be adjusted to the characteristics and materials so that learning objectives can be achieved optimally (Ayubi et al., 2024; Wardani et al., 2023). Teachers must facilitate learning activities in their implementation (Oviana et al., 2024).

Based on the statement above, it is necessary to apply learning with a fun learning model or method for students. With the right model or method, it can undoubtedly significantly influence the linear combination of science values (Seage & Turegun, 2020; Susilowati & Winanto, 2022; Tamalene & Jusuf, 2024). One of the learning models that is currently appropriate and helps improve student learning outcomes is the experimental learning model (Dakhi, 2020; Payu, 2023; Prahartiningrum & Fadiana, 2024; Susiloningsih et al., 2023). The experimental model is a model that provides opportunities for individual or group students to be trained to carry out a process or experiment (Gantina, 2020). Wandini et al. (2022) added that the experimental method presents lessons where students conduct experiments by experiencing and proving for themselves what is learned in the teaching and learning process. Experimental learning models also support 21st-century skills such as critical thinking, creativity, teamwork, and problem-solving can be done with this methodology (Laar et al., 2020). In addition, the application of experimental learning models can improve process skills. Science process skills allow students to learn science while actively participating in the learning process and conducting research appropriate for their age (Isiker & Emre, 2020). This model also effectively improves science skills in early childhood and elementary school students, especially grade IV students, such as research conducted by Astuti & Nurhafizah (2023) and Oma (2021).

The experimental learning model has systematic stages, including problem identification, data collection, experiments, testing, and concluding. These stages support the development of critical thinking indicators such as interpretation, analysis, and evaluation (Bintoro et al., 2022). With a learning model that supports critical thinking, students' cognitive science learning outcomes will increase (Fauziah, 2022; Septiani et al., 2022). In addition, current learning models must also follow technological developments. These developments include high-tech electronic devices equipped with internet facilities to facilitate communication and positively impact education (Ahmadi et al., 2019). One of the benefits of technology in education is that it facilitates the interaction process between students and teachers. One of its uses is to apply the experimental text learning model with technology as an Android-based flipped classroom model that allows students to learn independently at home and strengthen understanding in class (Ahmadi et al., 2020). In line with the statement above, learning models show a significant increase, especially in pedagogical competence in facilitating learning by combining various delivery methods, learning models, and learning styles to support interactions between teachers and students (Ahmadi et al., 2021). Applying experimental learning models to elementary school students certainly has advantages because it can build real perceptions of real objects (Shao et al., 2024). Thus, science education with the right learning model is critical. That way it will produce humans ready to face global challenges based on strong intellectuals (Desiyanti & Nugroho, 2024).

There are previous studies that discuss experimental learning models, such as research conducted by Putri & Meilana (2023) entitled "The Effect of Experimental Learning Methods on Students' Cognitive Abilities in Science Learning", the results of the study showed that experimental classes in science learning have much higher cognitive abilities, namely with an average of 81.718 compared to students in classes with classes that use lecture models during learning only getting an average of 73.857. Research by Vandho et al. (2024) entitled "The Influence of Experimental Methods on Understanding Concepts, Materials, Properties and Changes in the Form of Object", the results of the study showed that learning with experimental models can improve the material on the properties and changes in the form of objects as evidenced by the results of the hypothesis test of 0.000 and an increase in student learning outcomes. Research conducted by Setijani (2019) entitled "Implementation of Experimental Learning Model to Improve Learning Outcomes of Class VC Students of SDN Dukuh Menanggal I" showed that the average in cycle I reached 76.35 and in cycle II it got a score of 84.53. Meanwhile, classical completeness in cycle I obtained a percentage of 75% and cycle II was 93.75%. So, the experimental learning method can have a positive effect on improving the learning outcomes of class VC of SDN Dukuh Menanggal I Surabaya.

Based on the problems above, this study aims to determine the influence, variation, and effectiveness of students' cognitive learning outcomes on Energy Transformation material in grade IV of elementary school in Tugu District before and after learning with an experimental learning model. Based on the statement above, there is an urgency to conduct research in the form of novelty about the influence of experimental learning models on cognitive learning outcomes of energy transformation material in grade IV of elementary school in Tugu District in the context of the Independent Curriculum.

Method

This research is quantitative research with an experimental research type in the form of a quasi-experiment. This method has stages consisting of pretest, treatment, and posttest. The advantage of quasi-experimental research is that there are no strict limitations in randomization (Abraham & Supriyati, 2022).

This study used Nonequivalent Group Design. All participants in this study were 4th grade elementary school students in Tugu District, Semarang City. The sampling method used in this study was Non-Probability Sampling. This sampling technique does not provide equal opportunities to each member of the population (Sugiyono, 2019). Sampling was carried out using the total sampling technique or saturated sampling. This is often done when the population is relatively small, less than 30 people.

The population in this study came from 10 different primary schools with each class consisting of less than 30 students. The school with the largest number of students in this study was SDN Karanganyar 01. SDN Karanganyar 01 had a total of 51 students with class A consisting of 26 students and class B with 25 students. SDN Karanganyar 02 has 21 students, while SDN Mangkang Wetan 01 has 27 students. Similarly, SDN Mangkang Wetan 03 has 21 students. Furthermore, SDN

Mangkang Kulon 01 has 14 students, while SDN Mangkang Kulon 02 has 22 students and SDN Mangkang Kulon 03 has 16 students. The school with the smallest number of students is SD Islam Hasanuddin 03 with 4 students, while SDN Randugarut has 9 students. Finally, SDN Tugurejo 03 has 25 students. In total, 210 students participated in this study, spread across various schools in Tugu Subdistrict, Semarang City. This diverse population provides a comprehensive representation of students from different schools, allowing for a more in-depth analysis of the effect of the experimental learning model on the experimental class and the use of other learning models used by teachers in the control class.

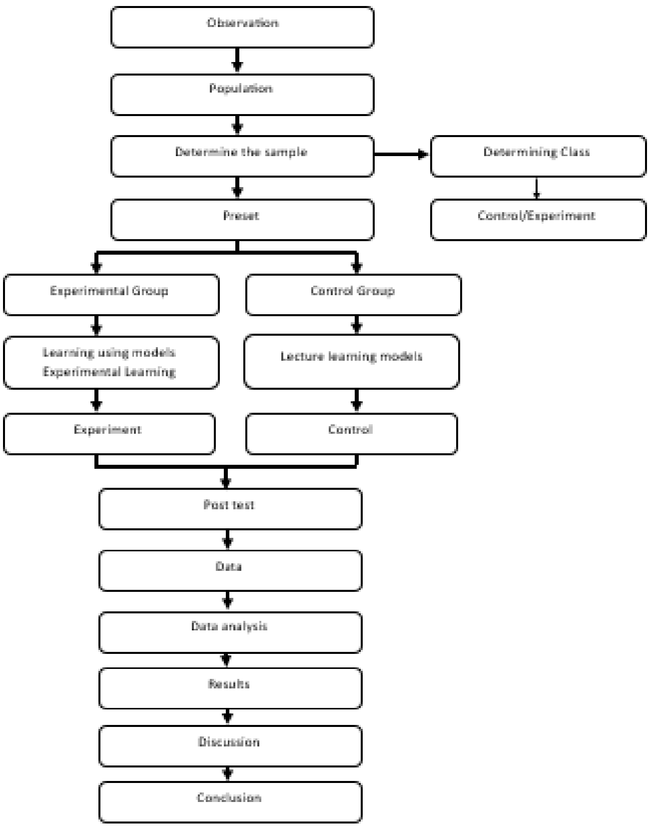

Figure 1. Research stages

The selected schools must have similarities in accreditation, curriculum, and geographical location. In line with these considerations, these 10 schools have the same accreditation, use the same independent curriculum, and have the same geographical location in a residential area in Tugu District, Semarang City, easy to reach. The overall data is divided into experimental and control classes using random division, but does not change the groups that have been formed. The division is done by considering the balance of numbers between the experimental class and the control class, so that classes are obtained as in Table 1.

Design. This study focuses on data on students' cognitive learning outcomes in science and social studies (IPAS) subjects. The results of cognitive learning instruments go through stages of validity, reliability, discriminatory power, and difficulty levels through descriptive data analysis. The data also goes through a testing stage using normality, homogeneity, t-test, N gain test, and hypothesis testing. This hypothesis testing is carried out to determine significant differences between the experimental and control groups.

Table 1. Data on the number of control and experimental classes

Control class		Experimental class	
School name	Amount	School name	Amount
SDN Karanganyar 02	21	SDN Karanganyar 01	26 (A)
SDN Mangkang Kulon 03	16		25 (B)
SDN Mangkang wetan 01	27	SDN Tugurejo 03	25
SD Islam Hasanuddin 03	4	SDN Mangkang Kulon 02	22
SDN Mangkang Wetan 03	21	SDN Randugarut	9
SDN Mangkang Kulon 01	14		
Amount	103		107

Results and Discussion

The findings of this study examine how the application of experimental learning models in fourth grade impacts the learning outcomes of science students related to energy transformation material. The data used are the results of pre-tests and post-tests from experimental and control courses in several schools in Tugu District, Semarang City. The analysis was carried out using homogeneity tests, normality tests, t-tests, and N-Gain tests to determine how experimental learning models affect the cognitive learning outcomes of fourth grade students, especially in elementary schools in Tugu District. The data were processed using Microsoft Excel and SPSS 27. The following are the results of the pretest and posttest scores for the experimental class.

Table 2. Pretest posttest experimental class

School	Pretest Average Score	Posttest Mean Value	Means
SDN Karanganyar 01 (4A)	60.53	86.23	73.38
SDN Karanganyar 01 (4B)	60.56	86.74	73.65
SDN Mangkang Kulon 02	60.92	86.72	73.82
SDN Tugurejo 03	62.84	86.48	74.66
SDN Randugarut	60.44	86.77	73.61

Based on Table 2, the experimental class increased the average score from pretest to posttest to the all schools. The average pretest score ranged from 60-62, while the posttest increased to 87. Meanwhile, in Table 3, the control class also experienced an increase in average scores. However, when compared to the experimental class, the increase was more minor. The average pre-test scores ranged between 60 and 61, while the average post-test scores ranged between 80. Furthermore, after the pretest and posttest data were collected, homogeneity testing was carried out on the experimental and control classes.

Table 3. Pretest posttest control class

School	Pretest Mean Scores	Posttest Mean Scores	Means
SD Islam Hasanuddin 03	60.00	80.00	70
SDN Mangkang Kulon 01	59.76	80.26	70.01
SDN Mangkang Wetan 01	60.96	80.75	70.85
SDN Mangkang Wetan 03	59.66	80.66	70.16
SDN Karanganyar 02	60.28	80.42	70.35
SDN Mangkang Kulon 03	60.18	80.37	70.28

Table 4. Results of the experimental class normality test

School	Signature (Shapiro Wilk) Pre-exam	Signature (Shapiro Wilk) Post-exam
SDN Karanganyar 01 (4A)	0.291	0.138
SDN Karanganyar 01 (4B)	0.516	0.369
SDN Mangkang Kulon 02	0.997	0.327
SDN Tugurejo 03	0.132	0.074
SDN Randugarut	0.393	0.600

Table 5. Results of the control class normality test

School	Signature (Shapiro Wilk) Pre-exam	Signature (Shapiro Wilk) Post-exam
SD Islam Hasanuddin 03	0.792	0.650
SDN Mangkang Kulon 01	0.548	0.681
SDN Mangkang Wetan 01	0.377	0.221
SDN Mangkang Wetan 03	0.742	0.481
SDN Karanganyar 02	0.607	0.148
SDN Mangkang Kulon 03	0.109	0.850

The normality test results showed that the pretest and posttest data in the experimental class are normally distributed. This is evidenced by the Shapiro-Wilk significance value above 0.05 in most schools. In SDN Karanganyar 01 class 4A, the pretest significance value was 0.291 and the posttest was 0.138, indicating a normal distribution at both stages. SDN Karanganyar 01 class 4B also had a pretest value of 0.516 and a posttest of 0.369, indicating the same results. SDN Mangkang Kulon 02 showed a very higtest value of 0.997 and a posttest of 0.327, indicating a normal data distribution. Meanwhile, SDN Tugurejo 03 had a pretest value of 0.132 and a posttest of 0.074. Although the posttest was close to the normality limit, the data was still acceptable as a normal distribution. SDN Randugarut showed a pretest value of 0.393 and a posttest value of 0.600, strengthening the overall expected distribution results in the experimental class.

The results of the normality test also show that the data in the control group control group is normally distributed. In SD Islam Hasanuddin 03, the pretest significance value was 0.792 and the posttest was 0.650, indicating a stable normal distribution. SDN Mangkang Kulon 01 recorded a pretest value of 0.548 and a posttest of 0.681, while SDN Mangkang Wetan 01 had a pretest value of 0.377 and a posttest of 0.221. Although the posttest value of SDN Mangkang Wetan 01 was smaller than the others, the results were still within normal limits. SDN Mangkang Wetan 03 showed a pretest value of 0.742 and a posttest of 0.481, indicating a normal distribution. SDN Karanganyar 02 had a pretest value of 0.607 and a posttest of 0.148; SDN Mangkang Kulon 03 recorded a pretest score of 0.109 and a posttest score of 0.850. Although the posttest value was slightly below the threshold of 0.05, the pretest results still showed a normal distribution.

Overall, the pretest and posttest data in most of the experimental and control classes showed a normal distribution based on the results of the Shapiro-Wilk test. This strengthens the validity of the data analysis because the assumption of normality is met in most of the schools involved in the study.

Table 6. Results of the experimental class homogeneity test

School	Sig. (based on average)
SDN Karanganyar 01 (4A)	0.073
SDN Karanganyar 01 (4B)	0.151
SDN Mangkang Kulon 02	0.207
SDN Tugurejo 03	0.915
SDN Randugarut	0.114

Table 7. Results of the control class homogeneity test

School	Sig (based on average)
SD Islam Hasanuddin 03	0.237
SDN Mangkang Kulon 01	0.196
SDN Mangkang Wetan 01	0.187
SDN Mangkang Wetan 03	0.061
SDN Karanganyar 02	0.898
SDN Mangkang Kulon 03	0.105

A homogeneity test should be conducted after the normality test. Based on the result, the homogeneity test of the experimental class, all schools have a have significance value above 0.05, which indicates that pretest and posttest data are homogeneous. SDN Karanganyar a significance value of 0.073, while SDN

Karanganyar 01 class 4B shows a class 4B shows value of 0.151. SDN Mangkang Kulon 02 significance value of 0.207, SDN Tugurejo 03 has a value of 0.915, and SDN Randugarut shows the value of 0.the 114. With homogeneous data, analysis result is more valid for comparison.

With a significance value of more than 0.05, the experimental class homogeneity test findings indicate that each school's pre-test and post-test data are homogeneous. This ensures a fair distribution of data variation among schools, making the comparative analysis more valid. Next, the determinateness of using experimental models in learning or the increase in the average pretest and posttest with the N-Gain Test will be the N-Gain criteria are in the table below.

Table 8. N Gain criteria (Lestari & Yudhanegara, 2018)

N-Gain	Criteria
N-Gain ≥ 0.70	Tall
0.30 ≤ N-Gain < 0.70	Currently
N-Gain ≤ 0.30	Low

Table 9. Interpretation of N Gain effectiveness (Lestari & Yudhanegara, 2018)

Percentage (%)	Interpretation
< 40	Ineffective
40 – 55	Less Effective
56 – 75	Quite Effective
> 76	very effective

Table 10. N-Gain test

Class	Means	Criteria	Interpretation
Test	0.676	Currently	Quite effective
Control	0.526	Currently	Less effective

The average N-Gain of the class based on the results of the N-Gain test was 0.676 (quite effective category), while the control class was only 0.526 (less effective category). This difference shows that learning with the experimental model is superior to traditional learning in improving student learning outcomes. It can be concluded that the experimental learning model is efficacious in improving science learning outcomes on energy transformation material at SDN Karanganyar 01 class A, SDN Karanganyar 01 class B, SDN Tugurejo 03, SDN Mangkang Kulon 02, and SDN Randugarut in Tugu District, Semarang City.

Furthermore, an independent samples test was conducted to find out whether there is a difference in the effectiveness of learning with experimental models and conventional learning models in the subject of science on energy transformation material. Below is a table of independent samples t-test.

Based on the experimental and control classes hypothesis test (independent samples t test). With a significance value of 0.00 < 0.05. In addition, it was obtained in the t stat column or t_{count} of 4.005 and t Critical two-tail or t_{table} 1.972. Based on this, it was obtained $t_{count} > t_{table}$ that = 4.005 > 1.972 was obtained concluded with a significance level of 5% that Ha is accepted and H_0 is rejected. Based on the reference for decision making, it means that there is a difference in value or learning outcomes between the experimental class that applies the experimental learning model and conventional learning (without using the experimental learning model).

Table 11. Hypothesis test results

T-Test: Two-Sample Assuming Equal Variances		
	Control	experiment
Mean	80.45	86.43
Variance	149.11	83.96
Observations	102	106
Pooled Variance	115.91	
Hypothesized Mean Difference	0	
Df	206	
T Stat	4.01	
P (T ≤ t) one-tail	0,00	
t Critical one-tail	1.65	
P (T ≤ t) two-tail	0.00	
t Critical two-tail	1.97	

This research was conducted in several elementary schools in Tugu District, Semarang City. The control class consisted of SD Islam Hasanuddin 03, SDN Mangkang Kulon 01, SDN Mangkang Wetan 01, SDN Mangkang Wetan 03, SDN Karanganyar 02, and SDN Mangkang Kulon 03. Meanwhile, the experimental class included SDN Karanganyar 01 class A, SDN Karanganyar 01 class B, SDN Tugurejo 03, SDN Mangkang Kulon 02, and SDN Randugarut.

Based on the results of the study, there is a significant difference between the average scores of the control class and the experimental class on energy transformation material. The average score of students in the control class was 80.45, while the experimental class was higher at 86.43. This difference shows that students who learn with the experimental learning model obtain better learning outcomes compared to students in the control class. Thus, the experimental learning model is proven to have a positive effect on improving student learning outcomes on energy transformation material.

Conclusion

The results and discussion above indicate that there is an influence on science learning of energy transformation material in the use of experimental models in experimental classes (SDN Karanganyar 01 class A, SDN Karanganyar 01 class B, SDN Tugurejo 03, SDN Mangkang Kulon 02, and SDN Randugarut) in Tugu District, Semarang City. This finding is supported by data and statistical analysis that show a positive increase in academic learning outcomes after the experimental learning model was applied in the classroom compared to the conventional learning model. This study concludes that applying experimental learning models can significantly improve student learning outcomes. This is evidenced by the statistical data of the average pretest or before learning with the experimental model of 61 and the posttest or after learning with the experimental model of 87, which means there is an increase in student learning outcomes. Thus, the experimental learning model in science learning on energy transformation material is effectively used in grade IV of elementary school in Tugu District, Semarang City.

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Author Contributions
Conceptualization, review and editing, F. and F.A.; methodology, data analysis using SPSS & Microsoft Excel, formal analysis, investigation, resources, data curation, preparation of initial draft of the paper, F.; validation, supervision, F.A. All authors have read and approved the published version of the manuscript.

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Conflict of Interest
The author declares no conflict of interest.

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