Borneo Engineering & Advanced Multidisciplinary International Journal (BEAM)
Volume 5, Issue 1, May 2026, Pages 53-60

The Effect of Model-Building Activity Towards Pupils' Achievement on Topic Human Blood Circulatory System Among Year Five Pupils

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Full Paper

Article history
Received
8 February 2026
Received in revised form
2 April 2026
Accepted
13 April 2026
Published online
5 May 2026

Abstract

The Human Blood Circulatory System (HBCS) is a challenging topic for primary pupils due to its abstract nature which often leads to misconceptions and low achievement when taught through conventional-teaching methods. This study aims to investigate the effectiveness of a model-building activity in improving Year Five pupils' achievement in the HBCS topic. A quasi-experimental design involving 68 pupils was employed, consisting of an experimental group taught using model-building and a control group taught using conventional teaching method. Data was collected through a pre-test and post-test using the Human Blood Circulatory System Achievement Test. The findings showed a significant improvement in the experimental group's mean scores between pre-test and post-test, as well as a significant difference in post-test scores between the experimental and control groups. These results indicate that model-building promotes better conceptual understanding and enhances academic achievement by enabling pupils to visualize abstract processes and engage in active learning. The study highlights the importance of incorporating hands-on and student-centered approaches to support deeper comprehension of scientific concepts and suggests that model-building can be an effective instructional strategy for teaching complex topics in science.

Keywords: - Model-building activity, human blood circulatory system, hands-on learning, primary science, academic achievement

1. Introduction

Teaching and learning abstract scientific concepts pose major challenges in primary education, particularly when pupils are required to understand complex internal biological systems. The Human Blood Circulatory System (HBCS) is a fundamental component of the Year Five Science curriculum and serves as the foundation for learning subsequent human body system topics. Pupils are expected to describe the functions of main organs involved in blood circulation, sketch blood pathways, explain their observations and summarize the importance of the circulatory system.

The primary problem addressed in this study is the persistently low achievement of pupils in the HBCS topic at the primary level. Research indicates that HBCS remains a difficult topic among primary school pupils due to its abstract nature and reliance on imagination rather than concrete experiences (Nurfitriah, 2023). Besides, pupils also struggled to visualize how blood circulates, how the heart functions and how the path of the oxygenated and deoxygenated blood differs due to its abstract and invisible nature (Khairaty et al., 2018). According to Heryani et al. (2022), this problem is aggravated by the dominance of conventional teaching approach in classroom, where teachers deliver content verbally while pupils listen passively and limits their cognitive engagement. Pupils are left struggling to imagine the anatomical structure and physiological processes solely through diagrams. Without concrete learning tools, pupils struggle to interpret textbook diagrams and mentally simulate how the system works (Suriani et al., 2022). Consequently, it leads to fragmented understanding and the formation of misconceptions, particularly regarding the function of the heart and lungs and the distinction between oxygenated and deoxygenated blood, leading to low pupils' achievement (Sodervik et al., 2019).

To address these learning challenges, active and engaging teaching strategies have been found to improve pupils' conceptual understanding of complex science topics. One promising strategy is the model-building activity that enables pupils to construct tangible representations of abstract scientific concepts. Model-building helps to improve pupils' achievement by enabling them to visualize and manipulate physical representations of abstract processes (Hetika et al., 2018). Burke et al. (2020) & Hacisalihoglu et al. (2020) found that active learning strategies, including model-based activity, significantly enhance pupils' conceptual understanding and achievement. Several past studies show that hands-on learning improves academic achievement and increases pupil motivation in science rather than just listen to the lecture (Hetika et al., 2018 & German & Lestari, 2020). However, there is limited research on the use of model-building specifically for teaching HBCS at the primary level. Therefore, this study addresses the gap by examining the effect of model-building activity towards pupils' achievement in HBCS topic to encourage active participation and support accurate understanding.

The purpose of this study is to investigate the effectiveness of model-building activity towards pupils' achievement on topic HBCS among Year Five pupils. Therefore, the study was instructed by the two following objectives:

1. To determine whether there is a significant improvement in the mean score of the achievement test in topic of Human Blood Circulatory System in the pre-test and post-test for the experimental group that followed the teaching using model-building activity.
2. To determine whether there is a significant difference in the mean score of the post-test for the achievement test in the topic of Human Blood Circulatory System between the group that followed teaching using model-building activity and the group that followed conventional teaching method.

To address these objectives, the study was structured through two research questions as shown below:

1. Is there a statistically significant improvement in the mean scores of the achievement test on topic Human Blood Circulatory System between the pre-test and post-test of the group that followed science teaching through model-building activity?
2. Is there a statistically significant difference in the mean scores of the post-test on the achievement test on topic of Human Blood Circulatory System between the group of pupils who followed science teaching through model-building activity and the group of pupils who followed conventional teaching method?

These questions were designed to correspond directly with the problem statement and to provide an organized structure for evaluating the effectiveness of model-building activity.

2. Literature Review

This intervention grounded on Constructivist Learning Theory (Piaget, 1970) which emphasizes that learning occurs when learners actively construct their own understanding through experience and interaction with their environment. According to this theory, learning occurs when pupils manipulate materials, collaborate and reflect on connecting new knowledge with prior experiences. Therefore, this study integrates model-building as a hands-on approach that allows pupils to explore abstract science concepts through concrete experiences rather than passively receiving information. Therefore, by incorporating model-building into science lessons, this study supports the theory's suggestion that meaningful learning occurs when pupils are given opportunities to experiment, discuss and reflect during the learning process.

Based on the review of previous studies, the researchers consistently report that pupils' achievement in the topic HBCS was low across various levels of education due to difficulty in learning, causing low learning achievement (Ramdani, et al., 2021). Khairaty et al. (2018) also noted that the HBCS is one of the challenging topics in science education, primarily due to the lack of concrete learning resources and teacher-centered teaching practices. Many pupils struggle to understand the abstract nature of this topic because it involves complex and invisible processes such as blood flow and organ interactions. Research also showed that high school pupils exhibit misconceptions about the blood circulation system due to the misunderstanding about HBCS concept and have low ability to understand how the system works (Suriani et al., 2022). Hence, due to pupils' limited comprehension of the HBCS, it demonstrates the need for more effective teaching methods that promote conceptual understanding rather than rote memorization. Therefore, these findings suggest that teaching strategies for abstract scientific concepts should move beyond conventional methods toward more interactive and student-centered approaches. Research using open-ended questions and interviews shows inefficiencies due to teachers' teaching methods causing the inability to detect true misconceptions.

In response to these issues, many researchers have proposed using intervention strategies that promote active learning. However, there were limited studies that focused on model-building activity as one of the hands-on activities in HBCS topic especially in primary school. Bryce et al. (2016) described that model-building is the one of the successful learning activities in science as it enables pupils to express what they are learning based on the phenomenon or system by developing the original model in an inquiry context practiced using inquiry-thinking skills. The activityprovidested is based on Piaget's constructivist theory that provides basis for hands-on learning in which pupils construct their knowledge through experience and supplementing it with previously acquired knowledge. Through constructing models, transform the abstract aspects into a tangible reality that can be clearly understood (Gilbert & Gusti, 2016), visualize the internal mechanisms of the circulatory system, test their assumptions and correct the misconceptions. Burke et al. (2020) & Hacisalihoglu et al. (2020) found that active learning strategies, including model-based activity, significantly enhance pupils' conceptual understanding and achievement.

Although researchers have reported the positive effects of hands-on and active learning strategies on pupils' understanding and achievement, most studies tend to examine these approaches in general or focus on secondary-level education. Research that specifically investigates structured model-building activities for the HBCS topic at the primary school level is still limited. Therefore, there is a clear research gap in investigating the effectiveness of model-building activity in enhancing Year Five pupils' achievement in the HBCS topic. This study seeks to address this gap by investigating how model-building activity can enhance pupils' achievement in HBCS topic.

3. Methodology

This study employed a quasi-experimental, non-equivalent control group design to examine the effect of model-building activity on pupils' achievement in HBCS. This design is appropriate when random assignment of participants is not feasible (Gay & Airasian, 2002). Instead, two intact Year Five classes from two different primary schools in Sungai Petani, Kedah were selected. A purposive sampling technique was used to select two schools with similar characteristics to avoid contamination between groups and ensure comparable academic backgrounds. The two selected schools shared similar characteristics where the pupils were comparable in academic performance based on their pilot test, pre-test and recent school examination results. Both schools were also located in semi-urban areas, with similar access to educational resources, school facilities and teaching environments to ensure comparable learning conditions for both groups. The sampling involved a total of 68 Year Five pupils, with 33 pupils in the experimental group and 35 in the control group. The design allowed comparison between the experimental group that was taught using a model-building activity, while the control group learned through the conventional teaching method.

The instrument used to measure pupils' achievement was the Human Blood Circulatory System Achievement Test, which consisted of multiple-choice, multiple-response and structured items. This test was self-developed based on the Year Five Science Curriculum and modified from the bank question that has been constructed following standard test development guidelines. The test was administered twice, which are as a pre-test before the intervention and a post-test after the teaching sessions. A formal permission was obtained from the school administration prior to the commencement of data collection. It was to ensure ethical compliance and facilitate the smooth implementation of the study. To ensure validity of the instrument, the test was reviewed by expert science teachers to provide feedback, enhance clarity and to confirm whether the questions were aligned with the Year Five Science curriculum and learning standards. These steps ensured that the achievement test met the required standards of measurement quality for educational research. A pilot study involving pupils Year Six pupils was conducted and the reliability of the instrument was calculated using the KR-20 formula, yielding a coefficient of 0.80 which indicates the test items demonstrated strong internal consistency (Cohen et al., 2018).

For data collection, both groups first completed a pre-test to measure their initial understanding of the Human Blood Circulatory System. Over three weeks, the experimental group underwent model-building activities, while the control group received conventional teaching. After the intervention, both groups completed a post-test under similar conditions. All test papers were scored using a standard marking scheme and the scores were recorded and securely stored.

After all the intervention and data collection procedure were done, the obtained scores in achievement test from both groups were analyzed using descriptive and inferential statistics. In descriptive statistics, the mean and standard deviation were calculated to summarize pupils' scores. Subsequently, before using parametric tests, assumptions of normality and homogeneity of variance were tested and met to ensure the appropriateness of parametric analysis. Then, the inferential statistics, specifically paired-sample t-test and independent-sample t-test were conducted. The paired-sample t-test was used to compare pre- and post-test scores within the experimental group, and independent-sample t-tests were used to compare post-test scores between the two groups. All analyses were conducted using SPSS Version 29, with a significance level set at $p < 0.05$. All analyses adhered to assumptions of normality and homogeneity of variance which followed the recommended procedures.

4. Result and Discussion

The findings of the study were presented according to the two research questions and provide comprehensive insights into the effectiveness of model-building activity in improving pupils' achievement in HBCS topic.

For research question (1), the descriptive statistics were conducted to obtain the mean scores and standard deviation of the pre-test and post-test for the experimental group. Table 1 shows the summary of the findings.

Table 1: Mean scores and standard deviation of pre-test and post-test scores for experimental group

Group	Type of Test	Mean	Standard Deviation (SD)
Experimental	Pre-test	31.09	5.50
	Post-test	84.48	4.26

Based on Table 2, the analysis presents that pupils in the experimental group showed a substantial improvement in their achievement after undergoing the model-building activity. This result has been revealed by the descriptive statistics where experimental group demonstrated a substantial increase from pre-test (M = 31.09, SD = 5.50) to post-test (M = 84.48, SD = 4.26). It shows that the mean post-test score increased significantly following the intervention. This substantial gain is also illustrated in Fig. 1 by using bar chart to highlight the clear shift values before and after the model-building intervention.

To determine whether there was a statistically significant difference between the mean scores of the pre-test and post-test for the experimental group, a paired sample t-test was conducted at $\alpha = 0.05$ significance level. The results of the paired sample t-test were presented in Table 2.

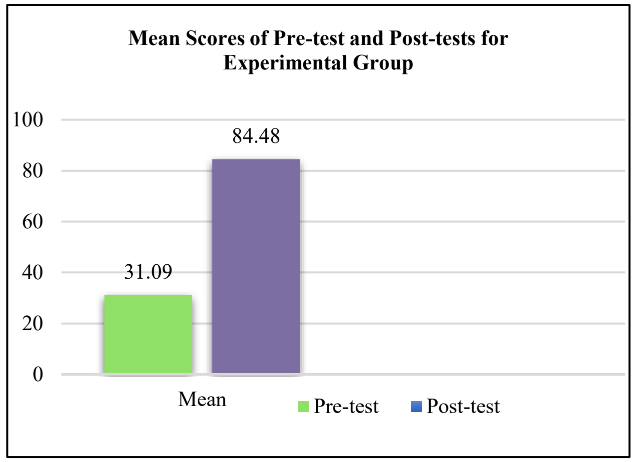

Fig. 1: Bar charts mean score of the pre-test and post-test for the experimental group

Table 2: Paired-samples t-test result

Paired Samples Test										
		Paired Differences							Significance	
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	Upper	t	df	One-Sided p	Two-Sided p
Pair 1	Pre_Test_Score - Post_Test_Score	-53.39	2.44	.42	-54.26	-52.53	-125.92	32	<.001	<.001

As shown in Table 2, there was a statistically significant improvement in pupils' scores from the pre-test (M = 31.09, SD = 5.50) to the post-test (M = 84.48, SD = 4.26), t(32) = 125.92, $p < .05$ (two-tailed). The eta squared statistic obtained is .99 which indicated a large effect size, suggesting that the intervention had a substantial positive impact on pupils' learning outcomes (Cohen, 1988). This result directly answers research question (1) by confirming that the experimental group showed statistically significant improvement after the intervention.

Table 3: Mean scores and standard deviation of the post-tests for experimental and control groups

Type of Test	Group	N	Mean	Std. Deviation
Post_Test_Score	Experimental	33	84.48	4.26
	Control	35	66.54	5.31

Table 3 above presents the descriptive statistics of the post-test for both experimental and control groups. The experimental group recorded a mean score of 84.48 (N=33, SD= 4.26) higher than the control group which is 66.54 (N=35, SD 5.31). This result indicates that the experimental group performed better in post-test compared to the control group. Fig. 2 below illustrates mean for the post-test for the experimental and control groups.

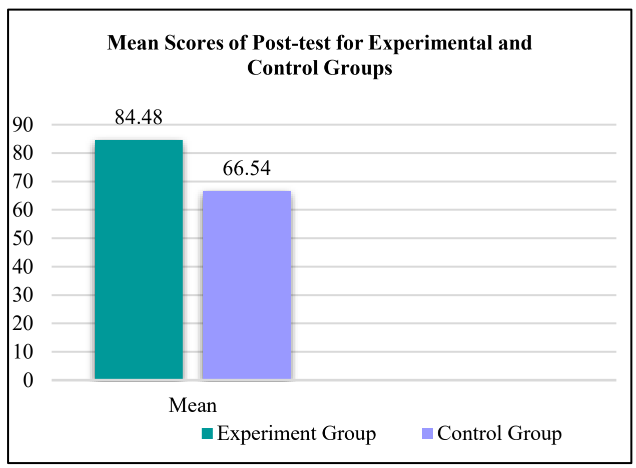

Fig. 2: Bar chart for mean scores of post-test for experimental and control groups

To determine whether there is a statistically significant difference in the mean score of the post-test between the group of pupils who followed science teaching through model- building activity and the group of pupils who followed conventional teaching method on HBCS topic, an independent-sample t-test was conducted to examine the difference of post-test scores between the experimental group and control group. The independent-sample t-test was conducted at $\alpha = 0.05$ significance level. Table 4 presents the results of the independent sample t-test.

Based on Table 4, since the homogeneity of variance was $F(1, 66) = 1.83$, $p = .18$ which is $p > 0.05$, thus, the equal variance is met. This result indicates that the variances between groups are homogeneous. Therefore, the independent sample test results for equal variances assumed row were interpreted. The interpretation of results of the row showed that the experimental group scored significantly higher than the control group, $t(66) = 15.31$, $p < .05$ with a large effect size ($\eta^2 = .78$). Thus, this finding answer research question (2) by demonstrating that pupils that followed teaching through model-building activity performed significantly better than those taught using conventional teaching method.

Table 4: Independent sample test result

Independent samples Test											
		Levene's Test for Equality of Variances		for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
Post_Test_ Score	Equal variances assumed	1.83	.18	15.31	66	<.001	<.001	17.94	1.17	15.60	20.28
	Equal variances not assumed			15.41	64.38	<.001	<.001	17.94	1.16	15.62	20.27

The findings of this study show strong alignment with existing literature that supports model- building activity in enhancing pupils' understanding and achievement. These outcomes align with constructivist assumptions, which argue that pupils learn best by actively constructing knowledge rather than passively receiving information (Piaget, 1970). Through building physical models, pupils externalized their conceptual understanding, tested ideas and negotiated meaning collaboratively. This active process supported deeper learning and reduced misconceptions, as highlighted in previous research (Bryce et al., 2016 & Gilbert & Gusti, 2016). The substantial gain in the post-test score of the experimental group convinced that model- building activity has positive impact on pupils' achievement. This result aligns with previous studies which reported that pupils who engaged in hands-on science activity achieved higher test scores compared to those that focused on lecture-based learning (Louca, 2023; Yılmaz, 2024 & Nwankwo, 2024).

Furthermore, the findings also show that the conventional method that used teacher-centered approach used did not produce comparable gains in the control group. This suggests that passive learning environments may be insufficient for abstract biological concepts, a finding echoed by prior research (Khairaty et al., 2018 & Yesilyurt & Gul, 2012). In relation, the lower performance of control group reinforces the limitations of conventional teaching methods often fail to support visualizations or higher-order cognitive processing (Hussain et al., 2011). In contrast, the hands-on model-building activity enabled pupils to form concrete mental models that strengthened understanding and retention, consistent with Dale's Cone of Experience (Dale, 1969). Hands-on activities produce stronger learning retention than reading or listening (Dale, 1969).

In this study, pupils formed concrete representations of how the gaseous exchange process, and the blood circulation works in human body. This tactile experience improved their ability to visualize the system's functional relationships which consistent with findings by Burke et al. (2020) & Hetika et al. (2018). During the intervention, pupils collaborated in small groups, promoting peer explanation, evaluation of reasoning and correction of misconceptions. Consistent with the findings of Kapici et al. (2019), collaborative model-building fosters deeper conceptual elaboration, as learners negotiate meaning and co-construct understanding. Overall, the findings support the argument that hands-on and constructivist approaches are not supplementary but essential for teaching complex biological systems, particularly at the primary level and contribute to new evidence showing that the model-building activity is effective in increasing achievement among Year Five pupils in HBCS topic.

5. Conclusion

Overall, the study successfully achieved all its research objectives. The findings of this study shows that model-building activity significantly enhances Year Five pupils' achievement in Human Blood Circulatory System topic. Pupils in the experimental group demonstrated significant improvement from pre-test to post-test and outperformed those taught using conventional teaching method. The substantial gain in the post-test scores indicates that pupils that have been taught using model-building activity in hands-on approach demonstrated a higher level of mastery compared to those who were taught through conventional-teaching method. These findings also prove that the intervention used is effective in improving pupils' achievements in science learning.

In relation to learning theory, the results support the Constructivist Theory of Learning which emphasizes that pupils construct knowledge actively through hands-on experiences. The process of building models enabled learners to visualize abstract concepts, engage in problem-solving and develop a deeper understanding of the circulatory system. This can be proved by the findings which has revealed a significant improvement in pupils' post-test scores after engaging in model-building activity compared to the pupils' who were taught through conventional-teaching method. These results also supported with several previous studies that highlighted the use of model-building activity has a positive impact on pupils' achievement in learning HBCS topic.

In conclusion, the use of model-building activity significantly enhanced pupils' achievement in learning the Human Blood Circulatory System topic. This study demonstrates that by incorporating hands-on and constructivist-based approaches in primary science classrooms, it can effectively bridge the gap between abstract biological concepts and pupils' conceptual understanding by promoting deeper understanding along with fostering pupils' engagement, collaboration and meaningful learning experiences. It also highlighted the growing body of evidence where model-building activity and hands-on approach can transform primary science instruction from a teacher-cantered approach to a more student-cantered learning experience. Hence, integrating model-building activity into classroom practice can serve as a practical and impactful approach to creating a more dynamic and meaningful learning environment.

6. Implications and Future Recommendations

The findings of this study present important implications for theory, practice and educational policy. The findings theoretically support Jean Piaget's constructivist learning theory, which highlights how knowledge is actively created by experience. The model-building activity allows pupils to visualize abstract processes more effectively which then leads to deeper conceptual understanding and reduced misconceptions. The value of constructivist pedagogies in supporting meaningful learning of abstract biological concepts was more affirmed along this study. In addition, the findings align with Edgar Dale's Cone of Experience, which highlights that active and hands-on learning can enhance retention and understanding. This indicates that model-building activity was highly effective in reducing misconceptions and enhancing visualization of abstract biological processes.

From a practical perspective, the study demonstrates that model-building is an effective instructional strategy for teaching abstract science topics. By engaging pupils in hands-on activities, teachers can promote active participation, creativity and collaborative learning. In this context, model-building offers a practical strategy that helps teachers to translate complex scientific concepts into concrete learning experiences as well as increasing pupils' engagement. Furthermore, the use of low-cost or reusable materials in building the model makes this strategy accessible and encourages environmental awareness among pupils.

In terms of educational policy, the findings suggest the need for greater support in implementing hands-on and student-centered approaches in science classrooms. This support can take the form of providing teachers with professional training, access to adequate resources and curriculum guidance. The strong impact of model-building suggests that constructivist and hands-on approaches can enrich classroom practice by shifting teaching from teacher-centered to student-centered and inquiry-based learning, aligning with 21st-century learning goals (Shaafi et al., 2021). Altogether, the study establishes this strategy as a valuable and impactful instructional approach for teaching complex science topics at the primary level.

Based on the study's results, there were several recommendations proposed for educational practice and future research. It is recommended that teachers incorporate model-building activities into science lessons to promote active learning and deepen pupils' conceptual understanding. For instance, teachers may integrate model-building regularly into lessons that involve complex systems, such as the digestive, respiratory or circulatory systems, as these topics benefit greatly from concrete visualization and experiential learning opportunities. Teachers should also provide opportunities for collaborative group work (Çetin et al., 2025), inquiry-based exploration and the use of simple, low-cost materials to support pupils' visualization of scientific processes. By integrating such strategies consistently across science topics, it may help nurture higher engagement, motivation and achievement among pupils.

For future studies, the researcher may expand this study across different science topics, age groups, sample size and involves schools from different regions to enhance the generalizability of the findings. To further strengthen the understanding of this teaching method, longitudinal studies could be conducted to examine the long-term effects of model-building on pupils' conceptual retention and sustained interest in science. Indeed, prior work has shown that active engagement techniques can support retention of conceptual learning over extended periods. Moreover, incorporating qualitative research methods such as interviews and classroom observations would provide deeper insights into pupils' learning experiences, engagement and the cognitive processes involved during model construction. These recommendations aim to strengthen instructional practices, enhance pupils' conceptual understanding and support the effective integration of student-centered approaches in primary science education.

Overall, the study concludes that the integration of model-building activity in primary science classrooms effectively connects abstract scientific concepts with pupils' concrete understanding and makes complex processes easier to grasp. It also helps students to visualize themselves on how the blood flows in their body. The findings offer strong empirical support for the use of hands-on, pupil-centered approaches in enhancing science instruction. In essence, model-building emerges as a practical and impactful teaching strategy that not only improves pupils' academic achievement but also fosters more engaging and meaningful learning experiences in science education.

Author Contributions: The research study was carried out successfully with contributions from all authors.

Conflicts of Interest: The authors declare no conflict of interest.

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