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# Development and Experimental Evaluation of a VR Based Cooperative Learning Model for the Human Circulatory System

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**ABSTRACT**

**Background.** The human circulatory system is a complex biological topic that requires students to understand spatial structures and dynamic blood flow processes. Conventional instruction often provides limited opportunities for immersive visualization and structured collaboration.

**Purpose.** This study aimed to develop and evaluate a Virtual Reality Based Cooperative Circulation Learning Model (VR CCL) to improve Grade XI students' biology learning outcomes.

**Method.** The study employed a research and development design based on the ADDIE model, followed by a quasi experimental pretest–posttest nonequivalent control group design. The participants were 52 students from two intact classes at a senior high school in Enrekang Regency, Indonesia. Data were collected using expert validation sheets, practicality questionnaires, observation sheets, and biology achievement tests.

**Novelty.** The model integrates immersive VR exploration with structured cooperative roles, group investigation, concept reconstruction, presentation, and individual evaluation.

**Results.** The model achieved an overall Aiken's V coefficient of .91. Teacher and student practicality scores reached 91.50% and 88.70%, respectively. The experimental group obtained a higher posttest mean than the control group (73.76 vs. 64.52), with a significant adjusted group effect, $F(1, 49) = 19.38$, $p < .001$.

**Conclusion**. VR CCL was valid, practical, and effective in improving students' learning outcomes on the human circulatory system.

**KEYWORDS**

Cooperative Learning; Learning Outcomes; Student Activities, Two Stay; Two Stray

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## INTRODUCTION

Digital transformation has become a global trend that is changing the way we view education, from the availability of learning resources to the design and delivery of more flexible, interactive, adaptive, and student centered learning experiences. Developed countries continue to strengthen infrastructure, governance, and teacher capacity to integrate technology into the learning process, but the availability of technology does not always result in meaningful pedagogical change (Abedi, 2024). Within this development, cutting edge technologies such as virtual reality (VR) are increasingly gaining attention among academics, as they create three dimensional learning environments that enable students to interact with objects and phenomena that are difficult to access in person (Mallek et al., 2024). This trend confirms that global educational innovation is moving toward learning that is not only digitalized but also more contextual, participatory, and experiential.

In Indonesia, digital education transformation needs to be implemented by considering the diverse characteristics of each region, students, and resources. National education data shows that educational processes and achievements are still influenced by the availability of educational units, classrooms, teachers, and learning facilities (Mkwama, 2023). At the regional level, South Sulawesi also shows educational dynamics reflected in indicators of participation and learning achievement at various levels of education (Rahman et al., 2025). Enrekang Regency has educational units spread across sub districts and villages, so the implementation of learning innovations needs to be tailored to the characteristics of schools and the needs of local students (Risman et al., 2026). This context makes Enrekang Regency relevant as a location for developing and testing a VR based cooperative learning model for high school students.

The differences in school and student characteristics in Enrekang Regency also require the selection of learning models that are appropriate to the needs of the learners. This need is related to the theory of social interdependence, which views individual learning outcomes as influenced by how students work and interact to achieve shared goals (Erwin et al., 2026; Khuder & Negretti, 2026). Learning will be more effective if each group member has positive independence, individual responsibility, promotive interactions, social skills, and the opportunity to reflect on group processes (León García et al., 2026; Mudinillah et al., 2024). Similarly, Slavin (1996) emphasized that the success of group learning is determined by the existence of shared goals and individual accountability, so that each student remains responsible for mastering the material.

The cooperative learning model is a model in which students are structured in small groups to achieve shared academic goals. This model does not simply group students, but organizes learning relationships through positive interdependence, individual accountability, direct interaction, interpersonal skills, and group process evaluation (Jeppu et al., 2023). Each member is required to contribute to the success of the group while demonstrating independent mastery of the material. Slavin (2015) explains that the effectiveness of cooperative learning is primarily determined by the provision of group rewards and individual accountability, as these two elements encourage students to help each other without reducing personal responsibility. Through this structure, cooperative learning can increase participation, exchange of ideas, problem solving skills, and student achievement.

The structure of cooperative learning can be strengthened through the use of virtual reality (VR) as a visual environment that supports collaborative exploration, discussion, and conceptualization. This technology allows students to observe three dimensional models of the heart, blood vessels, and pulmonary and systemic circulation pathways, which are difficult to understand through statistical images alone. In cooperative groups, students can play the roles of VR explorer, observer, note taker, and presenter, ensuring an immersive experience with individual interaction and responsibility. This integration is relevant because VR is known to have the potential to support collaboration, communication, engagement, and knowledge construction when implemented through a structured pedagogical design (Fowler et al., 2023). Research by Wang et al. (2023) also shows that combining VR and cooperative strategies can enhance understanding of complex anatomical structures. Thus, VR based cooperative learning models have the potential to help students develop a more comprehensive understanding of the relationship between organ structure and the mechanisms of human blood circulation.

Based on the principles of cooperative learning and the characteristics of immersive technology, the VR Based Cooperative Circulation Learning Model (VR CCL) prototype was designed through six stages: problem orientation, group formation and role assignment, VR environment exploration, cooperative investigation, concept reconstruction and presentation, and individual reflection and evaluation. In the exploration stage, each member plays the role of VR explorer, observer, recorder, or analyst to explore the structure of the heart and the pulmonary and systemic circulation pathways. This role assignment fosters positive independence and individual responsibility, key elements of cooperative learning (Slavin, 1996). Next, the VR observations are discussed and compiled into a shared concept representation before being tested through individual presentations and evaluations. Theoretically, immersive experiences can enhance psychological presence, learning control, motivation, and cognitive engagement, but still require directed tasks and reflection to avoid cognitive overload (Koudsia & Kirchner, 2024). Thus, this prototype positions VR not merely as a visual medium, but as a shared exploration space that supports the formation of the concept of a circulatory system through interaction, experience, and learning accountability, which is manifested in Figure 1.

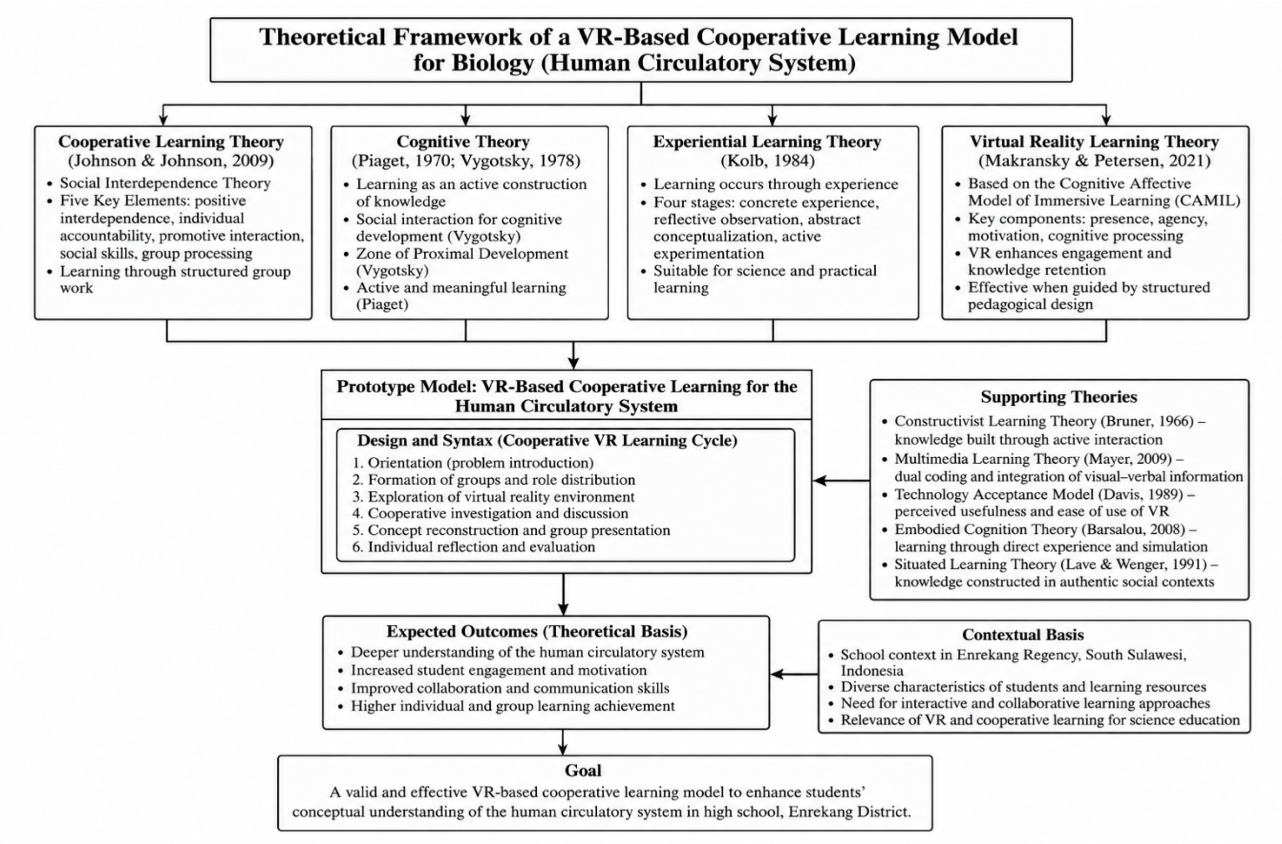


**Figure 1**. Conceptual Design of the VR Based Cooperative Learning Model

Based on this foundation, this research aims to develop a VR Based Cooperative Circulation Learning Model (VR CCL) that combines immersive exploration, group role allocation, collaborative investigation, concept reconstruction, and individual evaluation. The model was developed in stages through needs analysis, prototype design, expert validation, limited trials, and experimental testing on eleventh grade high school students in Enrekang Regency. This approach positions VR not as a complementary technology but as a learning environment that allows students to observe the mechanisms of blood circulation, exchange interpretations, and build understanding collaboratively.

The role of structured activities is necessary because the cognitive benefits of VR are influenced by students' levels of attendance, learning control, engagement, and cognitive load management (Bueno Vesga et al., 2021; Huang et al., 2020; Sulisworo et al., 2024), while its integration with cooperative learning has the potential to strengthen communication, participation, and group knowledge construction (Lenkauskaitė et al., 2020). Thus, this research offers a future oriented approach, yet remains grounded in theory and empirical evidence, to produce a valid, practical, and effective biology learning model.

## RESEARCH METHODOLOGY

### Research Design

This study employed design and development research followed by a quasi experimental design. Design and development research was chosen because it not only delivered learning but also systematically generated and validated the VR Based Cooperative Circulation Learning (VR CCL) model (Kutluca Canbulat et al., 2026). Model development was based on the ADDIE framework, which encompasses the stages of analysis, design, development, implementation, and evaluation (Reinbold, 2013). This framework was used because it provides a systematic and iterative procedure for aligning student needs, learning objectives, cooperative syntax, VR content, and the evaluation model (Rizki et al., 2024).

After being deemed feasible, the model's effectiveness was tested using a non equivalent control group design with pre test and post test. A quasi experimental design was chosen because the study involved established classes, making individual student randomization impossible (Ballance, 2024). The experimental class used VR CCL, while the control class followed the learning implemented in the school; both were given pre test and post test. Model quality is determined based on validity, practicality, and effectiveness as the primary criteria for educational products resulting from development (Dahal et al., 2023).

### Model Development Procedure

The development of the VR Based Cooperative Circulation Learning Model (VR CCL) followed the five ADDIE stages: analysis, design, development, implementation, and evaluation. The analysis phase encompassed student difficulties in understanding the circulatory system, student characteristics, cooperative learning needs, and VR device readiness. The design phase involved establishing learning objectives, a syntax model, group role assignments, VR exploration scenarios, worksheets, and assessment instruments. During the development phase, the model prototype and its supporting devices were validated by biology subject matter experts, learning experts, and media experts to assess content accuracy, construction consistency, ease of use, and technological suitability.

Input from validators was used to revise the prototype before conducting a limited trial with 11th grade students. This trial aimed to assess readability, VR usability, syntax feasibility, and initial teacher and student responses. The revised model was then implemented in an experimental class and evaluated for validity, practicality, and effectiveness. The revision process is carried out in stages so that the final product meets the quality criteria for educational interventions and can be applied consistently in biology learning (Dahal et al., 2023).

## Participants and Research Setting

The study was conducted at a senior high school in Enrekang Regency, South Sulawesi, Indonesia. The participants comprised 52 Grade XI students from two intact classes. Class XI A consisted of 27 students, including 18 male and 9 female students, whereas Class XI B consisted of 25 students, including 13 male and 12 female students. Overall, the sample included 31 male and 21 female students. The intact classes were retained to preserve the natural classroom setting, consistent with a quasi experimental design in which individual random assignment was not feasible (Sims et al., 2026).

**Table 1.** Distribution of Research Participants by Class and Gender

| Class | Male | Female | Total |
|---|---|---|---|
| XI A | 18 | 9 | 27 |
| XI B | 13 | 12 | 25 |
| Total | 31 | 21 | 52 |

## Research Instruments

Four instruments were used to evaluate the quality and effectiveness of the VR Based Cooperative Circulation Learning Model. First, an expert validation questionnaire assessed the model's content accuracy, theoretical consistency, instructional syntax, technological suitability, language clarity, and alignment with the human circulatory system curriculum. Expert judgments were analyzed using Aiken's V to determine the level of content validity (Muliana et al., 2020). Second, a teacher and student practicality questionnaire measured ease of use, clarity of learning procedures, accessibility of the VR environment, time efficiency, and perceived usefulness. These indicators reflect the practicality criteria for educational interventions proposed by Nieveen (1999).

Third, an observation questionnaire was used to assess the fidelity of implementation of each learning phase, student participation, cooperative interactions, role fulfillment, and teacher facilitation during class activities. Fourth, a biology achievement test was administered as a pretest and posttest to measure students' understanding of the structure of the heart, blood vessels, pulmonary circulation, systemic circulation, and blood flow mechanisms. Prior to implementation, the test was reviewed for content validity and checked for item validity, reliability, difficulty level, and discrimination. Internal consistency is evaluated to ensure that the instrument measures learning outcomes reliably (Suhartini et al., 2021).

## Experimental Procedure

The experimental procedure employed a pretest posttest nonequivalent control group design involving two intact Grade XI classes. One class was assigned as the experimental group and received instruction through the VR Based Cooperative Circulation Learning Model (VR CCL), whereas the other class served as the control group and received the regular biology instruction implemented at the school. The use of intact classes was consistent with a quasi experimental design because individual random assignment was not feasible within the existing classroom structure.

Before the intervention, both groups completed an identical pretest to assess their initial understanding of the human circulatory system. The experimental group then participated in a sequence of structured learning activities consisting of problem orientation, group formation and role assignment, VR based exploration, cooperative investigation, concept reconstruction, group presentation, and individual reflection. The control group studied the same topic, learning objectives, and instructional content within an equivalent learning period but without the VR CCL model. After the intervention, both groups completed an identical posttest to measure changes in biology learning outcomes. The implementation of VR CCL was monitored using an observation sheet to ensure that the model syntax, cooperative roles, and VR activities were conducted as designed, as implementation fidelity is essential for accurately interpreting intervention effects (Wang et al., 2023).

**Table 2**. Experimental Procedure of the VR Based Cooperative Circulation Learning Model

| Phase | Experimental Group | Control Group | Data Collection |
|---|---|---|---|
| Preparation | The teacher prepared the VR devices, learning materials, student worksheets, cooperative roles, and observation instruments. | The teacher prepared regular biology learning materials and assessment instruments. | Equipment checklist and learning preparation records |
| Pretest | Students completed a biology achievement test before receiving the intervention. | Students completed the same biology achievement test before regular instruction. | Pretest scores |
| Problem orientation | Students were introduced to a contextual problem related to blood circulation and the learning objectives. | Students received an introduction to the human circulatory system based on the regular instructional procedure. | Observation sheet |
| Group formation and role assignment | Students were organised into heterogeneous groups and assigned roles such as VR explorer, observer, recorder, concept analyst, and presenter. | Students participated in the grouping activities normally used by the teacher, where applicable. | Observation sheet |
| VR based exploration | Students explored three dimensional representations of the heart, blood vessels, pulmonary circulation, and systemic circulation through VR. | Students studied the same concepts using the learning resources regularly employed at the school. | Student worksheets and observation sheet |
| Cooperative investigation | Group members exchanged observations, analysed blood flow pathways, and jointly answered the assigned questions. | Students discussed or completed learning tasks according to the regular classroom procedure. | Student worksheets and observation sheet |
| Concept reconstruction | Each group organised its findings into a concept map or explanatory representation of the circulatory system. | Students summarised the learning materials using the regular instructional format. | Student learning products |
| Group presentation | Groups presented their findings and responded to questions or feedback from peers and the teacher. | Students reviewed the lesson through the teacher's regular discussion or presentation activities. | Presentation rubric and observation sheet |
| Reflection and reinforcement | Students reflected on their VR and cooperative learning experiences, while the teacher clarified misconceptions and reinforced key concepts. | The teacher reviewed the main concepts and clarified students' difficulties. | Reflection sheet and observation notes |
| Posttest | Students completed the same biology achievement test after the intervention. | Students completed the same biology achievement test after regular instruction. | Posttest scores |
| Practicality evaluation | Students and the teacher completed questionnaires concerning the usability, clarity, accessibility, and usefulness of VR CCL. | Not administered because the control group did not use the developed model. | Student and teacher practicality questionnaires |

### Data analysis

Expert validation data were analyzed using Aiken's V to determine the validity of the research model and instruments (Aiken, 1985). Teacher and student practical responses and observational data were summarized using means and percentages. Pretest and posttest scores were analyzed descriptively using means and standard deviations. The Shapiro–Wilk and Levene tests were used to check for normality and homogeneity of variance, respectively (Shapiro & Wilk, 1965). Model effectiveness was tested using ANCOVA, with posttest scores as the dependent variable, instructional group as the independent variable, and pretest scores as a covariate to control for initial differences between groups (Kim, 2026). Normalized gain and Cohen's d were calculated to determine learning gains and effect sizes. Statistical significance was set at $p < 0.05$.

**Table 3.** Summary of Data Analysis Techniques

| Data | Analysis | Purpose |
|---|---|---|
| Expert validation | Aiken's V (Aiken, 1985) | Assessing validity |
| Practicality and observation | Mean and percentage | Assessing practicality and implementation |
| Pretest and posttest | Mean and standard deviation | Describing learning outcomes |
| Statistical assumptions | Shapiro–Wilk and Levene's tests | Examining normality and homogeneity |
| Model effectiveness | ANCOVA (Vickers & Altman, 2001) | Comparing adjusted posttest scores |
| Learning improvement | Normalized gain (Hake, 1998) | Measuring score improvement |
| Effect magnitude | Cohen's *d* (Cohen, 1988) | Determining the intervention effect |

## RESULT AND DISCUSSION

The initial VR Based Cooperative Circulation Learning Model was evaluated by experts in biology education, instructional design, cooperative learning, and educational technology. Aiken's V was used because it represents the degree of agreement among experts regarding the relevance of each assessed component, with coefficients ranging from 0 to 1 (Aiken, 1985). The validation coefficients ranged from .87 to .94, with an overall coefficient of .91. The highest coefficient was obtained for biological content accuracy, whereas the VR interface and media design received the lowest coefficient. Based on the validators' comments, revisions were made to simplify the visual labels, clarify navigation instructions, and strengthen the alignment between VR activities and cooperative roles.

**Table 4.** Expert Validation Results for the VR CCL Model

| Validated Component | Aiken's V |
|---|---|
| Theoretical coherence | .92 |
| Learning syntax | .90 |
| Biological content accuracy | .94 |
| VR interface and media design | .87 |
| Assessment alignment | .89 |
| Language and usability | .91 |
| **Overall coefficient** | **.91** |

Practicality results showed a positive response from biology teachers and students. The teacher practicality score reached 91.50%, while the average student practicality score was 88.70%. Classroom observations indicated that 92.60% of the planned VR CCL procedures were implemented. The most consistently implemented activities were group formation, role assignment, VR exploration, and cooperative investigation. Minor difficulties were observed during transitions between VR users and during initial operation of the device.

**Table 5.** Practicality and Implementation Results

| Evaluation Component | Score (%) |
|---|---|
| Teacher practicality response | 91.50 |
| Student practicality response | 88.70 |
| Model implementation fidelity | 92.60 |

For this illustrative analysis, Class XI A was assigned as the experimental group and Class XI B as the control group. The two groups demonstrated relatively similar pretest scores. The experimental group obtained a pretest mean of 49.52 (SD = 5.83), while the control group obtained a mean of 49.69 (SD = 7.98). After the intervention, the experimental group achieved a posttest mean of 73.76 (SD = 7.96), compared with 64.52 (SD = 8.89) in the control group.

The normalized gain of the experimental group was .48, whereas that of the control group was .29. Based on the normalized gain classification introduced by Hake (1998), the experimental group demonstrated a moderate improvement, while the control group remained within the low improvement category.

**Table 6.** Descriptive Statistics of Students' Learning Outcomes

| Group | *n* | Pretest, Mean (*SD*) | Posttest, Mean (*SD*) | Normalized Gain, Mean (*SD*) |
|---|---|---|---|---|
| Experimental | 27 | 49.52 (5.83) | 73.76 (7.96) | .48 (.15) |
| Control | 25 | 49.69 (7.98) | 64.52 (8.89) | .29 (.17) |

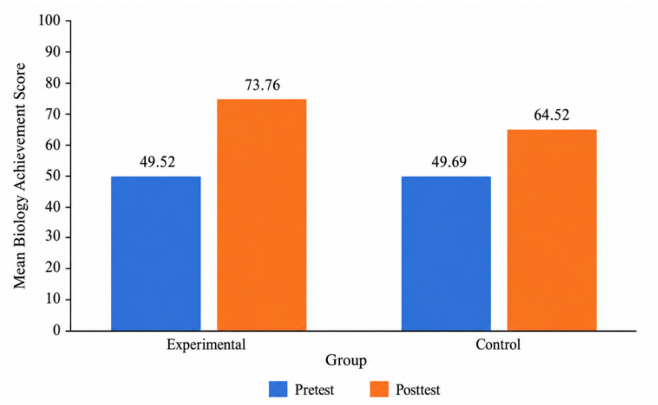


**Figure 2.** Comparison of Mean Pretest and Posttest Scores between the Experimental and Control Groups

The Shapiro Wilk test showed that the pretest and posttest scores of both groups were normally distributed because all probability values exceeded 0.05 (Shapiro & Wilk, 1965). The Levene test also showed homogeneity of variance for the pretest and posttest scores, with p values of 0.083 and 0.726, respectively (Levene, 1960). The interaction between pretest scores and instructional group was not significant, $F(1, 48) = 0.04$, $p = 0.840$, indicating that the assumption of homogeneity of regression slopes required for ANCOVA was met.

**Table 7.** Results of Statistical Assumption Testing

| Assumption | Test Result | *p* | Decision |
|---|---|---|---|
| Experimental group pretest normality | $W = .978$ | .827 | Satisfied |
| Experimental group posttest normality | $W = .964$ | .454 | Satisfied |
| Control group pretest normality | $W = .952$ | .275 | Satisfied |
| Control group posttest normality | $W = .969$ | .627 | Satisfied |
| Pretest variance homogeneity | $F = 3.14$ | .083 | Satisfied |
| Posttest variance homogeneity | $F = 0.12$ | .726 | Satisfied |
| Homogeneity of regression slopes | $F = 0.04$ | .840 | Satisfied |

An ANCOVA was conducted to compare posttest scores while controlling for students' initial achievement, as recommended for studies involving baseline and follow up measures (He & Huang, 2026). After adjusting for pretest scores, the estimated posttest mean was 73.81 for the experimental group and 64.47 for the control group. The effect of instructional group was statistically significant, $F(1, 49) = 19.38$, $p < 0.001$, partial $\eta^2 = 0.283$. The adjusted mean difference was 9.34 points, with a 95% confidence interval ranging from 5.07 to 13.60.

Pretest scores were also a significant covariate, $F(1, 49) = 11.68$, $p = 0.001$, indicating that prior knowledge contributed to posttest performance. The post test difference yielded a Cohen's d value of 1.10, indicating a large effect size according to the conventional measure proposed (Schmidt & Bohannon, 1988). These results indicate that the experimental group achieved higher adjusted biology learning outcomes than the control group.

**Table 8.** ANCOVA Results for Students' Posttest Scores

| Source | *F* | *p* | Partial $\eta^2$ |
|---|---|---|---|
| Pretest score | 11.68 | .001 | .192 |
| Instructional group | 19.38 | < .001 | .283 |

**Table 9.** Adjusted Posttest Means and Effect Magnitude

| Group | Adjusted Mean | Standard Error | 95% Confidence Interval |
|---|---|---|---|
| Experimental | 73.81 | 1.48 | 70.83–76.78 |
| Control | 64.47 | 1.54 | 61.37–67.57 |

The high validity, practicality, and implementation scores indicate that the VR Based Cooperative Circulation Learning Model was conceptually coherent and feasible for classroom use. The overall Aiken's V coefficient of .91 suggests strong agreement among experts regarding the alignment of biological content, instructional syntax, assessment, and VR activities. Nevertheless, the lower score obtained for the VR interface confirms that technological quality remains a critical component of immersive learning design. VR should therefore be evaluated not merely by its visual attractiveness, but by its capacity to support instructional objectives, learner control, and manageable cognitive processing (Desvaux et al., 2026; Sortwell et al., 2026).

The higher adjusted posttest score, normalized gain, and large effect size obtained by the experimental group suggest that VR CCL supported students' understanding of the human circulatory system. Three dimensional exploration enabled students to examine the relationship among heart structures, blood vessels, and pulmonary and systemic circulation, while cooperative activities required them to explain and reconstruct the observed processes. This finding is consistent who reported stronger anatomy achievement through VR supported cooperative learning (Hamizi & Mokmin, 2026). It also supports social interdependence theory, which emphasises that positive interdependence, individual accountability, and structured peer interaction are essential for productive cooperative learning (Qadeer, 2026).

However, the findings should not be interpreted as evidence that immersion automatically improves learning. Previous research found that immersive VR could generate greater presence but lower achievement and higher cognitive load than desktop based learning when pedagogical guidance was insufficient (Guiping et al., 2026; Herliana & Septiadi, 2026). Conversely, pre training has been shown to improve knowledge, transfer, and self efficacy in immersive VR environments (Hsu & Lee, 2026). This scientific tension suggests that the effectiveness of VR CCL was likely produced by its structured problem orientation, role assignment, guided exploration, cooperative investigation, and individual evaluation rather than by VR exposure alone. TICOL similarly argues that neither placing students in VR nor assigning them to groups guarantees meaningful collaboration without explicit pedagogical structure (Candia Véjar et al., 2026).

Although the results demonstrate promising educational potential, the large effect should be interpreted cautiously because the study involved only two intact classes from one school. Class characteristics, technology novelty, teacher facilitation, and unequal access to VR devices may have contributed to the observed outcomes. Future studies should therefore involve multiple schools and classes, delayed posttests, and measures of conceptual transfer. Overall, the findings indicate that VR becomes pedagogically valuable when immersive visualization is integrated with structured cooperation, cognitive guidance, and individual accountability rather than treated as an independent technological intervention.

## CONCLUSION

This study developed and evaluated the VR Based Cooperative Circulation Learning (VR CCL) model for teaching the human circulatory system to Grade XI students. The model demonstrated high levels of validity, practicality, and implementation fidelity, indicating that its theoretical foundations, learning syntax, biological content, and VR supported activities were highly appropriate for classroom settings. Furthermore, the experimental group achieved significantly higher adjusted posttest scores, normalized gain, and effect size than the control group, suggesting that integrating immersive visualization, structured cooperation, and individual accountability can substantially enhance students' learning outcomes in biology.

The findings indicate that VR is most effective when embedded within a structured pedagogical framework rather than utilized as an isolated technological tool. However, these results should be interpreted with caution, as the study was limited to two intact classes from a single school. Future research should encompass larger sample sizes, multiple institutions, delayed posttests, and assessments of conceptual transfer to investigate the consistency and sustainability of the model's effects. Ultimately, the VR CCL model provides a viable foundation for developing immersive and collaborative learning environments for other complex topics in biology.

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## DECLARATION OF GENERATIVE AI USE

ChatGPT was used to support language refinement and manuscript organization. All AI assisted content was critically reviewed, verified, and revised by the authors, who take full responsibility for the accuracy, originality, and integrity of the manuscript.

## AUTHORS' CONTRIBUTION

Author 1: Conceptualization, methodology, investigation, data analysis, and writing original draft.
Author 2: Instrument development, data collection, validation, and writing, review and editing.
Author 3: English translation, language editing, cross cultural review, and writing, review and editing.
Author 4: contributed to reviewing the grammar used.

## ETHICAL STANDARDS

This study was conducted in accordance with established ethical principles for educational research. Participation was voluntary, and all participants were informed about the study's purpose, procedures, confidentiality, and data use prior to their participation. Informed consent was obtained from all participants, and their identities were anonymized to protect privacy and confidentiality. The study protocol was reviewed and approved by the relevant institutional authorities/ethics committees of the institutions of authors.

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