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Development of a Web-Based E-SCIENCE Learning Model to Improve Science Learning Outcomes for Junior High School Students

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Abstract: This study aims to develop a web-based E-SCIENCE learning model to improve students' science learning outcomes on the topic of the human circulatory system. The study employed a research and development (R&D) method using the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The research was conducted at SMPN 1 Cilawu, Garut Regency, involving a sample of 40 eighth-grade students from class VIII G. The research instruments included expert validation questionnaires, student response questionnaires, and achievement tests to measure learning outcomes. The results indicate that the developed learning model meets the criteria of validity, practicality, and effectiveness. Students' learning outcomes showed a significant improvement after the implementation of the model, as evidenced by higher post-test scores compared to pre-test scores. Furthermore, expert evaluations revealed a high level of feasibility, with both media and content experts awarding scores of 94. These findings suggest that the web-based E-SCIENCE learning model is effective in enhancing students' understanding and learning outcomes related to the human circulatory system. Therefore, this model can be considered a viable and effective alternative for science instruction to improve student learning outcomes.

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Introduction

Science learning has a crucial role in education, namely shaping students' understanding of nature and the underlying scientific principles (Taufiq et al., 2014). Science learning not only aims to transfer knowledge but also to develop critical thinking skills, problem-solving skills, and scientific exploration and investigation abilities. Science plays a role in building the foundation for students to understand how nature works and apply scientific concepts in everyday life. However, in practice, science learning often faces various challenges that can hinder the effectiveness of the learning process. Some of the main challenges faced in science learning include low student engagement in learning, teaching methods that are still conventional and lack innovation, and limited resources and experimental tools available in schools. According to Riska Lili Yana (2021), student inactivity in the learning process can negatively impact their academic achievement. A low level of understanding of learning materials, especially in science subjects, is one of the main factors affecting academic achievement. Science subjects often contain abstract concepts that require active student involvement for in-depth understanding. To improve student learning

achievement, one approach that can be applied is the use of a learning model that is appropriate to the characteristics of the material and the needs of students. Learning models serve as a conceptual framework that provides a systematic structure in learning, thereby increasing student engagement, facilitating better understanding, and ultimately contributing to improved learning outcomes. This leads students to explore and investigate independently.

One of the important topics in science learning phase D grade VIII Chapter 2 in subchapter 2.2 is the human circulatory system. Understanding this system not only provides insight into the function of the human body, but also helps students understand broader biological concepts. To overcome challenges in science learning, an innovative approach is needed that can increase student engagement and learning effectiveness. Learning outcomes were chosen as the focus of the study in this research because learning outcomes are one of the main indicators for assessing the success of the learning process. Learning outcomes reflect students' abilities in understanding, mastering, and applying the material that has been learned, both in the cognitive, affective, and psychomotor domains.

Sudjana (2012) defines learning outcomes as the skills that students acquire following their educational experiences, encompassing the cognitive, emotional, and psychomotor domains. The concept of human blood circulation is also closely related to real phenomena in everyday life and requires in-depth understanding so that students can relate these concepts to real phenomena in everyday life (Arikunto, 2010), so that students are not only required to memorize concepts, but also able to relate these concepts to reality. Based on data on science learning outcomes of students at SMPN 1 Cilawu, it was found that 60% of students were able to achieve the KKTP while the other 40% had not achieved the expected level of mastery in the material on the circulatory system. This condition indicates an urgent need to improve learning outcomes through innovation in the applied learning model.

21st century learning requires various changes that involve all parties involved in the process with courage and willingness to change, so that it can achieve the expected success of the educational process (Dos Santos Cunha, 2025). One solution to face these challenges is the application of effective information and communication technology (ICT) and new pedagogical approaches (Stuchlikova, 2016). The selection of the web-based E-SCIENCE learning model as the focus of study in this research is based on its relevance to the challenges of 21st century learning. This model is designed to integrate science and technology literacy in a systematic learning unit, so that it can encourage students to be actively involved in technology-based scientific processes. The E-SCIENCE learning model facilitates exploration, investigation, collaboration, communication, and evaluation activities, all of which are integrated in a web-assisted learning flow. Another advantage of this model is the availability of interactive multimedia features that can visualize abstract concepts in the human circulatory system, so that the material is easier for students to understand and internalize. In addition, this model allows students to access learning flexibly, anytime and anywhere, and facilitates both independent and collaborative learning.

The web-based E-SCIENCE learning model is expected to provide innovative contributions in efforts to improve the quality of science learning, especially on the human circulatory system. This model is not only focused on improving cognitive aspects, but is also directed to foster critical thinking skills, creativity, collaboration skills, and technological literacy of students. The implementation of this model is expected to be an adaptive alternative to the development of information and communication technology, and in accordance with the characteristics of today's students who are familiar with the digital world. Students are encouraged to demonstrate positive attitudes such as curiosity, responsibility,

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and independence in learning, because they are directly involved in the process of exploring the material.

In line with this, the web-based E-SCIENCE learning model was chosen as the focus of the study because this model is relevant to the needs of 21st-century learning which demands the integration of scientific and technological literacy in the learning process. Trilling, B., and Fadel, C. (2009) stated that science literacy and technology literacy are essential competencies that students must have to be able to adapt to the dynamics of scientific and technological developments. The E-SCIENCE model integrates elements of exploration, study, creativity, investigation, collaboration, navigation, communication, and evaluation into one systematic learning flow as according to Darmawan (2014) this supports the occurrence of a comprehensive technology-based scientific process from problem formulation to reporting results. In addition, this model allows students to be actively involved in digital platform-based learning activities, by utilizing interactive multimedia features such as text, images, animations, experimental videos, and simulations. This is in line with Mayer's opinion (2001) which states that learning will be more effective if presented through a combination of words and images rather than just words alone. The web-based E-SCIENCE learning model also provides flexibility in access, allowing students to learn anytime and anywhere, both independently and collaboratively. This research is expected to provide a significant contribution in enriching adaptive science learning strategies with the development of information and communication technology. Based on this explanation, the researcher developed a web-based E-SCIENCE learning model to improve the science learning outcomes of junior high school students on the human circulatory system material.

Research Method

The research method used is research and development (R&D) with the ADDIE model. According to Branch (2009), the ADDIE process is one of the most efficient methods for creating a product. ADDIE is an acronym for the research steps: Analysis, Design, Development, Implementation, and Evaluation.

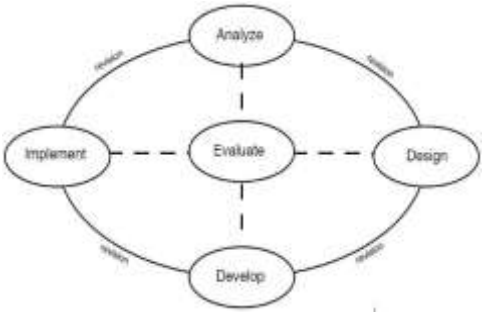

Figure 1. ADDIE cycle

The sample used in this study was 40 VIII G students at SMPN I Cilawu, Garut Regency.

1) Expert Validation
   Validation by media experts and material experts using a Likert scale with a score of one to five was used to determine whether the developed web-based E-SCIENCE learning flow was suitable for use. The following is the formula for calculating the results obtained, then interpreted in the following table.

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$$X = \frac{\sum k}{N}$$

Table 1. Interpretation of Expert Assessment

No	Interval *Mean Score*	Interpretation
1	1,00 - 2,49	Not feasible
2	2,50 - 3,32	Less than worthy
3	3,33 - 4,16	Worthy
4	4,17 - 5,00	Very Worthy

Sriadhi (2019)

2) Student Response
Analysis of student response data using a Likert scale of one to five to determine student responses to the web-based E-SCIENCE learning flow that was developed.

Table 2. Classification of Alternative Scores of Respondents' Answers in Checklist Form

Positive Questions (+)		**Negative Questions (-)**	
Answer	Score	Answer	Score
Strongly Agree	5	Strongly Agree	1
Agree	4	Agree	2
Doubtful	3	Doubtful	3
Don't agree	2	Don't agree	4
Strongly Disagree	1	Strongly Disagree	5

3) Learning Outcomes
Student learning outcomes data were obtained through pretests and posttests given to students after learning using a web-based E-SCIENCE model on the human circulatory system. Furthermore, student learning outcome scores were analyzed using SPSS version 27 to test the research hypothesis.

Results and Discussion

This study conducted several analyses in product development, namely by means of observation and interviews with students and teachers. The need for web-based learning is closely related to the implementation of the curriculum that serves as a guideline in the school environment, as is the case with SMPN 1 Cilawu, Garut Regency, which is currently implementing the independent curriculum, this curriculum encourages the creation of more flexible, student-centered learning and utilizes various learning resources, including web-based technology, therefore, the use of digital learning media is one strategy that can support the strengthening of student competencies in the digital era, the integration of web-based learning allows teachers to present more varied, interactive materials and support a more meaningful process for students, to support this implementation, this study produces a product in the form of a learning web to support more effective and efficient learning. The stages carried out in product development can be seen in the following table.

Table 4. E-SCIENCE Learning Flow Development Process

No.	Development Procedures	Details
1.	Analysis	1. Primary Data Analysis a. Analysis of teacher characteristics b. Analysis of student characteristics and learning problems c. Analysis of the school environment and facilities

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No.	Development Procedures	Details
		d. Analysis of learning resource needs 2. Secondary Data Analysis a. Curriculum analysis b. Analysis of student learning outcomes
2.	Design	1. Data collection 2. Designing a. Selecting and Determining Software b. Module Design c. Flowchart d. Storyboard
3.	Develop	At this stage, the following steps are carried out in ADDIE development: 1. Initial product development based on the design 2. Product/media prototype creation 3. Initial expert validation and revision 4. Product preparation for initial implementation
4.	Implementation	1. Field product trials 2. Implementing learning a. pretest b. learning using media/products c. posttest
5.	Evaluate	1. Distributing questionnaires for teacher and student responses 2. Final conclusions on product effectiveness

The results of the analysis stage obtained an initial draft of the development of the E-SCIENCE learning model consisting of: E (Exploration), S (Study), C (Create), I (Investigate), E (Engage), N (Navigate), C (Communicate), and E (Evaluate). The initial activity is to hone scientific literacy skills by exploring and conducting research, including the process of finding information from various learning sources that are not limited to books. Next, in the study stage, students learn the core concepts of the material through various learning sources such as textbooks, scientific articles, digital modules, or teacher explanations. In the create stage, students are given the opportunity to express their understanding through creative work. This product can be a poster, infographic, 3D model, or props that illustrate the concept being studied. In the investigate stage, students carry out simple investigations or experiments related to the material. Teachers can provide case studies or data that must be analyzed to develop critical and scientific thinking skills. In the engage stage, students work in groups to complete assignments, prepare presentations, or solve problems together. The teacher acts as a facilitator who guides the collaboration process to run effectively. In the navigate stage, students are directed to seek and navigate additional information from various sources, such as the internet, journals, or other interactive media, to broaden their horizons. In the communicate stage, students present the results of their understanding, investigations, or creative products to their classmates. The teacher provides space for feedback and questions from peers. In the evaluate stage, the teacher and students jointly evaluate learning outcomes. Evaluation can take the form of formative tests, reflections, quizzes, or learning journals to assess students' understanding of the material. In this case, the researcher used a posttest for the final stage of the evaluation.

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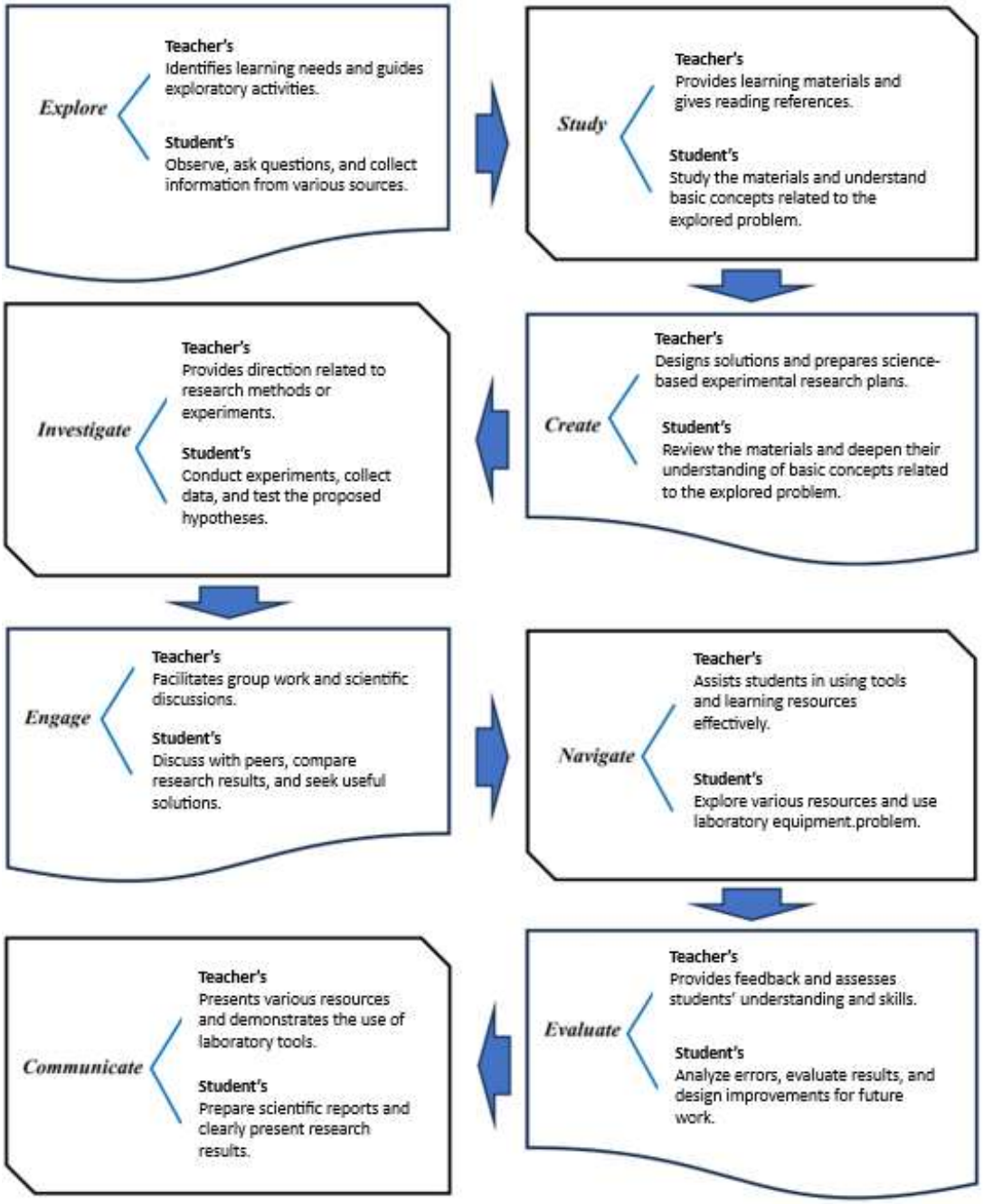

Figure 2. Teacher and Student Activities Using the E-SCIENCE Model

The web flowchart using the E-SCIENCE learning model can be seen in the following image.

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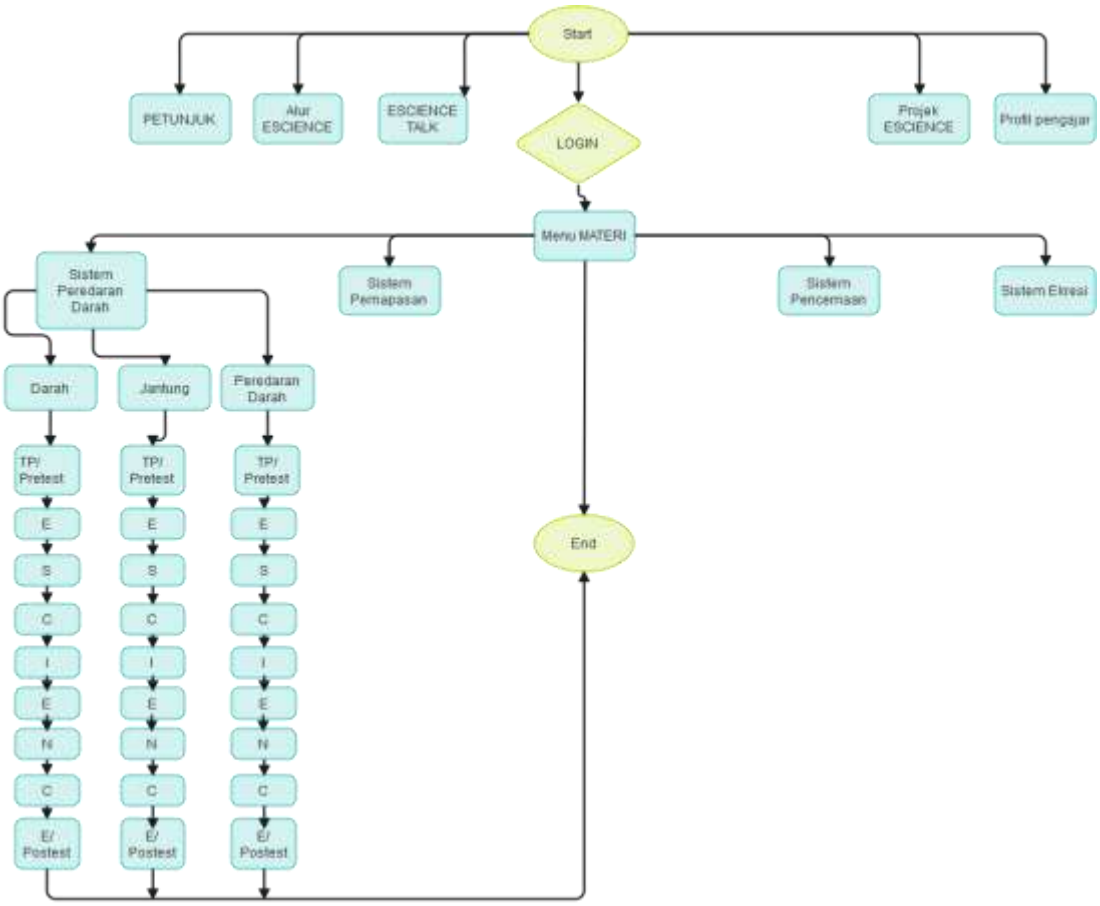

Figure 3. Flowchart of the E-SCIENCE Learning Model Web

The initial appearance of the learning web product with the E-SCIENCE model can be seen in the following image.

Figure 4. Learning Web with E-SCIENCE Model

After the web-based E-SCIENCE learning model was completed, the next step was to conduct an expert validation test consisting of media experts and material experts. The media expert was a postgraduate lecturer in educational technology at the Indonesian Institute of Education, Dr. Iman Nasulloh, M.Pd., with the validation results as follows.

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Table 5. Media Expert Validation Results

No	Aspect	Expected score	Score Achieved	Percentage Value	Criteria
1	Design	15	12	80%	Very good
2	Linguistics	20	18	90%	Very good
3	Content	25	25	100%	Very good
4	Interactive	15	14	93%	Very good
5	Use	25	25	100%	Very good
Amount		**100**	**94**	**94%**	**Very good**

The validation of the material expert was carried out by the supervisor of SMPN 1 Cilawu, Garut Regency, Mrs. Ida Nurfarida, S.Pd.., M.Pd., who has a background in science education and experience teaching the topic of the human circulatory system. This validation focused on the suitability of the material to the curriculum, the accuracy of the content, the depth of the concept, and the integration with the CP (Learning Outcomes), ATP (Learning Objective Flow) that apply to the 8th-grade junior high school level. The evaluation was carried out on all content displayed, including narratives, video explanations, practice questions, and their relevance to learning objectives. The results of the validation of the material expert can be seen in the following table.

Table 6. Results of Material Expert Validation

No	Aspect	Expected score	Score Achieved	Percentage Value	Criteria
1	Content suitability	25	24	96%	Very good
2	Presentation suitability	25	23	92%	Very good
3	Language eligibility	25	23	92%	Very good
4	Presentation of questions	25	24	96%	Very good
Amount		**100**	**94**	**94%**	**Very good**

Once the developed E-SCIENCE learning model is deemed suitable for use, the next step is the implementation phase. The implementation phase is where the developed learning model is used in real-life learning. This phase is conducted in three cycles, and student learning outcomes are collected for each cycle, as follows.

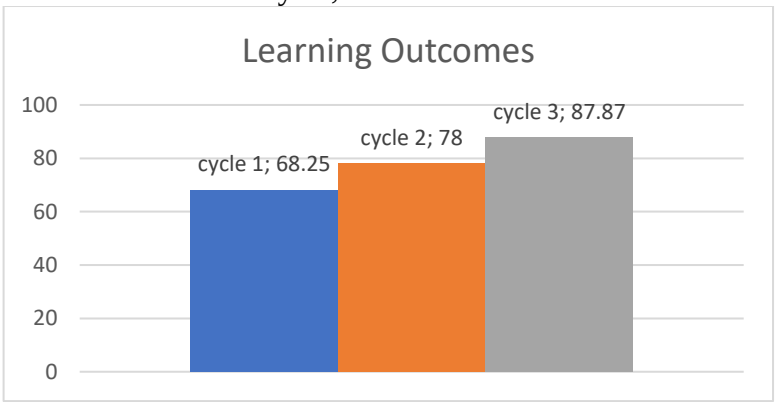

Figure 5. Student Learning Outcomes after Using the Web-Based E-SCIENCE Learning Model

Data on student learning outcomes and acceptance of the developed learning model were then analyzed using simple linear regression. The requirement for linear regression

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testing is that the data be normally distributed. Therefore, a data normality test was conducted using SPSS version 27, resulting in the following results.

Table 7. Data Normality Test

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
DataPretest	.192	40	<.001	.951	40	.081
cycle1	.165	40	.008	.955	40	.117
cycle2	.179	40	.002	.947	40	.059
cycle3	.180	40	.002	.948	40	.065
acceptance_E-SCIENCE	.162	40	.010	.950	40	.077

Based on the table above, the significance value of the pretest data, cycle 1 learning outcomes, cycle 2 learning outcomes, cycle 3 learning outcomes, and the acceptability of the E-SCIENCE flow is greater than 0.05, meaning that all data in the study are normally distributed. Therefore, the hypothesis test can be tested using a simple linear regression test with the following SPSS version 27 processing results.

Table 8. Hypothesis Test

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	12.361	7.666		1.613	.115
	Alur_E_SCIENCE	.879	.089	.848	9.849	<.001

Based on the table above, it is obtained that the significance value is <α (0.001 <0.05). The t-table value with the number of variables = 2 and samples = 40, then obtained df = 38 with the significance value used is 0.05 so that the t-table value is 1.682. Based on the table above, the calculated t-value = 9.849 so that the calculated t-value > t-table (9.849 > 1.686) which can be described as follows:

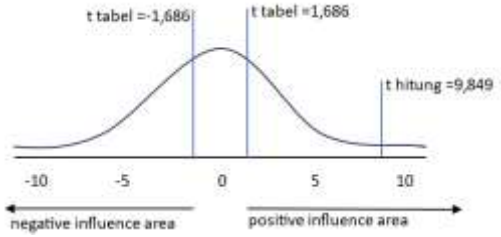

Figure 6. Comparison of t calculation and t table

Based on the two decision bases above, Ho is rejected and Ha is accepted, meaning that "the development of the E-SCIENCE learning model has a positive effect on improving student learning outcomes." In addition to these data, data on the magnitude of the influence of the web-based E-SCIENCE flow on student learning outcomes was obtained, namely as follows. Based on the table above, the R-squared value obtained is 0.719, meaning that the use of the e-science learning model flow, E-SCIENCE learning, has a 71.9% effect on student learning outcomes, while the remaining 28.1% is influenced by other factors.

Table 9. Percentage of Influence

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.849[a]	.719	.711	3.848

a. Predictors: (Constant), Alur_E_SCIENCE

b. Dependent Variable: Hasil_Belajar

The web-based E-SCIENCE learning model has been proven to positively contribute to improving overall student learning outcomes. The results of this study are in line with the research of Darmawan and Badriyah (2014) that the implementation of a web-based electronic learning system (WELS) at SMK Dharma Nusantara increased student learning effectiveness, encompassing cognitive, affective, and psychomotor aspects. Students not only understood the material better, but also showed increased motivation and practical skills in the field of computer engineering. As stated by Mayer (2009), learning with multimedia, including web-based, can improve conceptual understanding by combining visual and verbal elements synergistically. This is reinforced by the opinion of Darmawan (2014) who stated that information technology-based learning media can facilitate independent, interactive learning and are tailored to student characteristics. Meanwhile, Januarisman & Ghufron (2016) also emphasized that web-based learning media make a positive contribution to improving student learning outcomes. Based on this basis, the development of the E-SCIENCE learning web is designed to be able to bridge students' needs in understanding biological concepts more deeply.

The web-based E-SCIENCE model demonstrates advantages in terms of access flexibility, interactivity, and visual appeal. Previous research using print media or PowerPoint is limited in interactive presentations. Meanwhile, this study shows that students can learn more independently and actively thanks to access to various digital features. The circulatory system is dynamic (blood flows). Print media is static, while the web, with animated GIFs or Interactive Videos, can show blood flow in real-time. This "bridge" between technology and material characteristics needs to be emphasized. The web-based E-SCIENCE model demonstrates advantages in access flexibility, interactivity, and visual appeal. Research by Ismail et.al. (2023) states that "Audiovisual media such as films can provide visual and auditory stimuli simultaneously that help students understand the context of the material in a more concrete and interesting way." This proves that models that combine audio-visual and digital elements are more effective in building in-depth understanding. The results of research by Muslimah & Fauziah (2021) also strengthen this finding, where the e-learning-based learning model is able to improve student learning outcomes in the circulatory system material. Ruslaini et al. (2024) studied the implementation of a cooperative learning model and indicated a significant improvement in learning outcomes compared to a discussion model on human blood circulation. Therefore, the development of this e-science learning website is expected to make a significant contribution as a more interactive and applicable alternative model for science learning in schools.

The E-SCIENCE Model stages that make students active and creative. This E-SCIENCE model consists of eight stages, namely Explore (initial exploration), Study (more in-depth learning), Create (creative), Investigate (investigating), Engage (collaboration), Navigate (navigating sources and processes), Communicate (communicate), and Evaluate (evaluate). Each stage has its own role in encouraging students to not only memorize, but also understand and be able to explain the material they have learned. In the Create stage, students are invited to create learning products such as human blood flow posters, short presentations, or simple videos. This is not just an ordinary assignment, but also a means for students to channel their creativity.

Positive student responses and increased enthusiasm for learning, from the results of questionnaire answers, almost all students stated that they were more enthusiastic about learning when using this web-based learning media. They felt less bored because the display was attractive and the material could be learned flexibly. The role of teachers is more focused

and easier in teaching; from interviews with science teachers, they felt helped by this E-SCIENCE learning model. Teachers no longer have difficulty explaining abstract concepts such as the circulatory system, because the help of images and animations makes explanations more concrete. Teachers can also monitor student progress through a digital evaluation system integrated into the web media.

Conclusion

The conclusion obtained from the results of this study is that the web-based E-SCIENCE learning model developed meets the criteria of being valid, practical, and effective. Student learning outcomes showed a significant increase after using this model, with the average post-test score being higher than the pre-test. Thus, the web-based E-SCIENCE learning model is effective in improving students' understanding and learning outcomes on the human circulatory system. This finding is also supported by the evaluation results, which show that this web-based E-SCIENCE learning model has a high level of feasibility based on assessments from media experts and material experts, with a score of 94 each.

Recommendation

The recommendations based on the results of this study are as follows:

1) Web-based E-SCIENCE learning models should be used more widely because they can activate a wide range of student skills, from exploration and critical thinking to collaboration and scientific communication skills.
2) Schools and educational institutions are expected to integrate web-based E-SCIENCE learning models into their curriculum and project-based learning methods to make the learning experience more contextual and enjoyable.
3) Regular teacher training is needed to ensure they understand and implement each stage of the E-SCIENCE model development process consistently and creatively in the classroom.
4) Teachers are advised to develop learning media and student worksheets (LKPD) appropriate to the stages of the E-SCIENCE learning model so that each student activity is more focused and productive.

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