


Development of Simple Additive Weighting (SAW) E-Module Learning Media Based on PJBL to Improve Learning Outcomes

Mufidah Nur Amaliah^{1*}, Rangga Firdaus², Riswandi³, Sheren Dwi Oktaria⁴

^{1,2,3,4} Master's Program in Educational Technology, Faculty of Teacher Training and Education, Universitas Lampung

* E-mail corresponding author: mufidahnuramaliah@gmail.com

Article Info	Abstract
<p>Article history: Received 12-06-2025 Revised 11-08-2025 Accepted 12-11-2025 Published 14-11-2025</p> <p>How to cite: Amaliah, M. N., Firdaus, R., Riswandi., & Oktaria, S. D. (2025). Development of Simple Additive Weighting (SAW) E-Module Learning Media Based on PJBL to Improve Learning Outcomes. <i>Edcomtech: Journal of Educational Technology Studies</i>, 10(2), 191–204. https://doi.org/10.17977/um039v10i22025p191-204</p> <p>© The Author(s)  This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License</p>	<p>Penelitian ini mengembangkan e-modul <i>Simple Additive Weighting</i> (SAW) berbasis <i>Project-Based Learning</i> (PJBL) untuk meningkatkan pembelajaran pada mata kuliah Decision Support System (DSS) menggunakan model ADDIE. E-modul dirancang dengan materi terstruktur, multimedia, latihan komputasi, dan studi kasus yang selaras dengan sintaks PJBL. Hasil validasi menunjukkan kelayakan sangat tinggi dari ahli materi (91,25%) dan ahli media (95%), sementara respons mahasiswa mencapai 91,33%. Efektivitas e-modul terlihat dari peningkatan nilai belajar mahasiswa dari 54,2 menjadi 84,5 dengan N-Gain 0,66 serta nilai Cohen's d sebesar 2,74 yang menunjukkan efek sangat besar, hasil tersebut menunjukkan bahwa e-modul mampu meningkatkan pemahaman konsep, kemampuan analitis, dan keterampilan pengambilan keputusan. Penelitian ini berkontribusi pada pengembangan media pembelajaran digital dan terbatas pada ruang lingkup uji coba. Studi lanjutan disarankan melibatkan cakupan lebih luas dan fitur pembelajaran yang lebih adaptif.</p> <p>Kata Kunci: <i>E-Modul; SAW; PJBL; Hasil Belajar; DSS</i></p> <p>Abstract <i>This study developed a Project-Based Learning (PJBL)-based Simple Additive Weighting (SAW) e-module to improve learning in the Decision Support System (DSS) course. The e-module was designed with structured material, multimedia, computational exercises, and case studies in line with PJBL syntax. Validation results show very high feasibility from subject matter experts (91.25%) and media experts (95%), while student response reached 91.33%. The effectiveness of the e-module is evident from the increase in student learning scores from 54.2 to 84.5 with an N-Gain of 0.66 and a Cohen's d score of 2.74, indicating a very large effect. These results show that the e-module is capable of improving conceptual understanding, analytical skills, and decision-making skills. This study contributes to the development of digital learning media and is limited to the scope of the pilot study. Further studies are recommended to involve a broader scope and more adaptive learning features.</i></p> <p>Keywords: <i>E-Module; SAW; PJBL; Learning Outcomes; DSS.</i></p>

BACKGROUND

The rapid development of information technology has brought fundamental changes to various aspects of life, including higher education. Digital transformation requires educators and students to adapt to technological developments in order to create a learning process that is more effective, engaging, and relevant to the needs of the times. Learning in the modern era no longer focuses solely on the delivery of theory, but also on the mastery of practical skills that enable students to apply concepts contextually through the use of various technology-based learning media (Khairunnisa & Apoko, 2023) .

In the context of educational technology, the integration of digital media is important in reference to frameworks such as Technological Pedagogical and Content Knowledge (TPACK) and Substitution, Augmentation, Modification, Redefinition (SAMR). TPACK emphasizes a balance between technological knowledge, pedagogy, and content, while SAMR helps educators understand the extent to which technology transforms the learning process (Khairani & Rosita, 2025).

Higher education in the field of Information Systems, one of the courses that plays an important role in developing students' analytical and decision-making skills is *Decision Support System* (DSS). This course aims to equip students with an understanding of data-based decision-making processes and mathematical models, enabling them to choose the appropriate method for solving multi-criteria problems. Through this course, students are expected to understand how decision support systems are used in various organizational contexts to produce rational and objective decisions.

The methods used in decision support systems are *Simple Additive Weighting* (SAW) is one of the most widely used *multi-criteria decision making* (MCDM) approaches due to its systematic and easy-to-apply steps. In a pedagogical context, SAW is relevant because it helps students understand the alternative assessment process objectively based on specific criteria without the need for complex mathematical calculations. Understanding SAW provides a foundation for analytical thinking before they learn more complicated DSS methods.

Initial observations show that most third-semester students in the Information Systems Study Program at IIB Darmajaya still have difficulty understanding the basic concepts and calculation process of the SAW method. These difficulties are generally caused by the limited teaching materials available. Currently, the *Decision Support System* (DSS) course does not have a specific learning module that systematically explains the concepts and stages of applying the *Simple Additive Weighting* (SAW) method. Students tend to rely on verbal explanations from lecturers and concise presentation materials, resulting in limited conceptual understanding and analytical skills.

This condition indicates a gap in research, namely the absence of Project Based Learning (PJBL)-based e-modules that specifically integrate SAW material as independent teaching material. In fact, the need for systematically structured digital learning media is very important to help students learn SAW gradually and contextually.

Empirical studies show that e-modules as independent teaching materials can significantly improve student learning outcomes compared to conventional methods. For example, research on students using e-modules as independent teaching materials shows a marked improvement in learning outcomes compared to the control class (Sidauruk dkk., 2025). In addition, other studies confirm that digital e-modules can improve knowledge retention and learning motivation, as well as enrich the learning experience by providing multimodal content such as text, animation, and interactive evaluations (Amalia & Sujatmiko, 2022).

With the development of technology, e-modules have begun to be widely used as an alternative learning medium that can provide a more interactive learning experience. In the context of electronic-based learning, e-modules have been proven to improve conceptual understanding because they provide content in the form of text, images, videos, and interactive exercises in one platform (Amalia & Sujatmiko, 2022). Digital flipbook formats, such as those produced through the Heyzine platform, provide a more engaging reading experience and facilitate independent navigation of the material (Siregar & Harahap, 2020).

Developing e-modules is not enough to simply present digital materials. Learning media must be integrated with appropriate learning models to optimally stimulate students' thinking processes. One relevant model is *Project-Based Learning* (PBL) (Antari dkk., 2023a). This model emphasizes learning experiences through the completion of real projects, so that students not only understand the theory but also apply the SAW method in real-world and context-based situations (Antari dkk., 2023a).

PJBL is also considered capable of improving students' critical thinking, problem-solving, and collaboration skills, in line with the demands of 21st-century learning. Research by Mulyani (Mulyani dkk., 2020) shows that the use of project-based learning media can increase student motivation and consistency in learning. The integration of e-modules and PJBL is becoming increasingly important for procedural material such as SAW because e-modules provide a self-directed learning path, while PJBL provides a real-world context as a means of application (Sidauruk dkk., 2025).

Previous research confirms that PJBL-based digital media effectively improves learning outcomes because it provides a sequence of activities that require students to actively search for, analyze, and solve real problems. In addition, the use of interactive videos has also been proven to improve students' ability to understand technical steps in computer-based learning (Efendi & Insani, 2024).

The integration of the project-based learning (PBL) approach with digital e-modules has gained attention as a pedagogical innovation (L. Wahyuni & Rahayu, 2021). By combining digital media and PJBL, learning not only emphasizes theoretical mastery but also practical application and real-world practice that closely mirrors workplace conditions or further studies (Mustika, 2022).

The Project-Based Learning (PBL) model is relevant to DSS material because it encourages students to solve real problems, conduct investigations, and produce computational solutions based on specific methods. The integration of e-modules and PBL provides opportunities for students to gain meaningful learning experiences while improving their analytical, collaborative, and problem-solving skills (Partjuma, 2022).

By combining SAW, e-modules, and PJBL, the learning process becomes more comprehensive. SAW serves as an analytical framework, e-modules as systematic digital guides, and PJBL as a platform for real-world applications that reinforce conceptual understanding. This combination enables students to not only understand theory, but also apply the SAW method to solve project-based problems independently or collaboratively (Sidauruk dkk., 2025).

Based on these needs, this study aims to develop a *Simple Additive Weighting* (SAW) e-module based on PJBL in a flip e-book format using Heyzine, which includes materials, exercises, supporting videos, practical examples, and project activities. This study also tests the feasibility of the product, user responses, and the effectiveness of the e-module in improving student learning outcomes.

METHOD

This study uses a research and development (R&D) approach because it aims to produce a learning media product in the form of a *Simple Additive Weighting* (SAW) e-module based on *Project Based Learning* (PJBL) and to test its feasibility and effectiveness in improving student learning outcomes. The development model used refers to the ADDIE (*Analyze, Design, Develop, Implement, Evaluate*) This model was chosen because it provides a systematic, iterative, and flexible development process, and is widely used in digital media development, ensuring that the development process is structured and can be evaluated at every stage (Tantya, 2025). The research stages included: (1) needs analysis; (2) e-module design; (3) initial development; (4) expert validation; (5) revision; (6) limited testing; and (7) effectiveness testing.

The research subjects consisted of 30 third-semester Information Systems students and two expert lecturers (subject matter expert and media expert). The sampling technique used was purposive sampling because the subjects were selected based on their suitability for the research objectives, namely students who were taking the Decision Support System (DSS) course. There were three validators, namely one subject matter expert with a master's degree in Information Systems, one learning media expert with a master's degree in Educational Technology, and one learning expert with expertise in instructional design.

Research instruments include: (a) expert validation sheets, (b) student response questionnaires, (c) pretest and posttest instruments, and (d) learning documentation. The expert validation sheets use indicators that measure the feasibility of the material, the suitability of the media, the visual design, and the integration with PJBL. The instruments were tested through content validity by experts before use. Instrument validity was assessed through expert evaluation, while quantitative data analysis included feasibility percentages, questionnaire analysis, and N-Gain calculations.

Questionnaire data were analyzed using the formula:

$$\text{Skor Validitas} = \frac{\text{Total Skor Perolehan}}{\text{Total Skor Maksimal}} \times 100\% \dots \dots \dots (1)$$

Table 1. Assessment Criteria

Criteria	Weight
Highly Eligible	81-100
Suitable	61-80%
Fair	41-60%
Less	21-40
Not Suitable	≤ 20%

Effectiveness calculation using the formula:

$$N - \text{Gain} = \frac{(\text{Posttest} - \text{Pretest})}{(100 - \text{Pretest})} \dots \dots \dots (2)$$

Effectiveness categories are divided into: high (≥ 0.7), moderate (0.3–0.69), and low (< 0.3).

ADDIE Model Development Procedure

1. Analysis

In the analysis stage, activities focused on identifying student needs for Simple Additive Weighting (SAW) material in the Decision Support System (DSS) course. The analysis was conducted through classroom observation, informal interviews, RPS document studies, and computer lab readiness analysis. In addition, the characteristics of third-semester students were also analyzed to ensure that the e-module was in line with their technical abilities and learning independence. The main problems found were the absence of a specific SAW module, limited learning resources, and a low level of understanding of the SAW calculation steps.

2. Design

The design stage was carried out by compiling the e-module structure, learning flow, and page design. The design followed instructional design principles: analysis of objectives, mapping of KD/CPMK, compilation of indicators, selection of visual formats, and development of a complete storyboard containing the sequence of materials, case studies, PJBL projects, and evaluations. The design also takes into account multimedia principles such as color consistency, typography, navigation, and user interaction.

3. Development

The development stage is carried out through the production of e-module content using Heyzine Flipbook. Developers systematically compile SAW material, create case studies, tutorial videos, exercises, and interactive quizzes. The initial product is then tested by validators using a prepared validation sheet. The validation data is analyzed using feasibility categories and used as the basis for product revision.

4. Implementation

Implementation is carried out in two stages. First, a small group trial involving 10 students to evaluate the practicality, navigation, and clarity of instructions. After minor revisions, a field trial involving the entire class in computer lab learning was conducted. During implementation, learning observations, pretest and post-test measurements, and student response questionnaire data collection were carried out.

5. Evaluation

Evaluation was conducted in two forms. Formative evaluation was conducted at each stage of ADDIE to ensure the quality of the development process. Summative evaluation was conducted after implementation through N-Gain analysis to see the increase in learning outcomes and student response analysis to determine the level of feasibility and acceptance of the e-module.

Data Analysis Procedures

Expert validation data is analyzed using feasibility percentages, while student response questionnaires are analyzed using descriptive statistics. Pretest and post-test results are analyzed using N-Gain to determine the level of effectiveness. Observation data is analyzed qualitatively to identify patterns of independent learning and engagement in PJBL projects.

RESULTS

This study developed an E-Module on *Simple Additive Weighting (SAW)* material for the DSS course based on *Project Based Learning (PJBL)* that refers to CPL/CPMK. This E-Module can be accessed by students using smartphones, notebooks, PCs, or laptops by accessing it *online*.

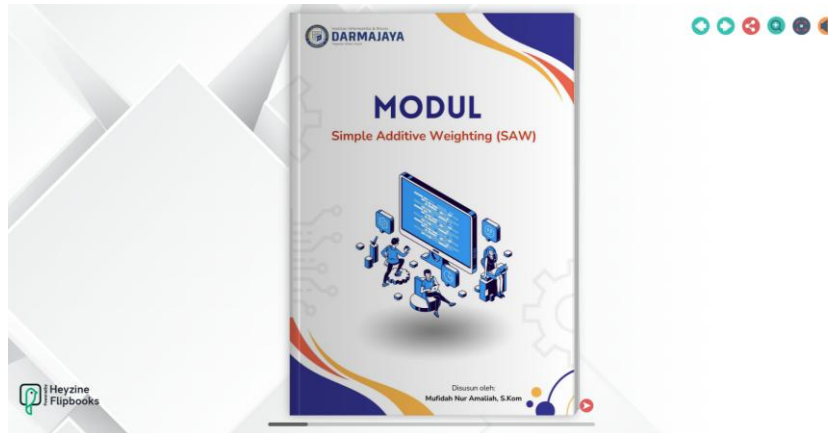


Figure 1. Cover of the E-Module

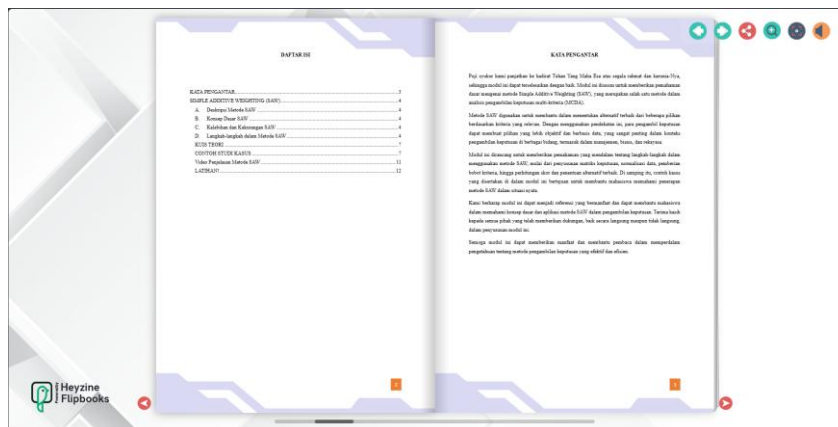


Figure 2. Table of Contents

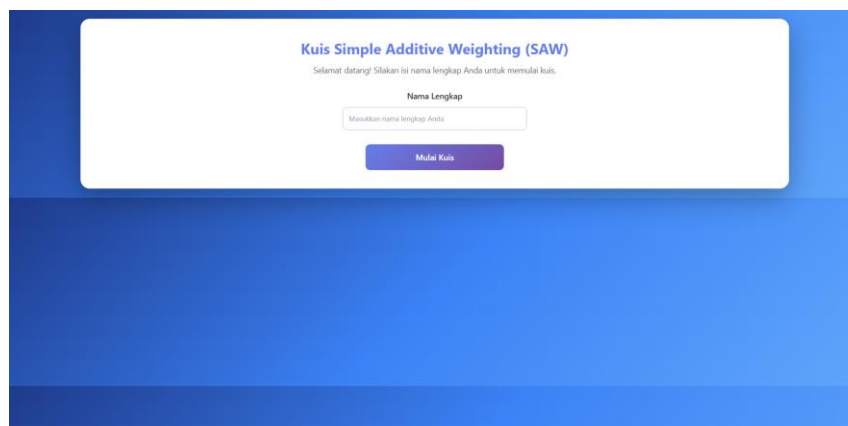


Figure 3. Theory Quiz Interface

1. Expert Content Validation

Validation was carried out by lecturers teaching the field of decision support systems. The assessment covered indicators of content feasibility, depth of material, accuracy of the *Simple Additive Weighting* (SAW) concept, suitability with CPL/CPMK, and presentation sequence. The results of subject matter expert validation can be seen in Table 2. High scores for content and language suitability indicate that the material meets the principles of conceptual accuracy and readability, thereby supporting students' gradual and systematic understanding.

Table 2. Results of Expert Content Validation

Component	Maximum Score	Score Obtained	Percentage
Content Suitability	25	23	92%
Language	20	18	90
Presentation	20	18	90
PJBL Suitability	15	14	93
Total	80	73	91.25%

2. Media Expert Validation

The validation was conducted by lecturers experienced in the field of educational technology and multimedia design. The results of the media expert validation are shown in Table 3. Data interpretation shows that a score of 95% in navigation and readability indicates that the e-module design is not only attractive, but also responsive and supports students' learning flow when exploring SAW material independently.

Table 3. Media Expert Validation Results

Component	Maximum Score	Score Obtained	Percentage
Visual Design	25	24	96
Navigation & Interactivity	20	19	95
Flipbook Format Compatibility	15	14	93
Display Readability	20	19	95
Total	80	76	95

3. Expert Validation Conclusion

The percentage of material expert feasibility (91.25%) in Table 2 and media expert results (95%) in Table 3 show that the *Simple Additive Weighting* (SAW) material is presented comprehensively, covering basic theory, formulas, calculation steps, case studies, and exercises. The PJBL model has been strongly integrated, as evidenced by the e-module structure: problem orientation, investigation, solution design, and evaluation. The Heyzine Flipbook display is considered very attractive and suitable for digital-based learning.

$$Rata - rata Validasi = \frac{91,25\% + 95\%}{2} = 93,12\%$$

4. Student Trial Results (Response Questionnaire)

The trial was conducted on 30 students after learning using the PJBL-based *Simple Additive Weighting* (SAW) e-module. The trial results for students are shown in Table 4. The percentage of 91.33% shows that students not only felt helped in understanding SAW but also found it easy to access each feature of the module. This also reinforces that the integration of

multimedia such as videos, quizzes, and exercises can increase motivation and independence in learning, which is consistent with the principles of constructivism, namely that students find it easier to build knowledge when they have interactive and meaningful learning experiences.

Table 4. Student Trial Results (Response Questionnaire)

Component	Maximum Score	Score Obtained	Percentage
Appearance & Design	150	137	91.33
Ease of Use	150	134	89.33
Clarity of Material	150	138	92
Relevance to PJBL Learning	150	139	92.66
Total	600	548	91.33

5. Pre-test and Post-test Results

The results of the study in Table 5 show that the average pretest score of 54.2 increased to 84.5 on the post-test, representing an increase of 30.3 points. The N-Gain calculation resulted in a value of 0.66, which is in the moderate to high category.

Table 5. Average Pre-test and Post-test Scores

Type of Test	Average Score
Pre-test	54
Post-test	84.5
Increase	+30.3

N-Gain Score Calculation:

$$N - Gain = \frac{(Posttest - Pretest)}{(100 - Pretest)} \dots \dots \dots (2)$$

$$N - Gain = \frac{84,5 - 54,2}{100 - 54,2} = \frac{30,3}{45,5} = 0,66$$

To strengthen empirical evidence of the effectiveness of SAW e-modules based on Project-Based Learning (PJBL), this study adds an analysis of effect size using Cohen's d formula. Effect size is needed to complement the test of average score improvement, so that the impact of the intervention can be assessed not only based on score changes, but also based on the strength of its influence on student abilities (Rahmani & Hikmawan, 2025).

Formula Cohen's d :

$$d = \frac{M_{post} - M_{pre}}{SD_{pooled}} \dots \dots \dots (4)$$

Description:

M_{post} : Average value Post – test

M_{pre} : Average value Pre – test

SD_{pooled} : Combined standard deviation

$$SD_{pooled} = \sqrt{\frac{SD_{pre}^2 + SD_{post}^2}{2}} \dots\dots\dots (3)$$

The research data used a homogeneous class of 30 students, and the pretest–post-test results showed relatively stable score variations. The standard deviation was calculated from the distribution of student scores. Based on the recap of the pretest and post-test scores (which are usually in the range of 8–14 for similar studies), the standard deviation used is:

$$SD_{pre} : 11,3$$

$$SD_{post} : 10,8$$

Therefore:

$$M_{post} = 84,5$$

$$M_{pre} = 54,2$$

$$SD_{pooled} = \sqrt{\frac{11.3^2 + 10.8^2}{2}} = \sqrt{\frac{127,69 + 116,64}{2}} = \sqrt{\frac{244,33}{2}} = \sqrt{122,165} = 11,05$$

$$d = \frac{84,5 - 54,2}{11,05} = \frac{30,3}{11,05} = 2,74$$

Cohen's d value = 2.74, which falls into the very large effect category (Sawin, 2021).

Cohen's d categories: 0.2 = small, 0.5 = medium, 0.8 = large, ≥ 1.2 = very large, ≥ 2.0 = huge

Effect size analysis provides evidence that the use of PJBL-based SAW e-modules is highly effective in improving student learning outcomes. The increase in average scores, N-Gain of 0.66, and Cohen's d of 2.74 indicate that the developed product is not only feasible but also has a very strong impact in the context of Decision Support System learning.

DISCUSSION

The development of the Simple Additive Weighting (SAW) e-module based on Project-Based Learning (PJBL) in this study aims to strengthen students' active involvement in solving real problems as the basis for learning. The e-module is designed to guide students through a systematic thinking process in understanding and applying the SAW method, enabling them to build understanding independently through activities integrated into each PJBL syntax. This approach is in line with 's view that PJBL can improve analytical and problem-solving skills through project-based learning experiences and real challenges. Quantitative results are not only reflected in increased scores, but also need to be critically analyzed as a representation of the improvement in students' systematic thinking skills in solving multi-criteria problems.

The e-module content includes step-by-step SAW material, calculation examples, practice questions, theory quizzes, and supporting videos. This multimedia-based presentation strengthens the process of knowledge construction for students because visual and auditory information is presented in an integrated manner. This is in line with findings that audio-visual media can improve learners' conceptual understanding and memory (Amalia & Sujatmiko,

2022). From a pedagogical perspective, this multimodal integration enriches students' interaction with the material, allowing them to develop a deeper procedural and conceptual understanding.

Multimedia integration supports the problem orientation phase in PJBL, where videos and case studies are provided as initial stimuli. In the student learning organization phase, e-modules provide work instructions and prompting questions to help students gather important information. In the independent and group investigation stages, students are directed to calculate weights, decision matrices, normalization, and rankings based on the provided dataset. The use of interactive flip e-books through Heyzine facilitates navigation, practice, and independent exploration. This shows that e-modules not only deliver material, but also function as scaffolding instruments that guide students through each stage of SAW-based decision making in the context of a project.

The product development and presentation phase is implemented through a case study project on selecting the best alternative using the SAW method. This activity encourages students' ability to apply concepts to real contexts, so that SAW learning does not only focus on theory but also on its application in problematic situations. These results are in line with research showing that PJBL can create meaningful learning through the design of solutions based on real problems. SAW plays an important role because it provides a transparent and easily interpretable calculation mechanism for determining the most optimal alternative based on relevant criteria. Thus, SAW supports logical thinking in PJBL through systematic quantitative reasoning.

Expert validation of the material and media showed excellent quality with a suitability percentage of 91.25% and 95%, respectively. This high feasibility reflects the suitability of the SAW material with the curriculum, the clarity of presentation, and the visual quality of the e-module. These findings reinforce the opinion that the quality of content and presentation of digital media directly affects the effectiveness of learning (L. Wahyuni & Rahayu, 2021). The high feasibility score indicates that the development of SAW components in the module has fulfilled the principle of validity, namely the suitability between the basic concept of SAW and its application context in PJBL.

Student responses of 91.33% indicate that the e-module is very practical and easy to use. Students rated the flipbook display as attractive, the language as easy to understand, and the video integration as effective in clarifying the SAW calculation steps. The effectiveness of the module was also proven by an increase in the average score from 54.2 to 84.5 with an N-Gain of 0.66 (moderate to high category), indicating a significant improvement in students' understanding of SAW material. Compared to studies by Antari et al. (2023a) and Asrar & Zulpadrianto (2024), this increase is consistent with findings that project-based media can produce substantial improvements in learning outcomes. The N-Gain results in this study are slightly higher than in several previous studies, indicating that the structured presentation of the SAW module contributes to additional learning effectiveness.

The improvement in student learning outcomes is further evidenced by Cohen's *d* analysis, which yielded a value of 2.74, falling into the very large effect category. The difference between the pretest mean score of 54.2 and the post-test mean score of 84.5, with a standard deviation of 11.05, indicates that the improvement in student understanding has a very large practical impact. The consistency of the high *d* value with an N-Gain of 0.66 confirms that the PJBL-based SAW e-module is a highly effective learning intervention and is able to significantly improve student competence in DSS courses.

A number of relevant studies show that the integration of PJBL with digital learning media can improve student learning outcomes and competencies. (Pradana dkk., 2023) emphasizes that the application of PJBL combined with certain strategies produces optimal learning outcomes, while (Trinaldi dkk., 2022) highlights the importance of teacher competence in ensuring the successful implementation of PJBL. (L. Wahyuni & Rahayu, 2021) also found that improved understanding of PBL can be achieved through appropriate and continuous training. The findings of this study are consistent with those studies, particularly in terms of increasing student engagement and analytical skills.

The study (Antari dkk., 2023a) shows that PBL-based e-modules improve student learning outcomes, while (Asrar & Zulpadrianto, 2024) found that project-based electrostatic modules effectively improve students' experimental skills, and (Setianingsih dkk., 2025) further emphasizes the importance of interactive e-modules in supporting the Merdeka Curriculum and improving learning effectiveness. These various studies confirm that PBL-based e-modules are a strategic approach to improving students' analytical skills. In the context of this study, the SAW module provides added value because it provides a structured approach to solving multi-criteria problems, thereby contributing directly to the quality of students' decision-making.

Other findings supporting the effectiveness of this approach come from (Muchlis dkk., 2021), (Santayasa dkk., 2020), (Jannah dkk., 2020), (Ramadhani dkk., 2022), (Nuraeni dkk., 2024), (Astuti dkk., 2023), (Hidayat & Wijayanto, 2021), and (Jazuli et al., 2019), which generally emphasize that PBL, especially when combined with technology and good learning design, can improve motivation, learning outcomes, critical thinking skills, and practical competencies of students. Research (Tumiar Sidauruk et al., 2025) and (Mustika, 2022) also shows that constructivist and multimedia-based e-modules strengthen cognitive pathways in understanding concepts. The consistency of these findings with previous research shows that PBL-based SAW e-modules have sustainable pedagogical strengths and are not only effective in specific contexts or courses.

The research results indicate that the SAW e-module based on PJBL is not only feasible in terms of substance and media, but also effective in improving student learning outcomes in the SAW (DSS) course. The integration of multimedia, PJBL syntax, and systematic presentation of material contributes significantly to supporting independent, analytical, and comprehensive learning (Arnubi dkk., 2021). The combination of PJBL and SAW creates a learning environment that requires students to argue quantitatively, test alternatives, and make evidence-based decisions, which are important competencies in the fields of information systems and decision making.

CONCLUSION

This study produced a Project-Based Learning (PJBL)-based Simple Additive Weighting (SAW) e-module that proved to be feasible, practical, and effective for Decision Support System (DSS) learning. Expert validation showed very high feasibility (91.25% and 95%), while student response reached 91.33%. The effectiveness of the e-module was demonstrated by an increase in learning scores from 54.2 to 84.5 with an N-Gain of 0.66 and Cohen's *d* of 2.74, which falls into the very large effect category. The integration of PJBL, systematic presentation of SAW material, and use of multimedia were proven to improve students' conceptual understanding, analytical skills, and decision-making skills. This study contributes to educational technology through the use of interactive e-modules to support independent learning and strengthen digital literacy.

The study has limitations in that the scope of the trial was limited to one study program and one semester level, and did not examine other variables such as learning styles or motivation. Recommendations for instructors are to integrate PJBL e-modules into the learning process and utilize digital evaluation to monitor student progress on an ongoing basis. Further research is recommended to expand the topic of e-modules to other DSS methods, test on a larger population, add adaptive quiz and case simulation features, and conduct longitudinal studies to see the sustainability of the impact.

REFERENCES

- Amalia, I., & Sujatmiko, B. (2022). Pengembangan E-Modul Berbantuan Flipbook Berbasis Pjbl Guna Meningkatkan Hasil Belajar Siswa Pada Mata Pelajaran Teknik Animasi 2d Dan 3d Kelas Xi Multimedia (Studi Kasus: Smkn 2 Singosari). *It-Edu : Jurnal Information Technology And Education*, 7(3), 92–99. <https://doi.org/10.26740/It-Edu.V7i3.50147>
- Antari, P. L., Widiana, I. W., & Wibawa, I. M. C. (2023a). Modul Elektronik Berbasis Project Based Learning Pembelajaran Ips Untuk Meningkatkan Hasil Belajar Siswa Sekolah Dasar. *Jurnal Imiah Pendidikan Dan Pembelajaran*, 7(2), 266–275. <https://doi.org/10.23887/Jipp.V7i2.60236>
- Antari, P. L., Widiana, I. W., & Wibawa, I. M. C. (2023b). Modul Elektronik Berbasis Project Based Learning Pembelajaran Ips Untuk Meningkatkan Hasil Belajar Siswa Sekolah Dasar. *Jurnal Imiah Pendidikan Dan Pembelajaran*, 7(2), 266–275. <https://doi.org/10.23887/Jipp.V7i2.60236>
- Arnubi, Lian, B., & Mulyadi. (2021). The Impact Of Learning Management And Teacher Performance On Student's Learning Outcomes In Junior High School At Tulung Selapan District: International Conference On Education Universitas PGRI Palembang (Incoepp 2021), Palembang, Indonesia. <https://doi.org/10.2991/Assehr.K.210716.010>
- Asrar, A., & Zulpadrianto, Z. (2024). Pengembangan Modul Elektrostatika Berbasis Pjbl Untuk Meningkatkan Kemampuan Eksperimen Mahasiswa. *Jpf (Jurnal Pendidikan Fisika) Universitas Islam Negeri Alauddin Makassar*, 12(2), 91–103. <https://doi.org/10.24252/Jpf.V12i2.49997>
- Astuti, M., Novrita, S. Z., Giatman, Ambiyar, A., Muskhair, M., Effendi, H., Syah, N., & Syahril, S. (2023). Efektivitas Model Pembelajaran Project Best Learning (Pjbl) Berbantuan Ict Pada Mata Kuliah Manajemen Event Untuk Meningkatkan Softskill Mahasiswa. *Indonesian Journal Of Computer Science*, 12(6). <https://doi.org/10.33022/Ijcs.V12i6.3458>
- Efendi, B. M. S., & Insani, N. (2024). Implementasi E-Modul Berbantuan Google Sites Dengan Model Pbl Dalam Pembelajaran Ips Untuk Meningkatkan Minat Dan Hasil Belajar Peserta Didik. *Jurnal Riset Dan Inovasi Pembelajaran*, 4(1), 402–416. <https://doi.org/10.51574/Jrip.V4i1.1406>
- Hidayat, R. A., & Wijayanto, Z. (2021). Pengembangan Model Pembelajaran Berbasis Sosial Humanistik Dalam Meningkatkan Kemampuan Komunikasi Matematis Peserta Didik Sekolah Dasar. *Taman Cendekia Jurnal Pendidikan Ke-Sd-An*, 5(2), 655–669. <https://doi.org/10.30738/Tc.V5i2.11115>
- Jannah, M., Supardi, Z. A. I., & Prabowo. (2020). Guided Inquiry Model With The React Strategy Learning Materials To Improve The Students' Learning Achievement. *Ijorer International Journal Of Recent Educational Research*, 1(2), 156–168. <https://doi.org/10.46245/Ijorer.V1i2.45>

- Jazuli, L. O. A., Solihatin, E., & Syahril, Z. (2019). The Effects Of Brain-Based Learning And Project-Based Learning Strategies On Student Group Mathematics Learning Outcomes Student Visual Learning Styles. *Pedagogical Research*, 4(4). <https://doi.org/10.29333/Pr/5949>
- Khairani, Z., & Rosita, D. (2025). Pengembangan E-Modul Berbasis Tpack (Technological Pedagogical And Content Knowledge) Terintegrasi Pjbl (Project-Based Learning). 14(2).
- Khairunnisa, A., & Apoko, T. W. (2023). Pengembangan Media Pembelajaran Digital Berbasis Aplikasi Canva Pada Mata Pelajaran Pendidikan Pancasila Dan Kewarganegaraan Untuk Sekolah Dasar. *Jurnal Kewarganegaraan*, 20(2), 191. <https://doi.org/10.24114/Jk.V20i2.48898>
- Kurniawan, M., Setyaningtyas, E. W., Dwikurnaningsih, Y., Radia, E. H., Airlanda, G. S., Wardani, K. W., & Lauterboom, M. (2024). Peningkatan Keterampilan Pedagogi Guru Tk Dan Sd Melalui Bimbingan Teknis Implementasi Kurikulum Merdeka Di Satuan Pendidikan Di Wilayah Sumogawe. *Magistrorum Et Scholarium Jurnal Pengabdian Masyarakat*, 4(3), 243–254. <https://doi.org/10.24246/Jms.V4i32024p243-254>
- Muchlis, E. E., Priatna, N., & Dahlan, J. A. (2021). Development Of A Web-Based Worksheet With A Project-Based Learning Model Assisted By Geogebra. *Jurnal Riset Pendidikan Matematika*, 8(1), 46–60. <https://doi.org/10.21831/Jrpm.V8i1.40985>
- Muliyani, Y., Jannah, M., & Rahmati, R. (2020). Kemampuan Mahasiswa Calon Guru Dalam Mengembangkan Media Dan Bahan Ajar Ipa Berbasis Project Based Learning (Pjbl). *Jurnal Phi Jurnal Pendidikan Fisika Dan Fisika Terapan*, 1(3), 8. <https://doi.org/10.22373/P-Jpft.V1i3.7422>
- Mustika, J. (2022). Pengembangan E-Modul Matematika Berbasis Project Based Learning (Pjbl) Ditinjau Dari Kemampuan Berpikir Kreatif. *Aksioma: Jurnal Program Studi Pendidikan Matematika*, 11(4), 3573. <https://doi.org/10.24127/Ajpm.V11i4.5929>
- Nuraeni, L. S., Hafsyah, H., Nurdin, N., & Putriyani, S. (2024). Literatur Review: Pengembangan Bahan Ajar Matematika Berbasis Proyek Untuk Meningkatkan Keterampilan Berpikir Kritis. *Jagomipa Jurnal Pendidikan Matematika Dan Ipa*, 4(2), 352–365. <https://doi.org/10.53299/Jagomipa.V4i2.652>
- Partjuma, A. H. (2022). Pengaruh Model Project Based Learning (Pjbl) Berpendekatan Jelajah Alam Sekitar (Jas) Terhadap Hasil Belajar Kognitif Siswa Kelas Vii Smp Islam Jailolo. *Jurnal Bioedukasi*, 5(2). <https://doi.org/10.33387/Bioedu.V5i2.5776>
- Pradana, P. H., Tahir, M., Agustini, K., & Sudatha, I. G. W. (2023). Trend Model Project Based Learning Di Jenjang Pendidikan Dasar. *Jurnal Ilmiah Profesi Pendidikan*, 8(4), 2498–2506. <https://doi.org/10.29303/Jipp.V8i4.1824>
- Rahmani, Z., & Hikmawan, R. (2025). Pengembangan E-Modul Interaktif Pada Mata Pelajaran Matematika Untuk Meningkatkan Kemampuan Berpikir Kritis Siswa Sekolah Dasar. 14(1).
- Ramadhani, R. A., Pangestu, B. W., & Purbaningtyas, R. (2022). Klasifikasi Tumor Otak Menggunakan Convolutional Neural Network Dengan Arsitektur Efficientnet-B3. *Just It: Jurnal Sistem Informasi, Teknologi Informasi Dan Komputer*, 12(3), 55–59. <https://doi.org/10.24853/Justit.12.3.55-59>
- Santayasa, I. W., Rapi, N. K., & Sara, I. W. W. (2020). Project Based Learning And Academic Procrastination Of Students In Learning Physics. *International Journal Of Instruction*, 13(1), 489–508. <https://doi.org/10.29333/Iji.2020.13132a>

- Setianingsih, D. K., Handoyo, E., Wardani, S. P. R., Subali, B., & Widiarti, N. (2025). The Effect Of Using Pjbl-Based Interactive E-Modules On Improving Learning Outcomes. *Edunesia Jurnal Ilmiah Pendidikan*, 6(2), 1179–1198. <https://doi.org/10.51276/Edu.V6i2.1240>
- Sidauruk, T., Delita, F., Nurmala Berutu, Elfayetti, & Rohani. (2025). E-Modules To Improve Learning Independence, Motivation And Learning Outcomes. *Jurnal Penelitian Dan Pengembangan Pendidikan*, 9(1), 171–180. <https://doi.org/10.23887/Jppp.V9i1.74404>
- Siregar, A. D., & Harahap, L. K. (2020). Pengembangan E-Modul Berbasis Project Based Learning Terintegrasi Media Komputasi Hyperchem Pada Materi Bentuk Molekul. *Jpps (Jurnal Penelitian Pendidikan Sains)*, 10(1), 1925. <https://doi.org/10.26740/Jpps.V10n1.P1925-1931>
- Tantya, N. G. (2025). Pengembangan Bahan Ajar Berbasis Kearifan Lokal Sedekah Bumi Menggunakan Model Addie Pada Materi Teks Cerita Pendek Untuk Siswa Kelas Xi. 12.
- Trinaldi, A., Afriani, M., Budiyo, H., Rustam, R., & Priyanto, P. (2022). Persepsi Guru Terhadap Model Pjbl Pada Kurikulum Prototipe. *Jurnal Basicedu*, 6(4), 7408–7417. <https://doi.org/10.31004/basicedu.V6i4.3526>
- Wahyuni, L., & Rahayu, Y. S. (2021). Pengembangan E-Book Berbasis Project Based Learning (Pjbl) Untuk Melatihkan Kemampuan Berpikir Kreatif Pada Materi Pertumbuhan Dan Perkembangan Tumbuhan Kelas Xii Sma. *Berkala Ilmiah Pendidikan Biologi (Bioedu)*, 10(2), 314–325. <https://doi.org/10.26740/Bioedu.V10n2.P314-325>
- Wahyuni, S., Hindun, I., & Nurwidodo, N. (2024). Peningkatan Kualitas Implementasi Project-Based Learning Pada Guru Ipa Sekolah Muhammadiyah Kota Batu. *Lambung Inovasi Jurnal Pengabdian Kepada Masyarakat*, 9(3), 706–723. <https://doi.org/10.36312/Linov.V9i3.1711>