



Improving IPAS Learning Outcomes through Differentiated Instruction and Assembler Edu

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Received Juni 29, 2025 • Revised July 16, 2025 • Accepted August 6, 2025

ABSTRACT

This study aims to analyze the implementation of differentiated instruction integrated with Assembler Edu media to enhance student learning outcomes in IPAS (Integrated Science and Social Studies). The issue addressed is the limited accommodation of students' diverse abilities and learning styles, which leads to suboptimal achievement. Differentiated instruction is considered an adaptive pedagogical approach, and the use of Assembler Edu is expected to support its innovative application. This Classroom Action Research (CAR) employed the Kemmis and McTaggart spiral model, conducted in two cycles involving 30 fourth-grade students at UPTD SDN 1 Weru. Data were collected through learning outcome tests, observation sheets, and documentation. Quantitative data were analyzed by calculating average scores and classical completeness percentages, while qualitative data were analyzed descriptively. The results show a significant improvement in student learning outcomes. The average score increased from 52 (pre-cycle) to 63 in Cycle I and 73 in Cycle II. Classical completeness improved from 26.67% in the pre-cycle to 40% in Cycle I and 83.33% in Cycle II, surpassing the success indicator of 75%. Observations also revealed increased student engagement and more effective teacher facilitation tailored to student needs. In conclusion, implementing differentiated instruction supported by Assembler Edu effectively enhances learning outcomes by addressing diverse learning needs and fostering interactive learning. It is recommended that teachers adopt pedagogical strategies aligned with student characteristics and leverage educational technology to optimize learning goals.

Keywords: Differentiated Instruction; Assembler Edu; Learning Outcomes; IPAS.

INTRODUCTION

Education plays a very strategic role in producing a generation that is intelligent, has good attitudes and behaviors, and is highly competitive in facing global challenges. Education is an essential process that plays a role in transferring and enriching knowledge, skills, and positive behaviors from one generation to the next through various approaches, such as teaching, training, and research [1]. Through education, individuals acquire provisions such as knowledge and skills, as well as the strengthening of moral and social values that form the foundation for national development [2].

Furthermore, the urgency of this educational role is emphasized in the laws and regulations that serve as the basis for the implementation of the national education system. One of these is stated in Article 3 of Law of the Republic of Indonesia Number 20 of 2023 concerning the National Education System, which states that the goal of national education is to develop the potential and shape the personality of students so that they become people who believe in and fear God Almighty, have noble morals, are physically and mentally healthy, intelligent, innovative, creative, independent, and responsible [3]. In addition, education also plays a role in creating democratic and law-abiding citizens, as

well as building a civilized, intelligent, and dignified national life.

In an effort to realize national education goals, the Indonesian government continues to promote the transformation of the education system through the implementation of the Independent Curriculum [4]. This curriculum offers flexible learning, focuses on essential materials, and emphasizes student character development [5]. Furthermore, the Independent Curriculum emphasizes the importance of student-centered, contextual learning that is responsive to the needs and challenges of the times. It is also designed to accommodate the diverse characteristics of students, including differences in how they acquire information, develop ideas, and express their understanding of the material [6]. In line with this, students are required to become independent learners who are able to acquire knowledge from various sources, both formal and informal [7]. Therefore, differentiated learning is a very relevant approach to implement, because it is able to adapt the learning process to the needs, readiness, and abilities of individual students [8].

Differentiated learning has the view that each student has diverse characteristics, both in terms of interests, cultural background, growing environment, and social and economic conditions [9]. This approach is also based on the awareness that students have diverse characteristics, both in terms of learning styles, speed in absorbing material, and individual interest in the lesson [10]. These differences cause each student's learning needs to be unique and cannot be generalized [11]. This concept was first developed by Carol Ann Tomlinson, who stated that differentiated learning is a learning strategy that accommodates, serves, and acknowledges differences in students' readiness, interests, and learning preferences [12]. This is reinforced by Tomlinson, who emphasized that differentiated learning is a conscious effort to adapt the learning process in the classroom to meet individual learning needs [13]. In other words, teachers need to provide learning services that take into account the characteristics and potential of each individual [14]. As a result, the learning process becomes more meaningful, relevant, and effective for each student.

On the other hand, the rapid development of digital technology presents strategic opportunities for the education sector to grow. One such opportunity is the use of digital technology to support the implementation of differentiated learning, particularly through the use of digital-based interactive media [15]. Teachers can now utilize various forms of media, such as videos, simulations, and even augmented reality (AR) technology, to adapt learning strategies to the diverse needs and learning styles of students [16]. In this context, the use of virtual media plays an important role in making the presentation of material more interesting while providing additional information that enriches students' understanding [17]. Thus, learning media must be designed to adapt to the conditions, interests, and learning styles of 21st-century students [18]. One relevant and applicable AR medium is Assemblr Edu, an application that allows the integration of virtual elements into the real world in three-dimensional (3D) visuals [19], thus creating a contextual and interactive learning experience. Furthermore, the visual design in AR applications has been proven to trigger students' interest in learning and encourage their active involvement in the learning process [20]. Fakhruddin's research results also show that the use of AR has a positive impact on improving student learning outcomes, especially in science subjects from a cognitive aspect [21]. Thus, utilizing Assemblr Edu as an innovative learning medium can be an effective strategy in supporting the optimal achievement of learning objectives.

However, on the ground, this transformation has not yet been fully implemented at

the elementary school level. Much of the learning process remains conventional, one-way, and involves minimal use of technology and interactive media. As a result, students struggle to understand the material, particularly in Natural and Social Sciences (IPAS), which require reasoning and understanding of abstract concepts.

One concrete example was found at the UPTD SDN 1 Weru Lor, specifically in the IVC class. Based on observations and interviews with the class teacher, it was discovered that science learning was still monotonous and not supported by varied learning media. Preliminary data showed that only 8 out of 30 students (26.67%) achieved scores above the Learning Objective Achievement Criteria (KKTP), while the other 22 students (73.3%) had not achieved completeness. This fact shows that the majority of students have not optimally understood the material.

Based on these challenges, learning strategies are needed that are responsive to the diverse characteristics of students and can utilize technology optimally. Differentiated learning is a relevant solution because it can be tailored to students' needs, interests, and readiness. In fact, this approach has been proven to improve learning outcomes across various subjects.[8]To support its effectiveness, the use of digital media such as Assemblr Edu is considered potential in creating more interactive and engaging learning. Therefore, this study examines the application of differentiated learning assisted by Assemblr Edu media to improve student learning outcomes in science subjects.

MATERIAL AND METHODS

This research was conducted for three weeks in May 2025 at the UPTD SDN 1 Weru Lor, Weru District, Cirebon Regency. The subjects were 30 students in grade IV-C of the 2024/2025 academic year (11 male students and 19 female students). The learning approach applied was differentiated learning assisted by Assemblr Edu digital media, with the Problem Based Learning (PBL) model as the basis for student learning activities. This study used a Classroom Action Research (CAR) approach with the spiral model from Kemmis and McTaggart [22], as a basis for its implementation. Classroom Action Research (CAR) is a scientific method that aims to solve learning problems in the classroom through systematic, reflective, and collaborative actions [23]. Kemmis and McTaggart's spiral model consists of four sequential stages, namely planning, implementing action, observing the process, and reflecting [24][25]. The following is a diagram of the Kemmis and McTaggart PTK spiral model used in this study [26].

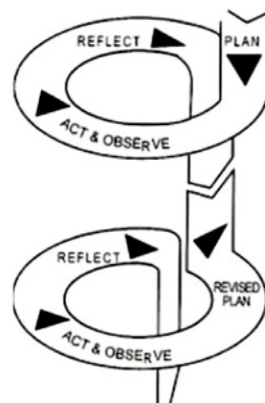


Figure 1. Kemmis and McTaggart Model

The planning stage carried out by the researcher included preparing learning materials (teaching modules, student worksheets (LKPD), evaluation questions), creating learning media using the digital application Assemblr Edu, and preparing observation sheets to observe teacher and student activities. Next, the implementation stage was carried out directly in the classroom with a series of activities that included: (1) opening the lesson; (2) conveying the learning objectives; (3) implementing differentiated learning with the help of Assemblr Edu; (4) working on the LKPD (discussing) and presenting the results of the work; (5) working on evaluation questions; (6) closing the lesson. The observation stage is carried out simultaneously with the implementation stage. The aim is to determine the suitability of the actions with the plans that have been prepared, evaluate the implementation of the actions and their impact on the learning process [27]. Meanwhile, the reflection stage is conducted after the learning process to analyze observation results and student learning outcomes, determine the success of the actions, identify shortcomings, and design improvements for the next cycle if necessary. The reflection stage serves as the basis for developing subsequent actions or ending the cycle once the target has been achieved.

The process of obtaining information in research is carried out through the application of appropriate data collection techniques from relevant sources and supports the research focus [28]. In this study, the main techniques used include: (1) tests in the form of pretest and posttest questions to determine and measure the achievement of student learning outcomes at the end of each cycle; (2) observation to assess the implementation of teacher and student activities during learning; and (3) documentation that functions as visual data supporting the implementation of actions. The data analysis process was carried out qualitatively and quantitatively. Qualitative data were collected through observation and documentation, then analyzed descriptively through the process of data reduction, data presentation, and drawing conclusions [29]. Meanwhile, quantitative data were obtained from the results of the pretest and posttest which were analyzed using simple statistical techniques by calculating the average value, the highest score, the lowest score, and the percentage of classical completion [29]. This analysis aims to evaluate the effectiveness of the actions carried out from the pre-cycle to cycle 1, cycle 2, and so on. The researcher expects a percentage of classical completion of at least 75% as the target for achieving increased student learning outcomes in this study.

RESULTS AND DISCUSSION

Results

The main focus of this research is to improve the quality of the teaching and learning process and the academic achievement of class IVC students at UPTD SDN 1 Weru Lor through the implementation of differentiated learning supported by Assemblr Edu digital media. Each cycle is analyzed based on student learning outcomes data, learning activities, and teacher reflections to determine the extent of improvements that have been achieved [30]. However, the focus of analysis in this study is directed at student learning outcomes obtained through posttests at the end of each cycle. This study was designed by grouping students based on learning styles (visual, auditory, kinesthetic) and adapting the content, process, and learning products to adapt the learning process to each student's needs [31].

Pre-cycle

The results of initial observations conducted at UPTD SDN 1 Weru Lor class IVC in the subject of Natural Sciences, especially on the material "Plant Body Parts and Their Functions". Observation activities are carried out directly to identify various problems in the learning process. During the researcher's observation of the conditions of the IVC class, the results showed that the learning atmosphere in the class was quite conducive.

However, a major obstacle hindering the learning process was identified: students' ability to maintain focus and concentration. Some students appeared sleepy, inattentive, or more interested in joking with friends. This resulted in students having difficulty understanding the science material presented. Furthermore, the learning approach used was still general and teacher-centered, not fully adapting to students' learning styles and ability levels.

Before implementing differentiated learning, students were given an evaluation test sheet to determine their learning outcomes. Based on the evaluation test conducted during the pre-cycle stage, out of a total of 30 students, only 8 students (26.67%) successfully achieved the Learning Objective Achievement Criteria (KKTP), while the other 22 students (73.33%) had not achieved learning mastery. This indicates that most students still require additional guidance in understanding the material being taught.

Table 1. Recapitulation of Learner Learning Results in Pre-cycle

No	Aspect	Pre Cycle
1.	Number of Learners	30
2.	Minimum Mastery Criteria (KKTP)	70
3.	Total score	1572
4.	Average Score	52
5.	Highest Score	70
6.	Lowest Score	10
7.	Number of Learners Completed	8
8.	Number of Incomplete Learners	22
9.	Percentage of Learning Completeness	26.67%
10.	Remax/Description	Incomplete

The low average learning outcomes and completion percentage in the pre-cycle stage are important considerations in designing corrective actions. As a solution, researchers designed a differentiated learning approach using the interactive digital media Assemblr Edu using the Problem-Based Learning (PBL) model. This strategy aims to create a more active, contextual learning experience that adapts to students' learning needs [32]. It is hoped that this strategy will improve learning outcomes and overall student engagement in the next learning cycle.

Cycle I

In cycle I, the researcher conducted the action in one meeting, lasting 2 x 35 minutes. The material studied in this cycle was Plant Body Parts (Roots, Stems, Leaves) and their Functions in the Science subject. The following are the research stages carried out by the researcher.

Planning

The action plan for cycle I was designed to implement the mapping results and learning design established in the previous stage. The researcher designed the learning using a

differentiated approach, aided by Assemblr Edu media, and a Problem-Based Learning (PBL) model. The planning carried out by the researcher included:

1. Preparing and designing learning media in the form of concrete objects (fresh plants) and 3D Augmented Reality (AR) images in the interactive and contextual Assemblr Edu application.
2. Develop teaching modules with differentiated principles (content, process, product) based on the learning styles (visual, auditory, kinesthetic) of students.
 - a. The content is the same core material, but presented in various forms:
 - 1) Visual: interactive 3D images of plant body parts via Assemblr Edu.
 - 2) Auditory: Assemblr Edu's 3D images are accompanied by explanatory audio.
 - 3) Kinesthetic: fresh (concrete) plants such as spinach.
 - b. The process in the form of learning activities is structured in a way that suits the students' learning styles:
 - 1) Visual: observing 3D images and noting the characteristics and functions of each part of the plant.
 - 2) Auditory: listening to audio explanations while observing 3D images, then having group discussions.
 - 3) Kinesthetic: observing directly (touching the texture, shape, and size) of the plant parts provided.
 - c. The final learning product is adapted to the students' choices, which reflect their understanding of the material, in the form of: pictures or posters, simple songs, collages from natural materials/used paper.
3. Create differentiated student worksheets (LKPD), pretest and posttest questions, evaluation questions, and observation sheets to record student activity and teacher performance during the learning process.

Action

The action in cycle I was carried out in one meeting, namely on May 15, 2025. The stages of learning activities in this cycle I were carried out in accordance with the syntax of Problem Based Learning (PBL) with a differentiated learning approach. Learning activities began with a warm greeting through the 5S approach (Smile, Greet, Greeting, Polite, and Courteous) and class conditioning. Considering that the implementation was at the end of the school hour, initial activities such as praying together, singing the national anthem, and ice breaking were eliminated. The teacher immediately linked the new material to previous knowledge about living things, then motivated students through visual-based discussions, namely images of skyscrapers to explain the importance of structure and foundation, before conveying the objectives and benefits of learning.

In the core activity, learning begins with a problem-oriented approach through the story "Magic Spinach and the Secret of Its Body" presented using Assemblr Edu digital media. Students are invited to observe plant parts and relate them to real-world problems. Next, the teacher divides students into groups based on their learning styles (visual, auditory, and kinesthetic), each equipped with differentiated learning media. Through observation, discussion, and exploration, students formulate initial hypotheses regarding the function of plant parts. The investigation process is carried out according to the learning style of each group, accompanied by the teacher who acts as a facilitator. The results of the observations are then expressed in the form of free products such as posters,

songs, or collages, which are presented in front of the class to obtain feedback from peers and the teacher.

In the final stage, the teacher guides group reflection and relates the learning to everyday life, such as the importance of caring for plants. The activity concludes with evaluation questions, material reinforcement, a question-and-answer session, appreciation for group work, and information regarding the next meeting's material.

Observation

The instruments used included observation sheets for teacher and student activities, compiled using PBL syntax. Observation results showed that both teachers and students scored 30 out of 40, with a percentage of 75%, which is categorized as "Good."

Table 2. Results of Observations of Teacher and Student Activities in Cycle I

No.	Information	Teacher Activities	Student Activities
1.	Total score	40	40
2.	Total scores obtained	30	30
3.	Presentation	75%	75%
4.	Category	Good	Good

In more detail, learning activities were analyzed based on three main components. In the preliminary activity, out of 9 observed aspects, a score of 5 (55%) was obtained, indicating the need for improvement in initial activities such as prayer, icebreaker, and attendance check. The core activity, consisting of 26 aspects, obtained a score of 22 (84%), indicating very good implementation despite some shortcomings in story telling, sparking questions, and strengthening learning resources. Meanwhile, the closing activity recorded a score of 5 out of 7 aspects (71%), with a note that the need for strengthening reflection and follow-up learning.

Overall, the implementation of learning in cycle I was quite effective, but there were still several aspects that needed to be improved to optimize the learning process in the next cycle.

Learning outcomes

The implementation of differentiated learning assisted by Assemblr Edu digital media has a positive impact on improving student learning outcomes in the material "Plant Body Parts and Their Functions", there was a significant improvement in their learning outcomes. Here is the table student learning outcomes in cycle I.

Table 3. Recapitulation of Learner Learning Results in Cycle I

No.	Aspect	Cycle I
1.	Number of Learners	30
2.	Minimum Mastery Criteria (KKTP)	70
3.	Total score	1880
4.	Average Score	63
5.	Highest Score	80
6.	Lowest Score	30
7.	Number of Learners Completed	12
8.	Number of Incomplete Learners	18
9.	Percentage of Learning Completeness	40%
10.	Remax/Description	Incomplete

According to the table above, the level of student learning completion in cycle I only reached 40%, with only 12 out of 30 students successfully meeting the Minimum Completion Criteria (KKTP) of 70. Although there was an improvement compared to the pre-cycle, these results indicate that the implementation of differentiated learning assisted by Assemblr Edu digital media in cycle I has not been running optimally. Thus, it is necessary to improve learning strategies and media utilization to achieve better learning outcomes in the next cycle.

Reflection

Reflections on the implementation of learning in Cycle I were conducted based on observations and evaluations of student learning outcomes. Several obstacles were identified that impacted the effectiveness of the learning process. First, learning took place after sports time, when students were already physically unwell and had not had time to change their clothes, resulting in a less conducive classroom atmosphere. Second, the teacher failed to optimally establish an initial learning atmosphere, such as by failing to check attendance, sing the required song, or conduct an icebreaker, resulting in delays in the start of core activities. Third, when forming groups based on learning styles, some students still preferred to work with close friends, hindering the grouping process designed to support differentiation. Fourth, some students tended to rely on friends during self-assessments, reflecting a lack of active and independent learning habits. Finally, limited resources such as infocus and audio devices impacted the smooth use of digital media, including the playback of 3D images with audio and interaction with visual content.

As a follow-up, the researcher designed several improvements in cycle II, including rescheduling learning time, getting used to initial routines, strengthening understanding of the importance of differentiated learning, fostering attitudes of academic responsibility, and optimizing supporting learning facilities and infrastructure.

Cycle II

In Cycle II, the researcher conducted the action in one meeting, lasting 2 x 35 minutes. The material studied in this cycle was Plant Parts (Flowers, Fruit, Seeds) and Their Functions in the Science subject. The following are the research stages carried out by the researcher.

Planning

The planning for cycle II was developed in response to the reflections from cycle I, with the aim of addressing existing constraints and optimizing learning strategies. The following is the planning carried out by the researcher.

1. Preparing and designing learning media in the form of concrete objects (fresh plants) and 3D Augmented Reality (AR) images in the interactive and contextual Assemblr Edu application.
2. Develop teaching modules with differentiated principles (content, process, product) based on the learning styles (visual, auditory, kinesthetic) of students.
 - a. The content is the same core material, but presented in various forms:
 - 1) Visual: Assemblr Edu 3D images of plant body parts (flowers, fruit, seeds) and explanations of their functions.

- 2) Auditory: Assemblr Edu's 3D images are complemented by interactive audio explanations.
 - 3) Kinesthetic: the use of fresh plants such as flowers, fruit and seeds to observe directly.
- b. The process in the form of learning activities is structured in a way that suits the students' learning styles:
- 1) Visual: observe interactive images and note the function of each part of the plant.
 - 2) Auditory: listening to audio explanations while observing pictures, then having group discussions.
 - 3) Kinesthetic: exploring plant parts directly, such as smelling flowers, touching seeds, and comparing the shape of fruit.
- c. The final learning product is tailored to the students' choices and reflects their understanding of the material, in forms such as flip books, simple 3D models, herbariums of dried plant parts.
3. Create differentiated student worksheets (LKPD), pretest and posttest questions, evaluation questions, and observation sheets to record student activity and teacher performance during the learning process.

Action

The second cycle was conducted on May 28, 2025, for 2 x 35 minutes. The material studied was plant parts (flowers, fruits, and seeds) and their functions, through a Problem Based Learning (PBL) model based on learning style differentiation with the support of interactive media Assemblr Edu.

The lesson began with a warm greeting, a prayer, and an explanation of the learning objectives and benefits in everyday life. To build motivation, the teacher displayed 3D images and animations of plant parts via Assemblr Edu, as well as videos of the factory production process, linking them to the functions of plant parts in life.

In the core activity, students are introduced to the problem through the contextual story "Danu and the Miracle of the Tomato Plant" with interactive images. Students are then divided into groups based on previously identified learning styles. Each group uses student worksheets and learning media appropriate to their learning style. The discussion is guided by prompting questions to formulate hypotheses about the function of plant parts. The visual group observes 3D images, the auditory group listens to audio explanations accompanied by images, and the kinesthetic group explores real plant parts. The teacher guides each group, provides support as needed, and encourages the use of additional learning resources. Next, each group develops a final product such as a flipbook, 3D model, or mini herbarium that represents their understanding and then presents it to the class. The teacher provides feedback and encourages students to analyze the learning process and relate it to real-life contexts.

In closing, students completed a self-evaluation. The teacher reviewed key points, clarified student questions, and collectively summarized the learning outcomes. The activity concluded with a prayer as a form of reflection and spiritual values.

Observation

Observations in cycle II were conducted to assess the implementation of learning based on the plan that had been prepared, as well as to improve on the previous cycle. The table below shows the results of observations of teacher and student activities during cycle II.

Table 4. Results of Observations of Teacher and Student Activities in Cycle I

No	Information	Teacher Activities	Student Activities
1.	Total score	40	40
2.	Total scores obtained	37	37
3.	Presentation	92.5%	92.5%
4.	Category	Very good	Very good

Observation results showed a significant improvement compared to cycle I. Both teachers and students obtained a score of 37 out of 40, with a percentage of 92.5%, and was categorized as very good. Further assessment of the three main components of learning showed that:

The preliminary activity received a score of 7 out of 9 (77.8%), reflecting increased student engagement from the beginning, even though the icebreaker and attendance check aspects had not yet been implemented. The core activity, which covered all stages of PBL syntax, was implemented perfectly with a score of 26 out of 26 (100%), demonstrating the effectiveness of collaboration and digital media optimization. Meanwhile, the closing activity also achieved a maximum score of 7 out of 7 (100%), with optimal implementation of reflection, evaluation, and follow-up.

Overall, differentiated learning assisted by Assembler Edu in cycle II showed very good implementation, creating an active, directed, and meaningful learning process for students.

Learning outcomes

The implementation of differentiated learning using Assembler Edu digital media in Cycle II demonstrated significantly better results than in the previous cycle. Based on the data in the following table, there was a significant increase in student completion and grades.

Table 5. Recapitulation of Learner Learning Results in Cycle II

No.	Aspect	Cycle II
1.	Number of Learners	30
2.	Minimum Mastery Criteria (KKTP)	70
3.	Total score	2180
4.	Average Score	73
5.	Highest Score	100
6.	Lowest Score	40
7.	Number of Learners Completed	25
8.	Number of Incomplete Learners	5
9.	Percentage of Learning Completeness	83.33%
10.	Remax/Description	Complete

Referring to the data in the table above, the level of student learning completion in cycle II increased sharply to 83.33%, with 25 out of 30 students successfully exceeding the Minimum Completion Criteria (KKTP) of 70. This achievement shows that the improvement of differentiated learning strategies by maximizing the Augmented Reality feature from Assembler Edu has succeeded in creating more interesting, adaptive, and effective learning for students. Thus, the implementation in cycle II can be said to have succeeded in optimally improving student learning outcomes.

Reflection

The implementation of learning in Cycle II showed significant improvement compared to the previous cycle. All syntax of the Problem-Based Learning model and differentiated learning approach were implemented optimally. Students appeared more enthusiastic, cooperative, and demonstrated increased learning independence. Activities proceeded on time in a conducive and orderly classroom atmosphere. The formation of groups based on learning styles proceeded smoothly without any obstacles, even strengthening the spirit of cooperation and mutual assistance.

Furthermore, the more sophisticated use of Assemblr Edu's digital media contributed to the effectiveness of learning. Students also demonstrated responsibility in completing evaluations independently, without copying answers. Overall, the implementation of actions in Cycle II was effective and efficient, successfully overcoming obstacles encountered in the previous cycle, thus positively impacting the learning process and outcomes of students.

Discussion

This study shows a significant improvement from cycle I to cycle II in the implementation of differentiated learning assisted by Assemblr Edu digital media. This can be seen through the diagrams of teacher and student activity observations, as well as improvements in student learning outcomes, as shown in Figures 2 and 3 below.

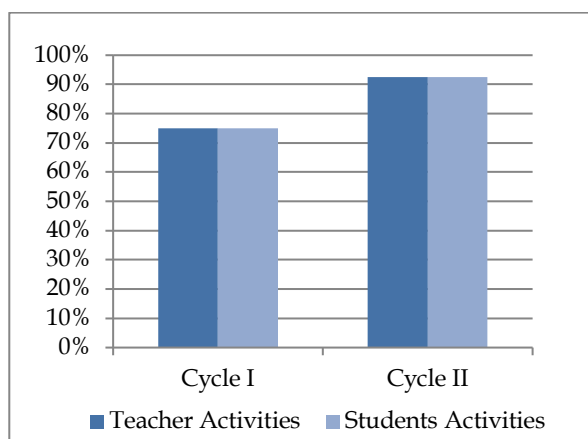


Figure 2. Observation Results of Teacher and Student Activities

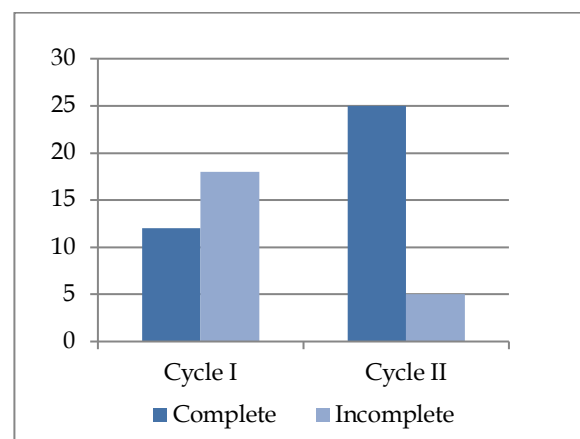


Figure 3. Student Learning Outcomes

The results of the study show that the application of differentiated learning assisted by Assemblr Edu digital media has a positive impact on students' understanding of concepts and learning outcomes. These improvements in both learning processes and outcomes confirm that the learning strategies used are capable of enhancing learning effectiveness. Teachers not only adjust methods and strategies based on the results of student learning needs analysis but are also able to create a responsive and adaptive learning environment. This aligns with Tomlinson's view that differentiated learning can improve student learning outcomes by taking into account the diversity of their learning styles and abilities [8]. In addition, the use of interactive digital media such as Assemblr Edu has been proven to enrich the learning experience through a contextual and multimodal approach, as emphasized in Mayer's multimedia learning theory, that the combination of visuals and interactivity can strengthen the understanding of concepts in greater depth [33].

Based on the research results, there are several limitations that need to be considered.

First, although it has been proven that this study only focused on one specific school or area, it still shows that a differentiated learning approach has a significant positive impact on student learning outcomes. This has the potential to limit the generalizability of the research findings to a broader population. Second, in this study, the primary focus was on the implementation of differentiated learning and classroom management, but other aspects such as the influence of school environmental factors or individual student characteristics were not explored in depth. Therefore, future research should involve a more representative population and variables. Furthermore, a more in-depth examination of the components that may influence student learning outcomes is necessary.

However, several limitations and challenges emerged during the research. First, limited technological support facilities at the school required teachers to prepare media in advance and share learning time with other classes. Second, classrooms became less conducive because most students showed enthusiasm, and some had difficulty operating Assemblr Edu's interactive features independently. Therefore, they required more intensive support during implementation to ensure everyone could participate in the learning process equally. Third, the need for more time in planning and implementing optimal differentiated learning requires teachers to develop efficient and meaningful learning scenarios. However, these challenges can be gradually overcome through ongoing training and support from the school.

Thus, it can be concluded that differentiated learning combined with Assemblr Edu interactive digital media and the Problem Based Learning model is not only able to increase the effectiveness of the learning process, but also contributes to improving student learning outcomes. This strategy has proven effective, especially in science learning on the material of plant parts and their functions, because it is able to facilitate the diverse learning needs of students in a more personal and meaningful way. This research also strengthens the discourse that adapting educational technology that is relevant to local characteristics can be an innovative solution in addressing the challenges of 21st-century learning.

CONCLUSION

The results and discussion outlined above lead to the conclusion that implementing differentiated learning using Assemblr Edu digital media within the Problem-Based Learning (PBL) model can improve student learning outcomes. Adapting learning strategies to individual needs has proven effective in creating more meaningful learning experiences. The significant improvement in learning outcomes indicates that the integration of interactive technology can support an adaptive and student-centered learning process.

Practically, these results emphasize the importance of developing teacher capacity in designing instructional materials responsive to diverse learning styles, as well as the need for supporting learning technology infrastructure in educational units. For policymakers, these results can serve as a foundation for encouraging the implementation of inclusive and responsive instructional materials in elementary schools. Further research is recommended with a broader student population and exploration of assessment dimensions encompassing the affective and psychomotor domains to obtain a more comprehensive picture of learning outcomes.

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