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Enhancing Science Learning Activities through the Implementation of Discovery Learning and Teaching at the Right Level Method

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Abstract: Education plays a vital role in cultivating qualified future generations, with active student participation serving as an indicator of effective learning processes. Preliminary observations at SMP Negeri 32 Padang revealed low engagement levels in science classes, prompting the need for interventions to boost students' involvement. The primary objective of this classroom action research was to enhance student engagement in science learning activities through implementing the Discovery Learning model and Teaching at the Right Level approach in a Grade 8 classroom at SMP Negeri 32 Padang. The study was conducted over three cycles, each consisting of planning, acting, observing, and reflecting phases. Data on student engagement in science learning activities was collected through observations using a rubric. The initial data in Cycle I revealed low engagement at 36.72%. After implementing interventions integrating Discovery Learning activities and personalized scaffolding based on students' ability levels in Cycles II and III, student engagement progressively increased to 45.76% and 62.28% respectively. Surveys and interviews indicated students found the learner-centered, inquiry-based activities more enjoyable and effective for understanding compared to traditional instruction. The findings demonstrate the potential of combining Discovery Learning and Teaching at the Right Level methods to significantly improve learning participation by stimulating intrinsic motivation through autonomous exploration while providing individualized support. The research offers practical strategies for enhancing science education engagement and contributes to the Kurikulum Merdeka goals of fostering participatory, flexible learning environments tailored to students' unique needs.

Keywords: Classroom Action Research; Discovery Learning; Science Learning Activity; Students; Teaching at the Right Level.

Introduction

Education plays a vital role in cultivating qualified future generations for a nation (Kementerian Pendidikan dan Kebudayaan, 2020). A crucial aspect of education is the learning process (Popovic, 2013). For learning to be effective, active participation from students is necessary (Hake, 1998). Students' engagement in learning serves as one indicator for the success of the learning process (Hake, 1998). However, preliminary observations at SMP Negeri 32 Padang revealed that students' engagement in science learning remained rather low (Fredricks et al., 2004). This is evidenced by the many passive students who tended to remain quiet during lessons (Ryan & Deci, 2000).

The low learning activeness of students can be influenced by several factors. One of them is the learning model applied by the teacher (Felder & Prince, 2011). If

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the learning model applied is not able to arouse students' interest and motivation to actively participate, their activeness will also be low (Ryan & Deci, 2000). In addition, the teaching approach used by the teacher also affects students' learning activeness (Tomlinson, 2017). If the teaching approach does not match the characteristics and needs of students, it will be difficult for them to follow the learning well (Abdi, 2014; Hendri & Setiawan, 2016).

These issues prompt the need for improvements in the science learning process at SMP Negeri 32 Padang specifically regarding boosting students' engagement in learning (Hake, 1998). One proposed solution is implementing the Discovery Learning model alongside a Teaching at the Right Level approach. Discovery Learning is a learning model emphasizing the process of independent knowledge discovery by students (jerome Bruner, 2012). With this model, pupils are trained to autonomously uncover concepts being studied through exploratory activities (Felder & Prince, 2011). Meanwhile, Teaching at the Right Level refers to an instructional approach tailored to students' actual ability levels (Banerjee et al., 2010). Through this approach, teaching materials and activities are provided according to learners' genuine level of comprehension (Adamson & Darling-Hammond, 2015).

Several previous studies validated the benefits of applying the Discovery Learning model and Teaching at the Right Level approach in heightening students' participation and learning outcomes (Prince & Felder, 2007). Research by (Dyamayanti et al., 2023) revealed implementing the Discovery Learning model could increase students' engagement and cognitive learning achievements in science subjects. Meanwhile, another study by Pratama (Yerimadesi et al., 2018) also found a significant enhancement in students' participation and learning accomplishment after using the Teaching at the Right Level strategy.

The Discovery Learning model encourages students to explore concepts through hands-on discovery of new knowledge rather than direct transmission from educators (jerome Bruner, 2012). It promotes active, self-directed inquiry which engages students cognitively and behaviorally in the learning process (Prince & Felder, 2007). When students take ownership of their learning through exploration, it enhances intrinsic motivation and boosts engagement (Ryan & Deci, 2000). Research shows Discovery Learning leads to improved achievement, longer retention of knowledge, and stronger higher-order thinking skills compared to traditional instruction (Felder & Prince, 2011). However, for optimal benefit, careful planning and scaffolding by educators is needed to guide student discovery (Vygotsky, 1978).

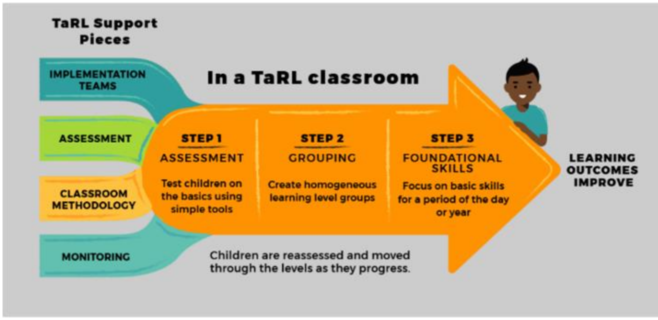

Figure 1. TaRL Implementation scheme

As we can see at figure 1 The Teaching at the Right Level approach aims to match instruction precisely to each student's current level of understanding (Author et al., 2011). It recognizes that students progress at different paces and possess diverse abilities, interests and prior knowledge (Putrawangsa & Hasanah, 2018; Tomlinson, 2017). By assessing students formatively, educators can pinpoint the "zone of proximal development" - the gap between what students can do independently and with guidance (Hastuti et al., 2018). Instruction is then tailored specifically to bridge this gap and propel each student just beyond their current abilities (Hastuti et al., 2018). Formative feedback also allows for timely adjustments to ensure continuous progress (Sadler, Royce, 1989). Research indicates individualizing instruction in this manner boosts engagement as well as cognitive and emotional development for all students (Tomlinson, 2014).

Implementing Discovery Learning alongside Teaching at the Right Level addresses both the learning model and instructional approach aspects highlighted as influential factors in students' engagement (Dyamayanti et al., 2023). Discovery Learning fosters active participation through inquiry-based exploration aligned with students' natural curiosity (Edelson et al., 1999). Meanwhile, Teaching at the Right Level matches this to students' current capabilities through individualized instruction, scaffolding and feedback (Abdi, 2014). Combined, these aim to stimulate interest, motivate participation and enable all students to learn effectively according to their unique needs, thereby improving science learning engagement at SMP Negeri 32 Padang.

Based on the description provided, the researcher is interested in conducting Classroom Action Research applying a fusion of the Discovery Learning model and Teaching at the Right Level approach to enhance the science learning participation of Grade VIII students at SMP Negeri 32 Padang. This study seeks to provide solutions to the issue of low involvement in science lessons through implementing appropriate models and methods for learning (Ismail & Insani, 2023)). In addition, this research is expected to serve as a reference for science educators in applying innovative instructional models and approaches to better the quality of learning processes and outcomes (Nurhalimah et al., 2017). The study will be conducted over three cycles, each consisting of planning, action, observation and reflection stages (Kemmis & McTaggart, 2005).

In the planning stage of Cycle 1, the researcher will design lesson plans integrating Discovery Learning and Teaching at the Right Level based on the school curriculum and students' characteristics (Kelas et al., 2023). Formative assessment tools will be prepared to gauge students' current understanding (Ismail et al., 2023). In the action stage, the lessons will be taught according to the plans with an emphasis on exploratory activities and individualized support. Students' participation will be observed using a rubric (McMillan, 2007). In the observation stage, data on engagement from observations and assessments will be collected and analyzed (Ismail et al., 2024). In the reflection stage, the researcher and cooperating teacher will evaluate the implementation process and students' responses, identify strengths and weaknesses, then decide on modifications for the next cycle (Maharani & Hardini, 2017).

Cycles 2 through 3 will repeat this sequence with adjustments based on reflections, continuing the practical experiments and evaluation of applying Discovery Learning and Teaching at the Right Level in the classroom setting over time. It is hypothesized that students' science learning engagement will increase significantly each cycle as their familiarity with the inquiry-based model and personalized support grows under this collaborative action research project between the school and university. The findings will provide valuable insights into strategies for improving other learning processes and offer a model that can potentially be applied in similar educational contexts. Overall, the research aims to enhance the quality of science education and better serve students through evidence-based teaching practices tailored to their unique potential.

Based on the description provided above, the objectives of this classroom action research are: 1) to enhance student engagement in science learning activities in a Grade 8 classroom at SMP Negeri 32 Padang through implementing the Discovery Learning model combined with the Teaching at the Right Level approach. 2) To provide evidence-based solutions to the issue of low participation in science lessons by applying innovative, student-centered instructional models and methods. 3) To serve as a reference for science educators on utilizing inquiry-based and personalized teaching strategies to improve the quality of learning processes and outcomes.

This research is significant as it aims to address the pressing need to boost student involvement and achievement in science education. By integrating Discovery Learning's emphasis on active, self-directed exploration with Teaching at the Right Level's tailored scaffolding based on individual abilities, the study offers a comprehensive methodology for creating an engaging, inclusive learning environment. The findings can contribute practical, actionable strategies grounded in educational theory to invigorate science classrooms and unlock students' scientific curiosity and potential. Furthermore, this study aligns with the overarching goals of the Kurikulum Merdeka curriculum reform to cultivate autonomous, participatory learning suited to Indonesia's diverse student needs. As such, the insights generated hold importance for enhancing science pedagogy and STEM competencies essential for the nation's future development(Rahman & Nuryana, 2019).

Method

This study utilized a classroom action research design to address the issue of low student engagement in science learning at SMP Negeri 32 Padang through implementation of Discovery Learning and Teaching at the Right Level (TarL) approaches (Juniati & Widiana, 2017).

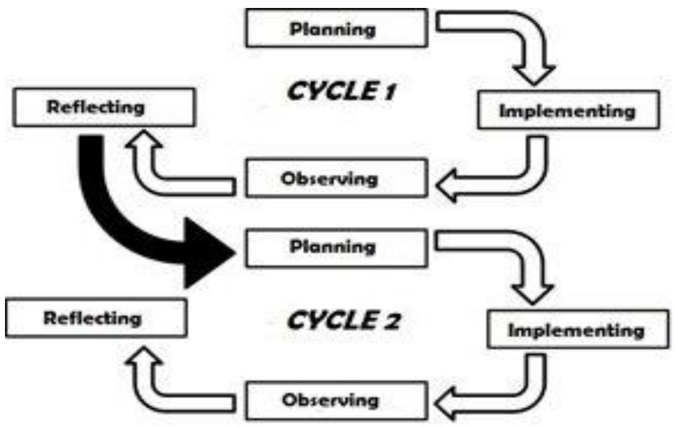

Figure 2. Classroom Action Research Cycle

Classroom action research was appropriate as it allowed examination of these methods through iterative cycles of planning, implementation, observation and reflection in an authentic classroom setting (Kimberlin & Yezierski, 2016). This aligns well with the current Kurikulum Merdeka curriculum promoting autonomy and flexibility in teaching approaches at the junior high school level (Siswa Jenjang SMP) in Indonesia (Kementerian Pendidikan dan Kebudayaan, 2020).

The study was conducted over 3 cycles with each cycle consisting of 3 meetings for a total of 9 lessons in grade 8 classroom B. In each cycle the researcher collaborated with the science teacher to plan lessons integrating Discovery Learning and TarL, implement the lessons, observe student engagement, analyze data and reflect on strengths/challenges to inform modifications for the next cycle (Prasetyo & Widjanarko, 2015). Student engagement was the primary variable measured through observation using a rubric with criteria of participation in group work, asking/answering questions, and completing tasks (Plomp & Nieveen, 2007). Parental consent was obtained for all participants.

Table 1. Student Learning Activity Engagement Categories

Percentage	Category
X ≤ 35%	Low
35% < X ≤ 75%	Medium
X > 75%	High

The research took place over 4 cycles to investigate the effect of different instructional approaches on student engagement in science lessons. During cycle 1, the topic taught was Elements, Compounds and Mixtures using a teaching module designed and validated by the Grade 8 science teacher at SMP N 32 Padang. At this stage, no additional treatment was provided to observe baseline levels of student activity. The lesson involved introducing the key concepts and definitions of elements, compounds and mixtures through a direct instruction approach. Students were shown examples and non-examples of each type and asked simple questions to check their understanding. There is no practical experiment conducted at this session. Student participation was mostly passive with limited interaction beyond answering direct questions posed by the teacher. Additionally, the situation was exemplified by instances where even students sitting at the front and close to the teacher fell asleep during the lesson, highlighting that without stimulating engagement, student interaction can become not just limited but nonexistent. As this was an familiarization stage, engagement metrics such as attendance, time on task and interest levels were noted but not actively encouraged through instructional design.

Figure 3. Cycle 1 of the lesson

Based on Figure 3, it can be seen that student activity was minimal in Cycle 1. Even students seated at the front row were seen dozing off during the lesson, as shown in the image. This indicates that science learning in this class had minimal enthusiasm and student engagement, which needed to be evaluated and addressed according to the steps of classroom action research in order to implement improvements in Cycle 2.

In cycle 2, the topic covered was Additive and Addictive Substances (basic chemistry context). To stimulate greater involvement from students, an intervention was introduced where part of the lesson was conducted outside the classroom in a reading corner provided by the school. Research has shown that changing the learning environment can increase novelty and attention (Ryan & Deci, 2000). The module content was adapted to incorporate group problem-solving tasks involving identifying whether common household products contained beneficial additives or harmful addictives. Students worked collaboratively in small teams to analyze information sheets and product labels before presenting their findings. This promoted peer discussion and cooperation beyond a whole-class format.

Figure 4. Student Activity Increased at Cycle 2

In Cycle 2, the researchers implemented their first intervention by changing the learning environment from the traditional classroom to an outdoor reading corner on the school premises. The topic covered was "Additive and Addictive Substances" related to basic chemistry concepts.

Figure 4 shows students actively engaged in group work and discussions in this new setting. By situating the lesson outside the formal classroom, an element of novelty and change of scenery was introduced, which can help capture students' attention and interest. The lesson plan was redesigned to incorporate collaborative problem-solving tasks where students worked in small teams to analyze household products and identify whether they contained beneficial additives or harmful addictive substances. This hands-on, inquiry-based approach promoted peer interactions, critical thinking, and application of concepts to real-world examples.

The image depicts students huddled together animatedly discussing the task, referring to information sheets and product labels provided by the teacher. Their body language and expressions convey active engagement, a stark contrast to the passive behaviors witnessed in Cycle 1's lecture-based lesson. This visual evidence, coupled with observational data and an end-of-lesson survey, indicated heightened levels of participation, enjoyment, and self-reported understanding compared to Cycle 1. Students responded positively to learning outside the classroom and having authentic, tangible examples to analyze. The teacher also noted students were more inquisitive and dynamic in this setting, asking more follow-up questions and actively participating compared to simply receiving direct instruction.

Observational data indicated heightened engagement levels as students were visibly more animated discussing topics in a less formal setting compared to a traditional classroom. An end of lesson survey found that 93% enjoyed learning outside and 92% felt it helped them understand better by having real examples to refer to. The teacher feedback was also positive, noting that the changed context stimulated more questions from students and dynamic participation compared to the direct instruction of cycle 1. This aligned with other studies emphasizing how situating learning in meaningful, authentic environments outside the school positively influences motivation and achievement (Ernst & Monroe, 2004).

Figure 5. Student Activity in their group

In Figure 5, we see a group of students collaborating actively on a hands-on science activity during one of the lessons in a later cycle of the action research study. The image depicts four students huddled around a workspace, engrossed in their task. Two students are carefully observing and manipulating materials or equipment on the table, likely conducting an experiment or practical investigation. Their focused expressions and body language suggest deep intellectual engagement as they concentrate on the process.

Meanwhile, the other two students are referring to worksheets or handouts, perhaps analyzing data or following procedural instructions. One student is using a pen to make notes, indicating they are recording observations or working through calculations. The group dynamics appear highly cooperative and interactive. The students are positioned in close proximity, leaning in towards each other and the materials, facilitating easy communication and shared attention on the activity at hand. Their body language conveys an open discussion taking place, with gestures and pointing that could represent them posing questions, explaining concepts to one another, or negotiating the next steps collaboratively.

In cycle 3 the topic discussed is Light (basic physics context). This lesson includes hands-on experiments with light sources, mirrors, and prisms to observe reflection and refraction. Ice Breaking in learning was presented in this session. Additional incentives are provided by providing small prizes such as school supplies to individuals and groups with the highest achievements. The use of gamification and rewards to reinforce efforts and recognize success has been shown to increase students' drive toward mastery of skills and concepts (Kapp, 2012). Competition is framed constructively as an effort to encourage the best, rather than outperform one's peers. Periodic comprehension checks were turned into mini quizzes with prizes to keep the momentum going.

Figure 6. Student Did Ice Breaking by Instructor

In Figure 6, we see the instructor leading an ice-breaking activity with the students at the start of one of the lesson sessions. This type of warm-up exercise is often used to energize the class, build rapport, and create an inclusive, participatory environment conducive to active learning.

The instructor, standing at the front of the room, has an animated stance and appears to be providing instructions or explanations to the students seated in a semicircle facing him. His body language is open and engaging, with gestures suggesting he is encouraging responses and participation from the students.

The students themselves are seated in a casual arrangement on the floor, which breaks away from the traditional row-based seating. This setup likely aims to foster a more relaxed, collaborative atmosphere where students feel comfortable contributing without barriers. Some students are visibly raising their hands, indicating they are volunteering to respond or share their thoughts with the class. Others are leaning forward or turning towards their peers, suggesting they are actively listening and potentially building on each other's ideas.

This ice-breaker seems designed to not only warm up the students for the upcoming lesson content but also to build a sense of community and comfort with expressing themselves. By encouraging active participation and interaction right from the start, the instructor is setting the tone for an engaging, student-centered learning experience(Wiyarsi et al., 2018). Overall, Figure 6 represents a deliberate effort by the teacher to implement strategies that increase student involvement, create an inclusive classroom culture, and prime students to be active participants in the forthcoming Discovery Learning activities.

Activeness increases significantly because the support from ice breaking keeps students' enthusiasm and motivation maintained, especially when students are deeply involved in challenging themselves to get the "most correct" answer. Feedback from individual interviews found that 62.28% said it helped them focus and try harder than usual. Ice Breaking presented This suggested award, especially for young students, can be a motivator if used wisely within a meaningful learning framework and aligned with learning outcomes. Overall, observable work time increased substantially with less off-task behavior recorded compared to previous cycles.

Result and Discussion

In cycle 1, where no specific intervention was implemented, students displayed largely passive participation with minimal voluntary interaction beyond directly responding to teacher questions.

Table 2. Indicators and Criteria for Assessing Students' Active Participation in Class

Indicator	Context
1	Paying Attention to Teacher's
2	Asking Questions
3	Responding to Questions
4	Group Discussion
5	Expressing Ideas
6	Observing Videos/Pictures
7	Group Presentation

Observational data showed students had low levels of observable work time, with some even falling asleep during the traditional direct instruction lesson on elements, compounds and mixtures. Attendance, time on task and interest metrics were present but engagement was not actively encouraged through the instructional approach. This provided a baseline illustrating the issues with student involvement under conventional teaching methods. At this cycle 36.72% Student is Active

Table 3. Percentage Distribution of Indicators for Cycle 1

Indicator	Percentage (%)
1	19.78
2	20.88
3	13.19
4	12.64
5	7.69
6	15.38
7	10.44
	Student Engagement = 36.72% (Low)

To address these challenges, cycle 2 introduced a change of setting by conducting part of the lesson outside the classroom in a reading corner. Students worked in small differentiate teams analyzing information sheets on common household products to identify beneficial additives or harmful addictives. This promoted discussion and peer learning. Surveys found 45.76% felt the real-world examples helped their understanding and enjoyed the outdoor context.

Observational data indicated increased animated participation and questioning, aligning with studies showing authentic environments enhance motivation and achievement (Ernst & Monroe, 2004).

Table 4. Percentage Distribution of Indicators for Cycle 2

Indicator	Percentage (%)
1	50.00
2	43.75
3	46.88
4	40.63
5	46.88
6	56.25
7	43.75
	Student Engagement 45.76%

Building on this, cycle 3 incorporated hands-on experiments and game elements. Students investigated light reflection and refraction using mirrors and prisms. Comprehension checks were gamified through mini-quizzes with small prizes for correct answers. Interviews indicated 62.28% felt the incentives and competition helped them focus and try harder. Observable work time rose substantially compared to earlier cycles, with less off-task behavior. This suggested judicious use of rewards can motivate greater mastery efforts, supporting literature on gamification and constructive competition (Anaelka, 2018).

Table 5. Percentage Distribution of Indicators for Cycle 3

Indicator	Percentage (%)
1	62.28
2	88.16
3	93.75
4	94.79
5	82.64
6	88.19
7	87.71
	Student Engagement 62.28%

The progressive interventions led to marked improvements in participation and engagement. In cycle 1 under direct instruction, students were largely disengaged with minimal interaction. By cycle 2, changing the setting stimulated more lively discussion and questions. In cycle 3, adding opportunities for hands-on discovery and incentive-based checks sustained the momentum. Each cycle built on the last to increasingly activate students through enhancements to the learning experience tailored to their needs and interests.

The qualitative and quantitative data converged to demonstrate the benefit of learner-centered, personalized interventions in boosting involvement. The Discovery Learning model encouraged inquiry-driven participation rather than passive reception of content. Complementing this, the Teaching at the Right Level approach allowed scaffolding and feedback aligned to each student's zone of proximal development (Griffin et al., 2012; Senggaweeng & Dungus, 2022). This twin focus on exploratory activities and individualized support was impactful.

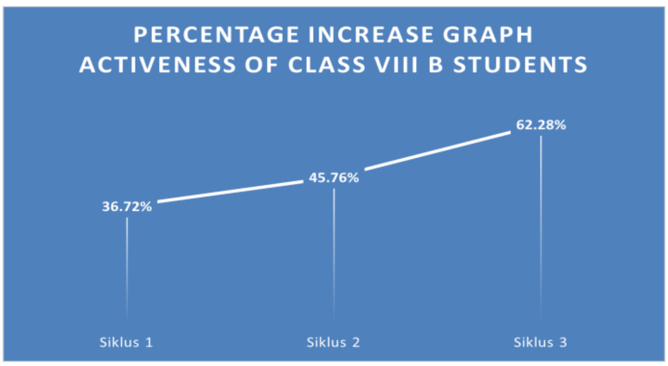

Figure 7. Increase in student engagement rates for Class VIII B from Cycle 1 to Cycle 3.

Student surveys and interviews consistently indicated the changes made learning more enjoyable and understandable. The cooperative teacher also noted the methods were easy to implement within the flexible Kurikulum Merdeka framework. This aligns with literature emphasizing Discovery Learning and Teaching at the Right Level's advantages for engagement and outcomes (Banerjee et al., 2016; Prince & Felder, 2006).

Through iterative cycles, the study provided insights into effective instructional designs. Novel settings and gamified elements stimulated extrinsic motivation. Meanwhile, investigative tasks leveraged intrinsic motivation from inquisitiveness. Combined, these helped create an engaging experience meeting adolescents' needs for autonomy, competence and relatedness (Ryan & Deci, 2000).

This research highlights the value of responsive, student-centered approaches in activating learning. Adjusting the where, how and why of instruction based on formative feedback allows education to become an interactive, dynamic process. Rather than "one-size-fits-all" transmission of content, the focus shifts to igniting the unique potential in each learner. This research provides a model for science educators to make classrooms springboards for growth.

In conclusion, this classroom action research demonstrated that implementing Discovery Learning and Teaching at the Right Level led to significant improvements in student engagement and participation in science lessons. The inquiry-based, personalized interventions addressed key factors influencing involvement. Each cycle built on the last to increasingly stimulate students through needs-aligned enhancements to the learning experience.

The findings offer practical strategies for science teachers to improve class engagement by incorporating hands-on discovery, varied settings, game elements and individualized scaffolding. This contributes to the Kurikulum Merdeka goal of learner-driven education(Ismail et al., 2023; Mahdiannur et al., 2022; Wardhani et al., 2022; Wiyono, 2023). With flexibility and autonomy, educators can design optimal environments for students to unlock their curiosity and highest abilities. Further research can explore the long-term impacts of these methods on knowledge application and STEM competencies(Dotimineli & Mawardi, 2021; Ješková et al., 2022; Lase, 2019; Rahman & Nuryana, 2019). Overall, the participatory pedagogy highlighted has strong potential to equip and inspire students for future success.

Conclusion

In conclusion, this classroom action research demonstrated that implementing the Discovery Learning model combined with the Teaching at the

Right Level (TaRL) approach led to significant improvements in student engagement and participation in science lessons. The inquiry-based Discovery Learning activities encouraged autonomous exploration and motivated students intrinsically, while the TaRL method provided personalized scaffolding and feedback aligned to each student's current ability level. This complementary focus on hands-on investigative tasks and individualized support effectively addressed factors influencing active involvement. Progressively enhancing the learning experience through novel settings, gamification, and needs-based enhancements stimulated students' interests and enabled them to learn optimally according to their unique needs and curiosities. The findings offer pragmatic, evidence-based strategies incorporating Discovery Learning's emphasis on self-directed discovery with TaRL's tailored instruction for science educators to cultivate an engaging, inclusive classroom culture that unlocks every student's scientific potential. This participatory, student-centered pedagogy aligns with Kurikulum Merdeka's goals of autonomous, flexible learning suited to Indonesia's diverse contexts. The researchers hope this study positively impacts science education nationwide by equipping teachers with methods to inspire active participation and lifelong passion for STEM competencies vital for the nation's future development.

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Author Contributions

Irfan Ananda Ismail contributed to the conceptual framework, literature review, hypothesis development, and theoretical foundation. Fadhila Ulfa Jhora designed the methodology, supervised data collection, analyzed results, guided action cycles, and ensured ethical adherence. Qadriati implemented interventions, observed impact, and provided feedback. Munadia Insani from Universitas Negeri Padang was significant in providing the emotional and moral support necessary for the research. The students actively engaged, gave honest feedback, and embraced new strategies, enabling insights. Each role was interdependent, exemplifying a well-coordinated, collaborative educational inquiry.

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Conflicts of Interest

The authors declare no conflict of interest. Fadhila Ulfa Jhora from Physics Departement, Universitas Negeri Padang, Padang, Indonesia served as the supervising lecturer for the classroom action research project. Qadriati from SMP N 32 Padang, Padang Indonesia is a teacher at the school where the study was conducted. Munadia Insani from Universitas Negeri Padang, Padang Indonesia has no relationship with the study beyond their personal connections to the researchers. The students participating in the study were eighth graders in classroom B at SMPN 32 Padang during the study period. None of the authors have any financial or non-financial competing interests to declare. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

Abdi, A. (2014). The Effect of Inquiry-based Learning Method on Students' Academic Achievement in Science Course. *Universal Journal of Educational Research*, *2*(1), 37–41. https://doi.org/10.13189/ujer.2014.020104

Adamson, F., & Darling-Hammond, L. (2015). Policy Pathways for Twenty-First Century Skills. In *Assessment and Teaching of 21st Century Skills*. https://doi.org/10.1007/978-94-017-9395-7_15

Anaelka, A. H. (2018). Education 4.0 Made Simple: Ideas For Teaching. *International Journal of Education and Literacy Studies*, *6*(3), 92. https://journals.aiac.org.au/index.php/IJELS/article/view/4616

Author, K., Duflo, E., Dupas, P., & Kremer, M. (2011). American Economic Association Peer Effects, Teacher Incentives, and the Impact of Tracking: Evidence from a Randomized Evaluation. *Source: The American Economic Review*, *101*(5), 1739–1774.

Banerjee, A. V., Banerji, R., Duflo, E., Glennerster, R., & Khemani, S. (2010). Pitfalls of participatory programs: Evidence from a randomized evaluation in education in India. *American Economic Journal: Economic Policy*, *2*(1), 1–30. https://doi.org/10.1257/pol.2.1.1

Dotimineli, A., & Mawardi, M. (2021). Development of STEM Integrated PBL-Based Student Worksheets in Energetic Materials of First-Year Students. *Journal of Physics: Conference Series*, *1788*(1). https://doi.org/10.1088/1742-6596/1788/1/012045

Dyamayanti, L., Fatimah, S., Lestari, I. D., & Kurniawan, D. D. (2023). The Effect of Discovery Learning Model on Students' Learning Outcomes on the Protists Concept. *Jurnal Pendidikan Indonesia Gemilang*, *3*(1), 15–19. https://doi.org/10.53889/jpig.v3i1.152

Edelson, D. C., Gordin, D. N., & Pea, R. D. (1999). Addressing the Challenges of Inquiry-Based Learning Through Technology and Curriculum Design. *Journal of the Learning Sciences*, *8*(3–4), 391–450. https://doi.org/10.1080/10508406.1999.9672075

Ernst, J., & Monroe, M. (2004). The effects of environment-based education on students' critical thinking skills and disposition toward critical thinking. *Environmental Education Research*, *10*(4), 507–522. https://doi.org/10.1080/1350462042000291038

Felder, R. M., & Prince, M. J. (2011). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of Engineering Education*, *95*(2), 123–138.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School Engagement Potential of The Concept. *Review of Educational Research*, *74*(1), 59–109.

Griffin, P., McGaw, B., & Care, E. (2012). Assessment and teaching of 21st century skills. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching of 21st century skills* (Vol. 9789400723). Springer Netherlands. https://doi.org/10.1007/978-94-007-2324-5

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64–74. https://doi.org/10.1119/1.18809

Hastuti, P. W., Tiarani, V. A., & Nurita, T. (2018). The influence of inquiry-based science issues learning on practical skills of junior high school students in environmental pollution topic. *Jurnal Pendidikan IPA Indonesia*, *7*(2), 232–238. https://doi.org/10.15294/jpii.v7i2.14263

Hendri, S., & Setiawan, W. (2016). The Effect Of Inquiry Based Learning On The Reasoning Ability Of Grade Vii Students About Heat Concept. *Jurnal Pendidikan Fisika Indonesia*. *12*(1), 65–76. https://doi.org/10.15294/jpfi

Ismail, I. A., & Insani, M. (2023). A Collaborative Action Research Model: Using Lesson Study to Optimize Guided Inquiry Teaching of Blood Structure and Function at Junior High School 32 Padang. *International Journal of Academic Pedagogical Research (IJAPR)* *3*(7), 1–6. http://dx.doi.org/10.35542/osf.io/tkedh

Ismail, I. A., Jhora, F. U., & Insani, M. (2024). " *Analysis and Reflection of STAR-Based Learning Assessment at SMP Negeri 32 Padang : Building Communication and Collaboration Skills* ". *January*.

Ismail, I. A., Mawardi, M., Suryani, O., Insani, M., & Mulyanti, M. (2023). Innovative Pedagogical Approaches to the Periodic Table for Freshman Chemistry Student at the State University of Padang. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 12249–12257. https://doi.org/10.29303/jppipa.v9i12.5623

Jerome Bruner. (2012). *30 mei 2012 WE05 1/4*. 2–5. https://books.google.fr/books?hl=fr&lr=&id=S6FKW90QY40C&oi=fnd&pg=PR29&dq=jerome+bruner&ots=lbjVjc61t1&sig=zjhrWnAgu4qNBwxEaAasqb9asTQ

Ješková, Z., Lukáč, S., Šnajder, Ľ., Guniš, J., Klein, D., & Kireš, M. (2022). Active Learning in STEM Education with Regard to the Development of Inquiry Skills. *Education Sciences*, *12*(10). https://doi.org/10.3390/educsci12100686

Juniati, N. W., & Widiana, I. W. (2017). Penerapan Model Pembelajaran Inkuiri Untuk Meningkatkan Hasil Belajar Ipa. *Journal of Education Action Research*, *1*(2), 122. https://doi.org/10.23887/jear.v1i2.12045

Kelas, S., Smp, V. I., & Kuta, N. (2023). Widyadari Penerapan Teaching At The Right Level (TARL) Berbantuan E-Lkpd Untuk Meningkatkan Motivasi Belajar Matematika. *Widyadari (Jurnal Pendidikan)*. *24*(2), 220–229. https://doi.org/10.59672/widyadari.v24i2.3186

Kimberlin, S., & Yezierski, E. (2016). Effectiveness of Inquiry-Based Lessons Using Particulate Level Models to Develop High School Students' Understanding of Conceptual Stoichiometry. *Journal of Chemical Education*, *93*(6), 1002–1009. https://doi.org/10.1021/acs.jchemed.5b01010

Lase, D. (2019). Education and Industrial Revolution 4.0. *Handayani Journal PGSD FIP Unimed*, *10*(1), 48–62. https://doi.org/10.24114/jh.v10i1.14138

Maharani, B. Y., & Hardini, A. T. A. (2017). Penerapan Model Pembelajaran Discovery Learning. *E-Jurnalmitrapendidikan*, *1*(2), 549–561.

Mahdiannur, M. A., Erman, E., Martini, M., Nurita, T., & Rosdiana, L. (2022). Eksplorasi Pengetahuan Guru Ipa Smp Tentang Pembelajaran Berdiferensiasi Dalam Kurikulum Merdeka : Pengukuran Berdasarkan Complex Multiple-Choice Survey. *Jurnal Tarbiyah*, *29*(2), 295. https://doi.org/10.30829/tar.v29i2.1812

Nurhalimah, S. R., Suhartono, S., & Cahyana, U. (2017). Pengembangan Media Pembelajaran Mobile Learning Berbasis Android pada Materi Sifat Koligatif Larutan. *JRPK: Jurnal Riset Pendidikan Kimia*, *7*(2), 160–167. https://doi.org/10.21009/jrpk.072.10

Plomp, T., & Nieveen, N. (2007). *An Introduction to Educational Design Research*.

Popovic, C. (2013). Teaching for quality learning at university. (2nd Edn.). In *Innovations in Education and Teaching International* (Vol. 50, Issue 4). https://doi.org/10.1080/14703297.2013.839332

Prasetyo, D., & Widjanarko, D. (2015). Enerapan Model Pembelajaran Inkuiri Untuk Meningkatkan Hasil Belajar Siswa Pada Kompetensi Memelihara Komponen Sistem Bahan Bakar Bensin. *Jurnal Pendidikan Teknik Mesin Unnes*, *15*(2), 123484.

Prince, M., & Felder, R. (2007). The Many Faces of Inductive Teaching and Learning. *Journal of College Science Teaching*, *36*(5), 14–20.

Putrawangsa, S., & Hasanah, U. (2018). Integrasi Teknologi Digital Dalam Pembelajaran Di Era Industri 4.0. *Jurnal Tatsqif*, *16*(1), 42–54. https://doi.org/10.20414/jtq.v16i1.203

Rahman, A., & Nuryana, Z. (2019). *Pendidikan Islam di Era Revolusi Industri 4.0*. 34–0. https://doi.org/10.31219/osf.io/8xwp6

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology*, *25*(1), 54–67. https://doi.org/10.1006/ceps.1999.1020

Sadler, Royce, D. (1989). Formative assessment and the design of instructional systems. *Instructional Science*, *18*, 119–144.

Senggaweeng, Y., & Dungus, F. (2022). Pengaruh Model Pembelajaran Kooperatif Tipe Student Teams Achievement Division Pada Materi Objek IPA Terhadap Hasil Belajar Siswa SMP Negeri 1 Remboken. *SCIENING : Science Learning Journal*, *3*(2), 119–124. https://doi.org/10.53682/slj.v3i2.2669

Tomlinson, C. A. (2017). The Rationale for Differentiating Instruction in Academically Diverse Classrooms. *Differentiate Instruction : In Academically Diverse Classooms*, 12–18.

Wardhani, G. A. P. K., Susanty, D., Oksari, A. A., Nurhayati, L., Nuranzani, A., & Faridha, F. (2022). Implementasi Kurikulum Merdeka Belajar Kampus Merdeka (MBKM) Di Program Studi Kimia Universitas Nusa Bangsa. *Jurnal Pendidikan Dan Pembelajaran Sains Indonesia (JPPSI)*, *5*(1), 53–59. https://doi.org/10.23887/jppsi.v5i1.42802

Wiyarsi, A., Sutrisno, H., & Rohaeti, E. (2018). The effect of multiple representation approach on students' creative thinking skills: A case of "Rate of Reaction" topic. *Journal of Physics: Conference Series*, *1097*(1). https://doi.org/10.1088/1742-6596/1097/1/012054

Wiyono, H. (2023). *Sistem Pembelajaran pada Kurikulum Merdeka Di SMP Negeri 21 Pontianak*. *6*(1), 85–94.

Yerimadesi, Kiram, Y., Lufri, & Festiyed. (2018). Development of guided discovery learning based module on colloidal system topic for senior high school. *Journal of Physics: Conference Series*, *1116*(4). https://doi.org/10.1088/1742-6596/1116/4/042044