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DESIGNING DEEP LEARNING TEACHING MODULES WITH AI: LEARNING FORMATION TOWARDS QUALITY EDUCATION FOR ALL

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ABSTRACT The 21st century education demands a transformation of learning that is not only informative, but also meaningful and contextual. In Parepare City, South Sulawesi, most junior high school math and science teachers and high school biology teachers still face challenges in designing deep learning and utilizing artificial intelligence technology effectively. This community service activity aims to empower these teachers through assistance in designing deep learning-based teaching modules with the support of artificial intelligence technology. The program uses a participatory approach through training, workshops, implementation assistance, and reflective evaluation. The activity was carried out for three months in three partner schools, with a total of 60 teachers as direct beneficiaries. The results showed a significant increase in the understanding of deep learning concepts from 30% to 95%, the use of artificial intelligence in learning from 15% to 80%, as well as the skills of preparing project-based teaching modules and AI from 10% to 90%. Teachers also show a paradigm shift in learning from teacher-centered to student-centered and problem-based. This activity succeeded in forming a collaborative, creative, and adaptive community of teachers. The conclusion of this activity is that hands-on experiential training with a reflective approach can significantly increase teachers' pedagogic and technological capacity. The recommendations of this program include the need for follow-up mentoring, improving the school's digital infrastructure, and replicating the program to other schools with a similar approach..

KEYWORDS: *Deep Learning; Artificial Intelligence; Teaching Modules; Mathematics, Science and Biology Teacher; Community Empowerment.*

1. INTRODUCTION

Quality education is the main pillar in creating a superior and competitive generation in the 21st century era. This is in line with research findings that emphasize the importance of integrating 21st century skills in the educational curriculum to prepare students for global competition and rapid technological advancements (Díez et al., 2020; Herlinawati et al., 2024; Höfrová et al., 2024). However, the challenge of delivering meaningful, contextual, and high-level thinking skills-oriented learning (HOTS) is still a major problem in many regions, including in Parepare City, South Sulawesi, Indonesia. One of the communities directly affected by this challenge is Mathematics and Science teachers at the junior high school (JHS) level, and Senior High School (SHS) Biology teachers who have a strategic role in forming the foundation of scientific and logical thinking for students.

The target population of this activity is Mathematics and Science teachers and high school Biology teachers in Parepare City, which administratively consists of 4 sub-districts and has 36 junior high schools (24 public and 12 private as well as 5 public high schools and 2 private high schools). Most of the schools are in semi-coastal urban areas with heterogeneous social characteristics. Although Parepare City has a fairly good educational infrastructure in the city center, many schools in the suburbs still experience limited access to the latest educational technology, including digital literacy and the use of artificial intelligence (AI) in learning.

Based on data from the Parepare City Education Office (2024), there are ±120 junior high school mathematics and science teachers, but only about 32% have participated in training based on the Merdeka curriculum, and less than 15% have experience in compiling teaching modules based on a deep learning approach. This shows that there is a competency gap between the demands of national education policies and the actual capacity of teachers to design transformative learning.

The results of preliminary observations and surveys show that the majority of teachers still use conventional methods, teacher-centered, and lack in-depth exploration, reflection, and problem-solving. As a result, students' critical and creative thinking skills tend to stagnate. Based on the 2023 ANBK results report: 74% of students do not achieve the minimum mastery indicators in numeracy literacy. Only 21% of the HOTS questions were answered correctly by students. This indicates the lack of learning strategies that are able to activate the process of high-level thinking, especially in the fields of science and mathematics.

Various training programs have been organized by the local education office and the Education Quality Assurance Agency (LPMP), but most of them are still generic and have not touched on the design aspects of AI-based contextual teaching modules and deep learning. Some

online trainings are also ineffective in reaching teachers in areas with limited internet access or lack of digital literacy. On the other hand, teachers feel burdened by administrative tasks so they don't have enough time to develop modules independently.

This service activity aims to empower junior high school Mathematics and Science teachers and high school biology teachers in Parepare City in designing deep learning-based teaching modules supported by artificial intelligence (AI) technology. Thus, it is hoped that the learning process will be more contextual, active, and able to improve the quality of student learning outcomes. with the objectives includeing: (1) Improving teachers' understanding of the concept of deep learning and its implementation in the National curriculum. (2) Improving teachers' skills in utilizing AI to design innovative and adaptive teaching modules. (3) Produce AI-based contextual teaching module products for junior high school Mathematics and Science subjects, as well as high school Biology lessons. (4) Building a community network of teacher practitioners who can share good practices and digital learning resources.

This service program is designed with a Community-Based Participatory Research (CBPR) approach (Evie et al., 2023), which emphasizes active collaboration between academics and the community in every stage of activities. In this context, junior high school mathematics and science teachers and Biology teachers in Parepare City are not only beneficiaries, but also equal partners in the process of problem identification, solution design, and evaluation of results.

Community participation will be realized through: (1) Open Discussion Forum: Involving teachers, principals, school committees, and parent representatives to identify needs and challenges in Mathematics and Science learning as well as Biology learning. (2) Collaborative Workshops: Teachers will work closely with the service team to design deep learning-based teaching modules that are relevant to the local context. (3) Continuous Mentoring: Through online platforms and direct visits, the service team will assist teachers in the implementation of teaching modules and the use of AI technology in learning (Ernanto & Hermawan, 2022). (4) Participatory Evaluation: Teachers and other stakeholders will be involved in the evaluation process to assess the effectiveness of the program and provide input for improvement.

This approach is in line with the findings (Evie et al., 2023), which emphasizes the importance of the integration of CBPR in educational studies to increase stakeholder engagement and produce sustainable educational change.

Previous relevant research results include, a study by (Wahyuniar et al., 2023) shows that community involvement in educational programs can increase cultural inclusivity and strengthen community partnerships, which ultimately has a positive impact on student learning outcomes. (Ernanto & Hermawan, 2022) found that community-driven education improvement programs in

rural Indonesia have been successful in increasing students' interest in learning through interventions such as classroom learning assistance and home tutoring.In addition, the scientific journal Potensia (Khusna & Priyanti, 2023) emphasizing the importance of participation in increasing teachers' pedagogic capacity and strengthening the collaborative network of schools-universities. Next (Mashudi, 2021) The Global Study emphasizes that 21st century skills such as critical thinking and problem-solving need to be facilitated through deep, reflective, and technology-based learning approaches.

The conceptual framework of the program is based on the principle that collaboration between educational institutions and communities can create a learning environment that is more responsive and relevant to local needs. By involving teachers as active partners in the learning module development process, the program aims to empower them in creating deep and meaningful learning for students.

2. METHOD

2.1 Time and Duration of Activities

This community service activity is planned to last for 3 months (February--April 2025) with stages, namely: (1) February 2025, Needs survey, partner coordination, and preparation of training materials. (2) March 2025, Training and workshop on the preparation of teaching modules based on deep learning and AI. (3) April 2025, Assistance in the implementation of teaching modules in the classroom and monitoring and evaluation, reflection on implementation results, documentation and publication.

2.2 Location and Venue

The entire series of activities will be carried out at the Training Location: the Parepare City Education Office Hall and the classrooms of partner schools. Implementation Location: Partner schools (2 State Junior High Schools and 1 State High School in Parepare City).

2.3 Number of Beneficiaries

The direct beneficiaries in this activity are 30 junior high school mathematics teachers, 25 junior high school science teachers and 5 high school biology teachers, as the main partners, approximately 900 students as indirect beneficiaries through transformed learning.

2.4 Techniques and Procedures

The methods and approaches used are Participatory Action Research (PAR), with stages as in Table 1:

Table 1. Stages of Activities PKM

Stages	Technic/Procedure
Needs Survey	Questionnaire and Focus Group Discussion (FGD) to map the initial competencies of teachers
Training and Workshops	Active learning through a problem-based andragogical approach (Problem-Based Learning/PBL)
Implementation Assistance	Class supervision, clinical coaching, critical reflection-based mentoring
Evaluation and Reflection	Learning observation, in-depth interviews, analysis of module implementation results

Data collection techniques include: (1) Non-participatory observation during the implementation of the module. (2) Semi-structured interviews with teachers. (3) Assessment of the developed teaching module documents. (4) Reflection questionnaire after implementation.

2.5 Method Justification

Method Participatory Action Research (PAR) chosen because it is effective in empowering the teacher community, involving them as the main actors of change, not just the object of training (Baum, F., MacDougall, C., & Smith, 2020; Vaughn & Jacquez, 2020). In addition, the andragogy-based workshop approach is in accordance with the principles of adult education, where participants learn from their actual experiences and problems (Knowles et al., 2020).

2.6 Method Adjustment/Modification

PAR method which usually focuses on community-based social change, in this program modified with, focusing on the professional empowerment of teachers in the development of AI-based learning competencies and deep learning. Integration of coaching and mentoring techniques to ensure reflective processes and changes in teaching practices. A combination of Problem-Based Learning (PBL) models in the workshop to stimulate the analysis of real educational problems in the classroom. This modification is carried out to overcome the challenges of implementing educational innovations which often fail due to weak internalization at the practitioner level.

3. RESULT AND DISCUSSION

3.1 Results

a. Teacher Conditions before Program Implementation

The results of the analysis of teacher conditions before implementing the mentoring program are shown in Table 2 below:

Table 2 Teacher Conditions before Program Implementation

Aspects	Percentage (%)	Information
Understanding deep learning	30% understand	Most people don't understand yet
Utilization of AI in learning	15% apply	Very minimal
Development of PBL and AI based modules	10% competent	There are almost no PBL and AI based modules
Readiness to innovate	40% ready	Low readiness, need assistance

Table 2 shows that before the mentoring program, the survey results showed that: (1) 70% of Mathematics, Science and Biology teachers were not familiar with the concept of deep learning. (2) 85% of teachers did not use AI technology in the learning process. (3) The teaching modules used were mostly conventional and less contextual to the needs of the 21st century. (4) The majority of teachers showed a high interest in improving the quality of learning, but felt less confident in designing technology-based innovations.

b. Participation and Interaction of Teachers in Activities

During the implementation of the program, teacher involvement was very active, marked by the fact that all participants (100%) completed the training and workshops. Group discussions were intensive, especially during the module design session. Teachers voluntarily contributed to microteaching practices using the modules that had been prepared. Student participation in the implementation is also high: most students responded positively to the use of the new module. The documentation of the accompanying activities is as follows:

Figure 1. Documentation of Training workshop Preparation AI- based Teaching Moduls

Figure 2. AI-based Deep Learning Implementation Assistance

c. Teacher Conditions After Program Implementation

The results of the analysis of teacher conditions after the implementation of the mentoring program are as shown in table 3 below:

Table 3 . Teacher Conditions After the Implementation of the Mentoring Program

Aspects	Percentage (%)	Improvement (%)
Understanding of Deep Learning	95%	+65%
Utilization of AI in Learning	80%	+65%
Development of PBL and AI Based Modules	90%	+80%
Readiness to Innovate	90%	+50%

Based on table 3 above, it shows that after mentoring: (1) 95% of teachers are able to identify the principles of deep learning in Mathematics and Science learning. (2) 80% of teachers successfully integrate simple AI technologies, such as AI-based learning platforms and automated question generation. (3) 90% of teachers have successfully compiled at least one AI-integrated

Problem-Based Learning (PBL)-based teaching module. (4) 90% of teachers have the readiness to innovate.

d. Analysis of Changes and Community Empowerment

Teacher empowerment in this activity has a concrete impact as shown in table 3, namely: (1) The increase in teacher innovation capacity is actually measured from the teaching module products produced. (2) A change in the learning paradigm, from just knowledge transfer to learning that encourages critical, creative, and collaborative thinking. (3) The independence of the school community to continue to develop and update the teaching modules on an ongoing basis. (4) There is the formation of a collaborative network between Mathematics and Science teachers to share good practices.

The following is a histogram that describes the teacher's competence before and after mentoring, as well as the magnitude of the increase in competence. It is as follows

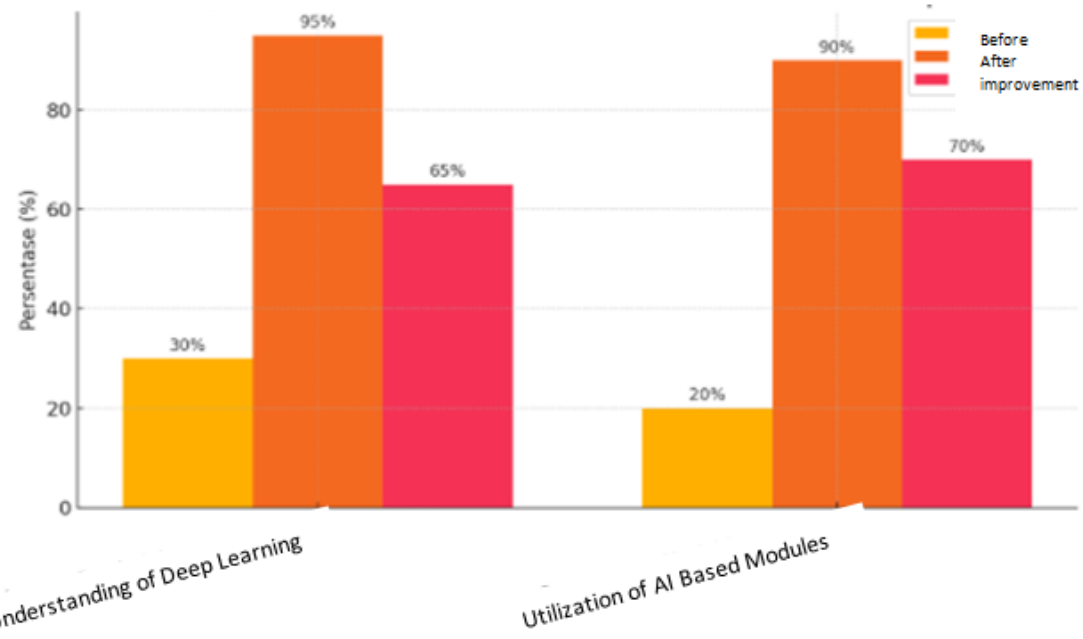

Figure 3. Histogram of Teacher Competence before and after Mentoring

3.2 Discussion

a. Improving Teacher Competence through Mentoring Based on Deep Learning and AI

The results of this mentoring program show that there has been a significant improvement in the understanding and skills of junior high school mathematics and science teachers and high school biology teachers in Parepare City related to deep learning and the use of AI. Prior to the intervention, most teachers still relied on conventional teacher-centered methods and rarely applied problem-based approaches or artificial intelligence-based technologies.

After the mentoring program is obtained: (1) 95% of teachers understand the concept of deep learning. (2) 80% of teachers are starting to integrate the use of simple AI in teaching and learning activities. (3) 90% of teachers have succeeded in developing teaching modules based on Problem-Based Learning (PBL) and AI. This increase indicates that active training-based mentoring, collaborative workshops, and microteaching are effective in improving teachers' pedagogical and technological literacy. This is in line with the findings of previous research by Alavi, et al, (2021) yang menunjukkan bahwa model pelatihan berbasis pengalaman langsung mampu meningkatkan adopsi teknologi dalam pendidikan secara lebih efektif dibandingkan metode ceramah pasif.

b. Changes in Learning Paradigms in Partner Schools

Qualitative analysis from teacher reflection and classroom observation revealed a shift in learning approaches such as: (1) From teacher-centered to problem-centered student-centered. (2) From the use of conventional media to the integration of simple AI-based digital platforms. This change supports the achievement of Sustainable Development Goals (SDG) goal No. 4 on Quality Education, especially in improving technology-based learning and innovation (UNESCO, 2022). In addition, teachers also showed an increase in awareness of the importance of building 21st century skills in students such as critical thinking, creativity, collaboration, and communication. These skills are a key component in the deep learning framework developed in various global studies (Ching, Y.-H., Hsu, Y.-C., & Baldwin, 2021; Fullan, 2018)

c. Supporting Factors For Program Success

Some of the key factors that contribute to the success of this mentoring program are: (1) Commitment and active participation of teachers during the entire series of activities. (2) Full support from the Education Office and the Principal of the partner school. (3) Adaptive program design, adapting to the needs and real conditions of teachers. (4) Hands-on approach in training, including hands-on practice in the creation and implementation of teaching modules. Strengthening teachers' skills in their own community contexts, with contextual and needs-based approaches, has proven to be more effective than general, abstract training (Ching at al, 2021).

d. Limitations And Challenges

Although the program is generally effective, there are also several challenges that need to be noted, namely: (1) There are still a small number of teachers who need longer time to adapt to AI

technology. (2) Digital infrastructure in several partner schools is still limited (unstable internet access, minimal ICT devices). Therefore, for the continuation of the program, it is necessary: (1) Continuous mentoring. (2) Strengthening technology infrastructure in partner schools.

4. CONCLUSION

Based on the results of the mentoring program for Mathematics and Science teachers in junior high schools and Biology teachers in senior high schools in Parepare City in designing teaching modules based on deep learning and the utilization of AI, it can be concluded that:

(1) The improvement in teacher competence in the mentoring activities successfully enhanced teachers' understanding and skills related to the concepts of deep learning and the integration of artificial intelligence (AI) in the learning process, the mentoring activities successfully improved teachers' understanding and skills related to the concept of deep learning and the integration of artificial intelligence (AI) in the learning process. The improvement in teachers' competencies is reflected in the data, where 95% of teachers understand deep learning and 90% are able to create AI-based teaching modules.

(2) The transformation of the learning approach has undergone a paradigm shift from teacher-centered to student-centered based on problem-solving, and the integration of simple AI-based digital platforms in the classroom has begun.

(3) Community involvement and participation, namely the active participation of teachers and support from the school and the education office, are the main factors in the success of the program.

(4) The experiential learning-based approach has proven effective in enhancing teachers' ability to design innovative learning.

Suggestion

Strengthening Advanced Programs Requires a follow-up mentoring program to ensure that the implementation of the teaching modules that have been prepared is truly implemented in the classroom and to support the sustainability of technology integration in learning.

1. Improving Digital Infrastructure for Schools The local government and schools are expected to strive to improve technological infrastructure, such as stable internet access and the provision of digital-based learning support devices.
2. The development of a Community of Practice is suggested to form a practice community between teachers (Professional Learning Community) that can share experiences, teaching

modules, and AI-based innovations so that the sustainability of deep learning can continue to develop.

3. Replication of the Program to Other Schools Given the success of this program, the expansion of the program to other schools in the Parepare area and surrounding areas can be a strategic step for the equitable distribution of quality education based on deep learning and AI.
5. Continuous Monitoring and Evaluation, it is necessary to always carry out periodic monitoring and evaluation to assess the effectiveness of the use of AI-based teaching modules in the classroom and to identify the need for further competency development.

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Our special award is aimed at all Mathematics, Junior High School Science, and High School Biology teachers in Parepare City who with high enthusiasm and dedication have participated in the entire series of activities ranging from training to the preparation of teaching modules based on deep learning and artificial intelligence. The collaborative spirit of teachers is an inspiration in realizing transformative education.

Finally, we would like to express our sincere gratitude to all students at partner schools who have been involved in microteaching activities and learning implementation. The active participation of students is an important part of the success of the program and reinforces our primary goal of delivering more meaningful and contextual learning.

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