



## Digital Learning Factory for Developing Soft Skills and Scientific Creativity of Prospective Science Teachers toward SDG 4

Dwi Pangga<sup>1,2\*</sup>, Made Hery Santosa<sup>2</sup>, I Wayan Widiana<sup>2</sup>, Ketut Suma<sup>2</sup>, Wayan Suastra<sup>2</sup>, Putu Artawan<sup>2</sup>

<sup>1</sup>Universitas Pendidikan Mandalika, Mataram, Indonesia

<sup>2</sup>Universitas Pendidikan Ganesha, Singaraja, Indonesia



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### ABSTRACT

**Objective:** This study aims to analyze the urgency of implementing the Learning Factory (LF) model in developing soft skills and scientific creativity in prospective science teachers at the Faculty of Science, Engineering, and Applied Sciences (FSTT) of Mandalika University of Education. This study also aims to identify the gap between the competencies acquired during education and the needs of the world of work in the era of the Industrial Revolution 4.0. **Method:** This study uses a survey approach through a tracer study involving alumni of the Physics Education, Chemistry Education, Biology Education, and Mathematics Education study programs at FSTT Undikma. Data were collected through questionnaires to determine the relevance of graduates' competencies to the needs of the world of work, then analyzed descriptively. **Results:** The results showed that most alumni were able to find employment relatively quickly after graduation. However, some alumni felt that the jobs they obtained were not fully in line with their field of study. This indicates a gap between higher education competencies and the needs of the world of work. The Learning Factory model, which is based on project-based learning and industrial experience, has the potential to improve technical skills while strengthening students' collaboration, communication, and innovation abilities. **Novelty:** This study highlights the importance of integrating the Learning Factory model with the Outcome-Based Education (OBE) approach to improve graduate employability through the development of more holistic competencies that are relevant to the needs of the world of work.

## INTRODUCTION

Higher education in the era of the Fourth Industrial Revolution faces significant challenges in preparing graduates who not only master technical skills but also possess the social skills and creativity needed to thrive and evolve in an increasingly complex job market. The modern workforce now demands graduates who have more than just academic knowledge; they must be able to quickly adapt, collaborate in multidisciplinary teams, and possess communication, innovation, and critical thinking skills that are highly valued by industries (El-Tabal, 2020; Raphael et al., 2021; Jalinus et al., 2023). Research shows that soft skills, such as communication and teamwork, are increasingly sought after by companies across various sectors, and graduates who can adapt quickly and innovate have a significant competitive advantage (Efendi et al., 2020; Raphael et al., 2021; Yılmaz & Torun, 2024).

However, there is still a significant gap between the skills students acquire during formal education and the real-world requirements they face in the workforce. Many graduates feel that, despite receiving relevant education, they still need to continue their studies or undergo training to develop more specific or non-technical skills (Shah et al., 2023). This highlights the need for a more holistic approach to higher education, one that focuses not only on the development of technical skills but also on interpersonal skills and scientific creativity, which are becoming increasingly important.

One innovative approach that can bridge this gap is the Learning Factory (LF) model, which integrates hands-on learning experiences with the industrial world. LF provides a platform that allows students to engage in real-world projects, which not only strengthen technical skills but also hone social skills such as communication, teamwork, and problem-solving in contexts that are relevant to the job market (Ahmad et al., 2023; Riwayani et al., 2024). The LF model has proven effective in helping students develop their scientific creativity, which is crucial in education, especially in the fields of science and technology (Yamin et al., 2020; Nursiwan & Hanri, 2023).

However, despite providing valuable practical experience, the main challenge faced is ensuring that LF focuses not only on technical aspects but also on the development of non-technical skills and scientific creativity necessary to enter an increasingly competitive job market. Scientific creativity, which encompasses critical and innovative thinking skills, is crucial in education and technology fields, particularly for future teachers who will prepare the next generation to face greater challenges (Agustin et al., 2021; Liu et al., 2021).

Research shows that project-based approaches, such as those used in the LF model, can encourage students to think creatively and critically, which are essential skills in addressing challenges in the digital era (Yusnaeni et al., 2020; Vonny et al., 2023). Through these projects, students not only apply the knowledge they have gained in the classroom but also learn to face real-world situations that require them to innovate and adapt quickly to changes (Gandi et al., 2023; Fikri & Rhalma, 2024). Therefore, the development of scientific creativity and soft skills should be a central focus of higher education curricula, especially in preparing future teachers who will play a key role in shaping the future of education.

Although several studies have addressed the importance of soft skills and scientific creativity in higher education, there is still a gap in understanding how the Learning Factory-based learning model can effectively develop these two competencies, particularly for prospective science teachers. In this regard, this research is novel in linking the implementation of the LF model with the development of soft skills and scientific creativity, as well as exploring how this model can be more effective in preparing students to meet the demands of an increasingly competitive workforce. Based on a survey of alumni from the Faculty of Science, Technology, and Applied Sciences (FSTT) of Universitas Pendidikan Mandalika (Undikma), important findings indicate an urgent need to integrate the learning factory model into the curriculum to better prepare graduates for the challenges of the job market.

This survey revealed that alumni who graduated in 2023 and 2024 were able to secure full-time jobs relatively quickly, but most felt that the jobs they were doing were not directly related to their field of study. These findings highlight a gap between the skills acquired during their studies and the demands of the workforce, which require graduates to possess additional skills such as the ability to adapt to change, collaborate in teams, and innovate. Even though graduates have education relevant to the job they hold, many feel the need for further education or additional training to align themselves with the job requirements.

This situation underscores the importance of developing non-technical skills, such as effective communication, teamwork, and problem-solving, which are key factors in obtaining jobs related to their field of study. This data also reflects the need for educational institutions to adopt learning models that not only emphasize technical skill acquisition but also focus on developing the soft skills required in the workforce.

Thus, the integration of the Learning Factory with the Outcome-Based Education (OBE) approach becomes highly relevant in this context (Haryani et al., 2021). The OBE approach focuses on achieving competencies that are measurable and relevant to industry needs, including the development of soft skills and scientific creativity. The project-based learning offered by LF can help students be better prepared to face the workforce, whether in the industrial sector, government institutions, or as entrepreneurs. Therefore, the implementation of the Learning Factory in science teacher education is expected to produce graduates who not only possess adequate technical skills but also the non-technical skills required to adapt to the rapidly changing job market.

This research aims to fill the research gap by investigating how the Learning Factory model, integrated with OBE, can help develop soft skills and scientific creativity in prospective science teachers and provide recommendations for improving graduate readiness to enter the increasingly dynamic job market. The integration of the LF model based on OBE will ensure that students are not only technically ready but also possess the social and creative competencies needed to face future challenges in education and industry.

## RESEARCH METHOD

This study employs a mixed-method approach with the aim of analyzing the urgency of applying the Learning Factory model in developing soft skills and scientific creativity in prospective science teachers. The research sample consists of alumni from the Physics Education, Chemistry Education, Biology Education, and Mathematics Education programs of the Faculty of Science, Technology, and Applied Sciences (FSTT) at Universitas Pendidikan Mandalika (Undikma), who graduated between 2021 and 2024. The sample was selected using purposive sampling techniques to obtain a diverse representation of alumni experiences and statuses.

Data collection was conducted through a questionnaire distributed using Google Forms as part of a tracer study. The questionnaire includes questions about the alumni's employment status, the time taken to secure their first job, the type of companies or institutions where they are employed, and the extent to which their field of study is related to their current work. The questionnaire aims to gather quantitative data regarding alumni preparedness for the workforce and the relevance of their education.

Additionally, qualitative data were obtained through semi-structured interviews with several alumni to gain a deeper understanding of their experiences regarding how their campus education influenced the skills needed in the workforce. The data collected through the questionnaire were analyzed quantitatively to describe the distribution of employment status and the time taken to secure a job, while the interview data were analyzed thematically to explore alumni perceptions of the development of soft skills and scientific creativity through the Learning Factory model. Through this approach, the study aims to provide insights into the relevance of this learning model in preparing students for the increasingly complex job market..

## RESULTS AND DISCUSSION

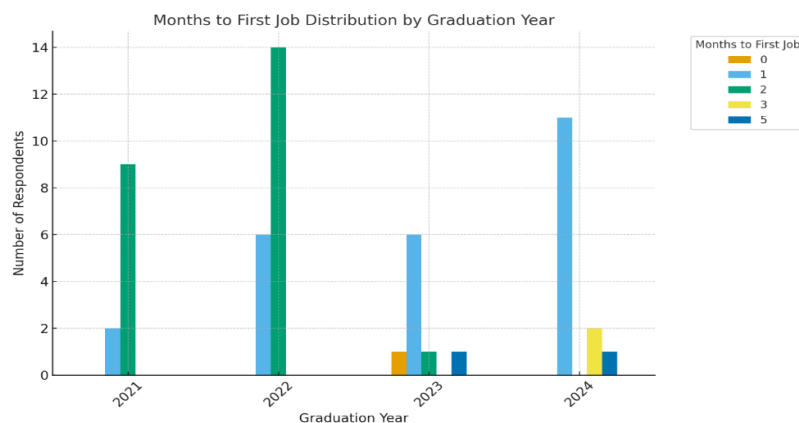
### *Results*

Based on the results of a tracer study survey conducted through a Google Forms questionnaire to alumni of the Physics Education, Chemistry Education, Biology Education, and Mathematics Education Study Programs at the Faculty of Science,

Engineering, and Applied Sciences (FSTT) of Mandalika University of Education (Undikma), a number of important findings were obtained regarding the conditions of graduates after completing their studies. The data obtained provides an overview of the time required for alumni to obtain their first job, the level of suitability between their field of study and the job they are doing, as well as the sector of the institution where alumni work. These findings provide empirical information about the work readiness of graduates and indicate the need to strengthen certain competencies in the higher education process.

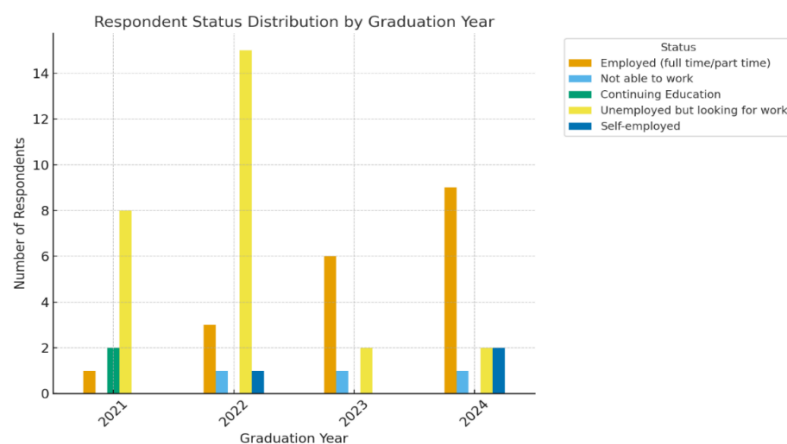
### *Time taken to secure employment*

The results of the data analysis show that most alumni who graduated in 2023 and 2024 were able to find employment in a relatively short time. The majority of respondents from both cohorts stated that they found their first job within less than a month after graduation. This condition shows that graduates from the science study program at FSTT Undikma have sufficient basic competencies to enter the job market and are able to compete with graduates from other institutions.



**Figure 1.** Questionnaire of time needed to get first job

However, when viewed from the distribution of data based on cohort, there is a clear difference between alumni who graduated in 2023–2024 and alumni who graduated in 2021–2022. Among the alumni who graduated earlier, the percentage of respondents who are still looking for work or choosing other career paths, such as entrepreneurship, is relatively higher than among the newer cohort.

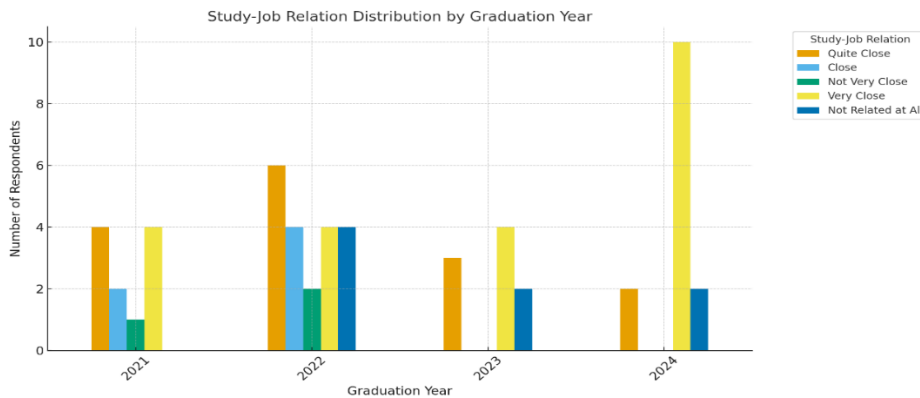


**Figure 2.** Alumni employment status questionnaire after graduation

This difference shows that the transition from education to work is not always linear for every graduate. Some alumni need more time to find a job that matches their interests and competencies. This situation can also be influenced by various factors, such as labor market conditions, previous work experience, and individual ability to adapt to the ever-changing needs of the world of work. In addition, the data also shows that although most alumni are able to find work quickly, the type of work they obtain is not always directly related to the field of study they pursued during their studies. This shows that success in finding employment is not only determined by academic competence, but is also influenced by the individual's ability to take advantage of available job opportunities.

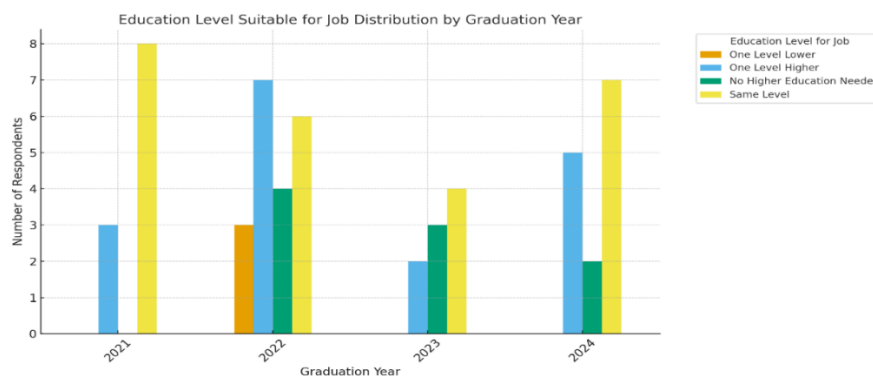
**Relationship between studies and employment**

Another finding from this study relates to the level of suitability between the field of study pursued during education and the jobs held by alumni after graduation. The survey results show that most alumni feel that their jobs are not entirely directly related to the field of study they pursued during college. Only a small percentage of alumni stated that their jobs were very suitable for their academic background.



**Figure 3.** Questionnaire on the suitability of the relationship between the field of study and alumni's work

In addition, alumni responses to questions about the level of education most relevant to their jobs also showed interesting results. Some alumni stated that their jobs did not always require specific competencies directly related to their study programs, but rather emphasized general skills such as communication, teamwork, and the ability to adapt to a dynamic work environment.

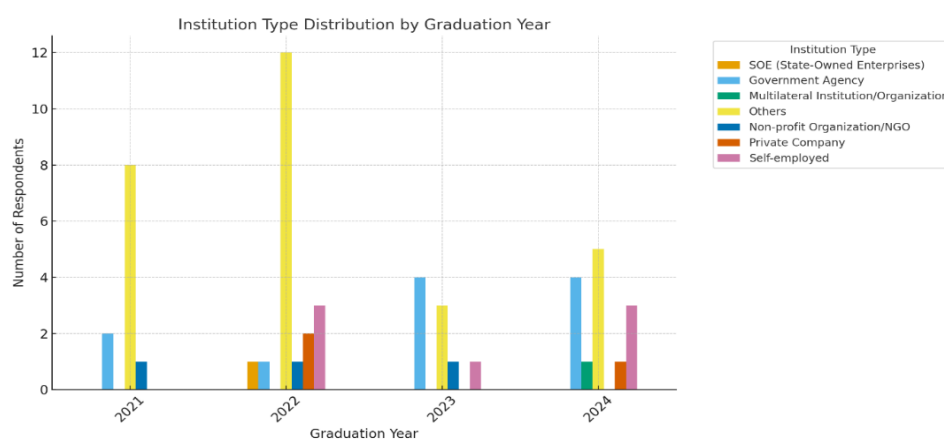


**Figure 4.** Questionnaire: What level of education is most appropriate/suitable for alumni jobs?

These findings indicate the phenomenon of skills mismatch, which is a condition where the competencies acquired during education are not fully aligned with the needs encountered in the world of work. This condition poses a challenge for higher education institutions in designing curricula that can produce graduates who not only have academic competencies but also competencies relevant to the increasingly complex and dynamic needs of the world of work.

### *Type of institution where alumni work*

In addition to examining the suitability between fields of study and employment, this study also analyzes the types of institutions where alumni work after completing their education. The survey results show that most alumni work in the private sector, both in national companies and other private institutions. Meanwhile, some alumni work in government agencies, and a small number choose to become entrepreneurs.



**Figure 5.** Questionnaire on the type of company/agency/institution where alumni work

The dominance of the private sector as a place of work for most alumni shows that science program graduates have quite broad employment opportunities outside the formal education sector. This also shows that graduates not only play a role as prospective educators, but can also contribute in various other sectors that require analytical skills, problem solving, and scientific thinking skills. However, the private sector generally has higher demands for practical skills, innovation, and the ability to adapt to rapid technological developments. Therefore, graduates are not only required to have a strong theoretical understanding, but also must have practical skills that can be directly applied in the workplace.

### *Discussion*

#### *Time taken to secure employment*

The results of the study show that most alumni are able to find employment relatively quickly after graduation. These findings indicate that graduates of science programs at FSTT Undikma have sufficient basic competencies to enter the job market. The speed at which they find employment can be an indicator that graduates have the basic knowledge and skills considered adequate by the world of work. However, the research findings also show that there are differences between different graduating classes. Alumni from older graduating classes tend to take longer to find employment than more recent graduates. These differences can be influenced by various factors, such as

changes in labor market conditions, the level of competition among job seekers, and the ability of individuals to take advantage of available opportunities. In addition, graduates' ability to develop non-technical skills such as communication, teamwork, and adaptability to new work environments can also affect the speed at which they find employment. This shows that graduates' success in entering the workforce does not only depend on the academic competencies acquired during their studies, but is also influenced by personal abilities related to soft skills.

In this context, strengthening learning that can develop these skills is very important. Learning models such as the Learning Factory can provide a more contextual learning experience because students are directly involved in project-based activities that mimic real-world working conditions. Through these experiences, students not only gain conceptual understanding but also develop communication, teamwork, and problem-solving skills that are highly sought after in the workplace (Zhao et al., 2023).

### ***Relationship between studies and employment***

Research findings show that most alumni feel that their jobs are not directly related to the fields they studied during college. This condition indicates a gap between the competencies acquired during education and the needs faced in the workplace. This phenomenon is often referred to as skills mismatch, which is a condition where the competencies possessed by graduates are not fully aligned with the demands of available jobs. This gap shows that higher education curricula need to focus not only on mastering theoretical concepts but also on developing broader competencies, including critical thinking, creativity, communication, and collaboration skills. In an increasingly dynamic world of work, the ability to adapt to new situations is one of the most important competencies.

Some alumni also stated that although the education they received was theoretically relevant to their jobs, their practical skills still needed to be strengthened. This shows that the learning process in higher education still needs to provide more space for students to develop practical skills that can be directly applied in the workplace. The Learning Factory model can be one solution to overcome this gap. This approach allows students to engage in project-based learning activities related to real problems faced in industry or education. Through these activities, students can develop creative thinking skills, problem-solving skills, and the ability to work in teams more effectively (Baena et al., 2017).

### ***Type of institution where alumni work***

The results of the study show that most alumni work in the private sector. This finding indicates that science program graduates not only have job opportunities in the formal education sector, but also have opportunities to pursue careers in various other sectors that require analytical and problem-solving skills. The private sector generally has a dynamic work environment and demands a high level of adaptability to technological developments and ever-changing industry needs. In the private sector, companies generally require workers who not only have theoretical knowledge but are also able to apply that knowledge practically in various work situations. In addition, the ability to innovate and work in multidisciplinary teams are also very important competencies. This shows that higher education graduates need to be equipped with a range of interdisciplinary skills in order to adapt to the increasingly complex demands of the world of work.

A learning approach that emphasizes real-world experience, such as that applied in the Learning Factory model, can help students develop these competencies. Through projects designed to simulate real working conditions, students can learn to understand problems more comprehensively and develop innovative solutions. This kind of learning experience is very important to improve students' readiness to face the world of work after graduation (Ahmad et al., 2023).

### *Integration of learning factory with outcome-based education (OBE)*

The findings of this study also show that the development of graduate competencies does not only depend on the learning methods used, but also on how the curriculum is designed to achieve clear and measurable learning outcomes. In this context, the Outcome-Based Education (OBE) approach is very relevant because it emphasizes the achievement of competencies that are in line with the needs of the world of work. The integration of the Learning Factory model with the OBE approach allows the learning process to be designed more systematically to achieve the expected learning outcomes. In this approach, learning activities do not only focus on delivering material, but are also designed to ensure that students are able to demonstrate certain competencies through various authentic learning activities.

Project-based learning implemented in the Learning Factory provides opportunities for students to apply the knowledge acquired in class in the context of real-world problems. Through these activities, students can develop scientific creativity, critical thinking skills, and the ability to work collaboratively in teams. In addition, students can also learn to manage projects, make decisions, and evaluate solutions developed systematically (Gräßler et al., 2016). Thus, the integration of the Learning Factory and the OBE approach can be an effective strategy for improving the quality of higher education. This approach not only helps students master academic concepts but also prepares them to face the increasingly complex and competitive challenges of the world of work (Widiatna et al., 2019).

## CONCLUSION

**Fundamental Finding:** This study shows that the Learning Factory (LF) model integrated with the Outcome-Based Education (OBE) approach is relevant in developing soft skills and scientific creativity in prospective science teachers. The tracer study results show that most alumni are able to find employment quickly, but there is still a gap between the competencies acquired during lectures and the needs of the world of work. This highlights the importance of strengthening non-technical competencies such as communication, collaboration, and innovation. **Implication:** The application of the Learning Factory model through project-based learning can improve graduates' work readiness by developing technical skills as well as soft skills. The integration of LF with OBE also allows the curriculum to be designed more in line with the needs of the world of work. **Limitation:** This study is limited to tracer study data of alumni from specific study programs at FSTT Undikma and uses a descriptive survey approach. **Future Research:** Further research is recommended to empirically test the application of the Learning Factory in learning and explore its integration with technology and industry collaboration.

## AUTHOR CONTRIBUTIONS

**Dwi Pangga** contributed to the conceptualization, methodology development, data collection, data analysis, and manuscript drafting. **Made Hery Santosa** contributed to the research design, validation of the study, and critical review of the manuscript. **I Wayan Widiana** contributed to the interpretation of results and methodological review. **Ketut Suma** contributed to the theoretical foundation and refinement of the manuscript. **Wayan Suastra** supervised the research process and ensured academic and methodological rigor. **Putu Artawan** contributed to data curation, visualization, and project administration. All authors have read and approved the final version of this manuscript.

## CONFLICT OF INTEREST STATEMENT

The authors state that no financial or personal relationships exist that might have affected the research or its findings.

## STATEMENT ON THE USE OF AI OR DIGITAL TOOLS IN WRITING

The authors acknowledge the use of digital tools, including AI-assisted technologies, during the research and manuscript preparation of this study. In particular, ChatGPT (OpenAI, GPT-5) was utilized to assist with language improvement, organization of the manuscript, and summarization of bibliometric information. Bibliometric analysis and data visualization were conducted using VOSviewer and Microsoft Excel. All materials generated with the assistance of these tools were carefully evaluated, validated, and revised by the authors to maintain academic integrity, originality, and compliance with ethical research standards. The authors assume full responsibility for the accuracy, interpretations, and conclusions presented in this manuscript.

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**\*Dwi Pangga (Corresponding Author)**

Physics Education, Universitas Pendidikan Mandalika  
Jl. Pemuda No.59A, Kota Mataram, Nusa Tenggara Barat 83125  
Email: [dwipangga@undikma.ac.id](mailto:dwipangga@undikma.ac.id)

**Made Hery Santosa**

Department of Informatics Education, Universitas Pendidikan Ganesha  
Jl. Udayana No. 11, Banyuasri, Buleleng, Bali 81116  
Email: [mhsantosa@undiksha.ac.id](mailto:mhsantosa@undiksha.ac.id)

**I Wayan Widiana**

Department of Informatics Education, Universitas Pendidikan Ganesha  
Jl. Udayana No. 11, Banyuasri, Buleleng, Bali 81116  
Email: [wayanwidiana85@undiksha.ac.id](mailto:wayanwidiana85@undiksha.ac.id)

**Ketut Suma**

Physics Education, Universitas Pendidikan Ganesha  
Jl. Udayana No. 11, Banyuasri, Buleleng, Bali 81116  
Email: [ketut.suma@undiksha.ac.id](mailto:ketut.suma@undiksha.ac.id)

**Wayan Suastra**

Physics Education, Universitas Pendidikan Ganesha  
Jl. Udayana No. 11, Banyuasri, Buleleng, Bali 81116  
Email: [wsuastra@undiksha.ac.id](mailto:wsuastra@undiksha.ac.id)

**Putu Artawan**

Department of Informatics Education, Universitas Pendidikan Ganesha  
Jl. Udayana No. 11, Banyuasri, Buleleng, Bali 81116  
Email: [artawan.putu@undiksha.ac.id](mailto:artawan.putu@undiksha.ac.id)

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