Implementation of Differentiated Learning Based on Computational Projects to Improve Student Skills Data Analysis and Digital Literacy on Economics Faculty, Universitas Negeri Medan

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Abstract. This research investigates the differences in students' data analysis and digital literacy skills by controlling students' prior knowledge through differentiated learning based on computational projects. Differentiated learning was implemented to accommodate students' varying readiness levels, learning preferences, and interests. Employing a quantitative, posttest-only control group design, the subjects of this study consisted of two classes from the economics education study program. Data were collected by observations, test of data analysis competence, and digital literacy questionnaire. The findings with Analysis of covariance (ANCOVA) revealed statistically significant differences between students engaged in the differentiated learning based on computational project those in direct learning, with controlling student prior knowledge. These outcomes suggest that combining differentiation with computational projects offers a promising pedagogical framework, particularly beneficial for supporting learners with diverse digital competencies. This approach aligns with current educational goals to foster digital transformation in higher education environments.

Keywords: Differentiated Learning, Computational Projects, Data Analysis, Digital Literacy

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1 Introduction

The development of information technology in the digital era requires higher education to adapt rapidly, particularly in preparing students to acquire 21st-century skills. One of the key skills required by students, particularly in the Faculty of Economics, is data analysis and digital literacy. These two skills are crucial for facing the challenges of an increasingly complex workplace, where data-driven decision-making and the use of digital technology are essential.

Field studies show that not all students have the same level of readiness and skills in mastering data analysis and digital literacy. Differences in student background knowledge, learning styles, and motivations often hinder effective learning. This situation requires learning strategies that accommodate student diversity, ensuring optimal learning [1].

One relevant approach to addressing these challenges is differentiated learning. Differentiated learning is an approach that adapts learning strategies, content, and processes to the needs, interests, and readiness levels of students [2]. This learning is important in meeting the diversity of student needs and optimizing lecturers' capacity in classroom management [3]. With this approach, lecturers not only deliver material uniformly but also design learning that provides space for students to develop according to their individual potential.

Differentiated learning can be combined with project-based learning methods, particularly those based on computing. Through computing projects, students are challenged to apply concepts, theories, and technical skills in real-world data-based problem-solving. These projects encourage students to think critically, work collaboratively, and hone their digital literacy in the process of searching, processing, and interpreting data. Through project-based learning, students are able to correlate their learning experiences and real life experiences and then independently construct the new knowledge they have acquired [4].

The implementation of differentiated learning based on computing projects at the Faculty of Economics, State University of Medan, is expected to meet the need for adaptive and critical graduates. Furthermore, this learning also encourages students to be more independent, creative, and sensitive to the use of technology in education and economics. Thus, learning outcomes go beyond mastering theory to developing practical skills relevant to the workplace. Lecturers' readiness to utilize technological developments and integrate them into learning is also a contributing factor in efforts to improve learning effectiveness. Students' freedom to be proactive and innovative must be prioritized to create a superior, intelligent, and character-driven generation [5].

Several previous studies have demonstrated the effectiveness of both differentiated and project-based learning in improving 21st-century skills. For example, studies have shown that project-based learning can improve creative thinking skills and science learning outcomes [6]. Furthermore, differentiated learning has been shown to be effective in increasing student mathematical critical with diverse characteristics [7]. However, research specifically combining the two, focusing on data analysis and digital literacy in education and economics, is still limited.

Given this research gap, this study presents a novel approach in designing and implementing differentiated learning based on computational projects to improve students' data analysis and digital literacy skills in the Faculty of Economics. This novelty lies in the integration of two complementary learning approaches: differentiation provides space for diversity and computational projects provide contextual experiences.

The hypothesis of this study is that there will be a significant difference in students' data analysis skills before and after participating in differentiated learning based on computational projects. There is a significant difference in students' digital literacy before and after participating in the learning; and differentiated learning based on computational projects has a positive influence on improving students' data analysis skills and digital literacy simultaneously. Based on this description, it is hoped that the results of this study can provide an empirical basis as well as recommendations for the development of curriculum and learning strategies at the Faculty of Economics, State University of Medan. In addition, the results of the study can also serve as a reference for lecturers and other higher education practitioners in developing adaptive, innovative learning methods that are in line with the demands of the digital era.

2 Method

This research is a comparative quantitative experimental study. The quantitative approach was chosen because it focuses on measuring numerical data that can be statistically analyzed to determine differences in students' data analysis and digital literacy skills. The comparative approach was chosen because this study aims to compare learning outcomes between the experimental group, which received differentiated learning based on computing projects, and the control group, which used conventional learning.

The research design used was a post-test-only control group design. In this design, the research subjects were divided into two groups: the experimental group and the control group. The experimental group received treatment in the form of differentiated learning based on computing projects, while the control group received learning using conventional methods. After the learning was completed, both groups were given a post-test to measure data analysis skills and a questionnaire to assess students' digital literacy. The following is a 2x2 level experimental design in this study.

Table 1. Experiment Design by Level 2 x 2

Digital Literacy Skill (B)	Learning Model (A)	
	Differentiated Learning (A_1)	Direct (A_2)
High (B_1)	A_1B_1	A_2B_1
Low (B_2)	A_1B_2	A_2B_2

The population in this study was all students of the Faculty of Economics, State University of Medan, who were taking statistics courses. The sampling technique used purposive sampling, selecting research subjects based on certain criteria. In this case, the criteria referred to were two research classes at the same level in the statistics course. A total of 60 students served as the sample: 30 for each experimental group and 30 for the control group.

The data collection technique in this study used two main instruments: a multiple-choice data analysis ability test to measure students' skills in processing, interpreting, and presenting data; and a digital literacy questionnaire designed using a Likert scale and a verbal frequency scale to measure students' ability to access, understand, evaluate, and use digital information effectively.

The research procedure was carried out in several stages. The initial stage was preparation, including the development of learning materials, the development of instruments,

and the administration of a pre-test to determine students' initial abilities in the statistics course. The implementation stage began with the experimental group being given treatment in the form of differentiated learning based on computational projects over several sessions, while the control group received conventional learning. After the entire learning process was completed, the next step was administering a post-test and questionnaire to both groups to obtain research data.

The data analysis technique used was Analysis of Covariance (ANCOVA). This analysis was chosen because it can test the difference in average post-test results between the experimental and control groups while controlling for the covariate variable, namely the students' prior knowledge obtained through the pre-test. ANCOVA can determine the extent to which differentiated learning based on computational projects has improved students' data analysis skills and digital literacy, after accounting for the influence of other variables that may influence learning outcomes.

3 Result and Discussion

3.1 Result

The data collected in this study were based on the research variables and research design. The independent variable data consisted of students' digital literacy skills, the dependent variable data consisted of students' data analysis skills, and the covariate variable data consisted of students' initial abilities from a pre-test. All data were then analyzed computationally using the Covariate Analysis technique. The following is a general tabulation of the data description.

Table 2. Statistics Descriptive of Data Analysis Skill Mean Score

Digital Literacy Skill (B)	Learning Model (A)				n	Mean
	n	DL (A1)	n	D (A2)		
High (B1	15	86	15	79.67	30	82.83
Low (B2)	15	83.33	15	63	30	73.17
Mean	30	84.67	30	71.33	60	78

Based on the data in Table 2, it shows that the average value of data analysis skills of students with differentiated learning based on computational projects (A1) is 84.67, greater than students with direct learning (A2), which is 71.33. Meanwhile, the average digital literacy skills of high students (B1) is 82.83, greater than the average digital literacy skills of low students (B2), which is 73.17. The following is a tabulation of the results of the data normality test analysis based on residual values.

Table 3. Summary of Normality Test Results

	Kolmogorov-Smirnov		Shapiro-Wilk	
	df	Sig. Value	df	Sig. Value
Residual for Y	60	0.200*	60	0.305

Based on the data in Table 3, the Kolmogorov-Smirnov residual significance value is 0.2 > 0.05, indicating a normal distribution of the data. This is supported by the Shapiro-Wilk significance value of 0.305 > 0.05, which also indicates a normal distribution of the data. The

following are the results of the homogeneity test for this research data, conducted using the Levene test.

Table 4. Summary of Homogeneity Test Results

F	df1	df2	Sig. Value
1.172	3	56	0.329

Based on the data in Table 4, the residual significance value is 0.329 > 0.05, indicating that the research data is homogeneous. After the research data met the classification assumption test, the analysis continued with hypothesis testing using covariate analysis techniques. The following are the results of the hypothesis testing analysis in this study.

Table 5. Hypothesis Test (ANCOVA) Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5376.903[a]	4	1344.226	49.850	0.000
Intercept	69.949	1	69.949	2.594	0.113
X	573.570	1	573.570	21.271	0.000
A	2800.491	1	2800.491	103.855	0.000
B	113.956	1	113.956	4.226	0.045
A * B	701.250	1	701.250	26.006	0.000
Error	1483.097	55	26.965		
Total	371900.000	60			
Corrected Total	6860.000	59			

a. R Squared = 0.784 (Adjusted R Squared = 0.768)

Based on the data from the hypothesis test analysis in Table 6 above, it shows that:

a. There is a significant difference in students' data analysis skills using differentiated, project-based computing learning compared to direct learning, after controlling for students' initial abilities, with a significance value of 0.000 < 0.005, meaning H_0 was rejected and H_1 was accepted.
b. There is a significant difference in students' digital literacy skills between high and low students, after controlling for students' initial abilities, with a significance value of 0.045 < 0.005, meaning H_0 was rejected and H_2 was accepted.
c. There is an interaction between the learning model (A) and students' digital literacy skills (B), after controlling for students' initial abilities on students' data analysis skills, with a significance value of 0.000 < 0.05, meaning H_0 was rejected and H_3 was accepted.

3.2 Discussion

Results of the Analysis of Differences in Students' Data Analysis Abilities between Differentiated Learning Based on Computational Projects (A1) and Direct Learning (A2). The results of the study showed a significant difference in students' data analysis skills between the group participating in differentiated learning based on computational projects and the group participating in direct learning. A significance value of 0.000 <0.005 indicates that H0 is rejected. This means that the applied learning model has a significant impact on improving students' data analysis skills. This finding supports previous research that stated

that project-based learning can improve students' critical thinking, problem-solving, and data analysis skills [8]. This significant difference can be explained by the characteristics of differentiated learning, which adapts strategies, materials, and learning activities to students' readiness and interests. With this approach, students have the space to learn at their own pace and style. Coupled with the context of computational projects, students are directly involved in data analysis activities based on real-world problems, making learning more meaningful and applicable. This is also in line with previous findings which emphasize that differentiated learning encourages active involvement and is able to increase students' learning motivation towards a variety of disciplines [9].

Results of the Analysis of Differences between High Digital Literacy Skills (B1) and Low Digital Literacy Skills (B2). The results of the study showed a significant difference in the digital literacy skills of students in the high and low categories after controlling for initial abilities. A significance value of $0.045 < 0.005$ indicates that the difference is statistically significant. Thus, digital literacy is a crucial factor influencing student success in participating in the learning process. This finding is consistent with previous research which emphasizes that digital literacy is important and has a positive impact on increasing students' knowledge, understanding, and skills as a source of learning information [10]. It was also further stated that the effect of increasing students' digital literacy was able to improve the quality of teaching and exploration of lecturers' teaching strategies in accordance with modern methodologies [11]. Students with high digital literacy tend to adapt more easily to computational project-based learning because they are accustomed to utilizing digital technology to access information, process data, and use analytical software. Conversely, students with low digital literacy face greater challenges, especially in understanding technology-based instructions. This demonstrates the importance of educational interventions focused on strengthening digital literacy so that all students can optimally benefit from innovative learning.

Results of the Interaction Test between Learning Models and Digital Literacy Skills. The interaction test results showed a significant relationship between learning model (A) and students' digital literacy levels (B) on data analysis skills, with a significance value of $0.000 < 0.05$. This indicates that the effectiveness of differentiated learning based on computational projects in improving data analysis skills is influenced by students' digital literacy levels. In other words, students with high digital literacy benefit more from implementing this learning model than students with low digital literacy. This interaction is understandable because computational project-based learning requires technical skills, such as the use of statistical software, digital data processing, and technology-based presentations. Students with high digital literacy are able to integrate these skills more effectively, resulting in a more significant improvement in their data analysis. These results are in line with other studies that found that digital literacy influences student learning outcomes through the creation of a learning atmosphere in the classroom and the efficacy of digital technology for each student [12]. Theoretically, the results of this study strengthen the integrative model between differentiated learning, technology-based projects, and digital literacy as important determinants in improving student learning outcomes. These three factors are interrelated: differentiation provides equal access for students from diverse backgrounds, computing projects provide contextual learning experiences, and digital literacy serves as a key asset in optimizing the use of learning technology. Thus, this research broadens our understanding of the synergy between pedagogical approaches and digital competencies in higher education. Practically, the

findings of this study have important implications for curriculum development at the Faculty of Economics, State University of Medan. First, lecturers need to design project-based learning that adapts to student characteristics. Second, digital literacy improvement programs need to be prioritized so that students with low literacy levels can keep pace with the demands of technology-based learning. Third, the results of this study can serve as a reference for higher education institutions in formulating innovative learning strategies that meet the needs of 21st-century competencies, particularly in mastering data analysis and digital literacy.

4 Conclusion

This study concluded that the implementation of differentiated, project-based computing learning significantly improved the data analysis skills of students at the Faculty of Economics, State University of Medan. The ANCOVA test results showed a significant difference between the experimental and control groups after controlling for students' initial abilities, with a significance value of $0.000 < 0.005$. This demonstrates that an adaptive, project-based learning approach can improve data analysis skills more effectively than direct learning. This study also found a significant difference between high and low digital literacy skills of students after controlling for initial abilities, with a significance value of $0.045 < 0.005$. These findings indicate that digital literacy is a critical factor in student success in innovative learning. Students with high digital literacy achieved better results in project-based computing learning, while students with low literacy required greater support to achieve equivalent learning outcomes.

This study also revealed a significant interaction between the learning model and digital literacy level on students' data analysis skills, with a significance value of $0.000 < 0.05$. This means that the effectiveness of differentiated, project-based computing learning is significantly influenced by students' digital literacy levels. These results emphasize the importance of integrating adaptive pedagogical strategies with the strengthening of digital literacy competencies in higher education. Therefore, this research contributes to the development of relevant learning models in the digital era and serves as a basis for faculty and lecturers in designing curricula that are more responsive to student needs and the demands of the workplace.

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