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Digital project-based learning (PBL) on students' academic achievement and technological skills in grade 10 science

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Abstract
Project-Based Learning is grounded in the idea that educating students about real-world problems will help connect the concepts to a student's life and transfer their learning to new situations using authentic products. This study investigated the effects of Digital Project-Based Learning on students' academic achievement and technological skills in the two sections of Grade 10 Science at Macapari National High School, Macapari, Damulog, Bukidnon. The instrument used were both academic and non-academic assessment. Descriptive statistics and Analysis of Covariance (ANCOVA) were employed in the study. The study's findings revealed a significant difference in students' academic achievement in favor of the students taught under the digital PBL which obtained "Satisfactory", while Non-PBL obtained a "Did Not Meet Expectations" result. Both groups exhibited an overall mean that indicates "High" technological skills. Further, there was a significant difference in the students' academic achievement and technological skills between groups.

Keywords: academic achievement, technological skills, and; digital project-based learning

Introduction

Currently, the education system aims to equip learners with 21st-century skills, namely creativity, innovation, critical thinking, problem-solving, communication and cooperation, technological literacy, and life and career skills (Stehle & Peters-Burton, 2019) [24]. The outcomes of these expectations give rise to change and transformation along with educational reforms and investments. Due to the problems of low academic achievement of students, more is needed to settle for a school that is limited to instilling basic and fragmented knowledge through simple and repetitive activities. Results of international studies such as Trends in International Mathematics and Science Study (TIMSS) 2019 and the Programme for International Students Assessment (PISA) 2018 revealed that the Philippines ranked second from the bottom out of 357 countries in science literacy in which Filipino students only shows limited understanding of the scientific concepts and little knowledge of foundational science facts (Mullis *et al*., 2020) [19].

In addition, the Department of Education (DepEd) (2019) reported that the performance of Filipino high school students in the National Achievement Test (NAT) attained low proficiency levels, especially in Science. In Macapari National High School, for instance. Based on the school's consolidated performance report for 2019-2022, results showed that the most significant number of Junior High School students fail in Science because they lack interest and conceptual knowledge to comprehend the lessons.

Due to the problems of low academic achievement of students, more is needed to settle for a school that is limited to instilling basic and fragmented knowledge through simple and repetitive activities. Therefore, a good learning strategy that would cater to the student's holistic development and address Filipino learners' problems is needed. One attractive way to achieve this goal is through project-based Learning (PBL) (Guo *et al*, 2020) [14], a teaching method in which students learn by actively engaging in real-world and personally meaningful projects. Project-based work is a real and authentic instruction strategy in which students can solve problems, make decisions, and perform complex and challenging tasks (Alamri, 2021) [4]. Nowadays, technology is being integrated into the classroom as it empowers teachers to develop creative and interactive classrooms and gives them access to innovative resources. Along with using new technological tools, teachers may also need a new approach to teaching like PBL coupled with digital technology to help address students' learning problems to meet new higher levels of student learning in school.

Methodology

The study utilized a quasi-experimental pretest-posttest control group design to assess the use of Digital Project-based Learning in academic achievement and Science students' technological skills. The design involved two intact groups of students, the experimental and the control groups. The experimental group comprised 34 students, while the control group comprised 35 students. Both groups received the same lesson content; however, the experimental group was taught Digital Project-based Learning using the 7E framework, while the control group was taught using Non-Project-based learning with the 7E Learning framework.

This study used academic assessment that consist of fifty (40) item multiple-choice exam and non-academic assessment that consist of fifty (50) questions adapted from Gomez-Pablos *et al*. (2017) was employed. Both instruments were content validated by three science experts, pilot tested, and showed reliability of 0.747 (academic assessment) and 0.906 (non-academic assessment). The participants were given an orientation and accomplished the informed consent prior to the study. Statistical tools that were used includes descriptive statistics and ANCOVA.

Results and discussion

This presents the interpretation and analysis of data gathered following the order of the specified problems of this study.

Table 1: Comparison of Students' Mean Scores in Science in the Pretest and Posttest

Range	PBL				Non-PBL				Qualitative Interpretation
	Pretest		Post-test		Pretest		Post-test		
	(f)	%	(f)	%	(f)	%	(f)	%	
90-100	0	0	4	11.76	0	0	0	0	O
85-90	0	0	9	26.47	0	0	0	0	VS
80-84	0	0	8	23.53	0	0	1	2.86	S
75-79	0	0	8	23.53	0	0	6	17.14	FS
below 75	34	100	5	14.71	35	100	28	80.00	DNME
Total	34	100	34	100	35	100	35	100	
Mean		11.85		28.44		12.74		19.23	
MPS		29.63%		71.1%		31.85%		48.07%	
QI		DNME		S		DNME		DNME	

Legend: Percentage Qualitative Interpretation
90-100 Outstanding (O)
85-89 Very Satisfactory (VS)
80-84 Satisfactory (S)
75-79 Fairly Satisfactory (FS)
below 75 Did not meet Expectations (DNME)

The low pretest scores in both groups indicating "DNME" indicate that students have weak prior knowledge about the concepts in Earth Science. The findings corroborate with Rogayan's (2019) [21] study, which reported that achievement low scores were expected during the pre-test since the teacher did not discuss the topics yet; insufficient students' pretest scores resulted from their little knowledge about the subject matter (Chanpet *et al*., 2020) [7]. Steinmayr *et al*. (2019) [25] pointed out that prior knowledge significantly influences students' academic achievement. This means that misconceptions about the topic are more likely to affect their academic achievement, as seen in their pretest scores. Albeit the pretest results of the students mirror students' prior knowledge, and it will serve as teachers' indicator of how to deliver instruction. Moreso, Agarwal, *et al*. (2017) [2] stated that prior knowledge is one of the most influential factors in learning; hence, prompting learners to recall previous learning before presenting new knowledge is essential (Dangol & Shrestha, 2019) [9]. Conversely, the posttest results of students exposed to PBL revealed that they have improved their academic achievement in Earth Science; from an MPS indicating "DNME" on their pretest, it had increased to "Satisfactory" achievement of students. These findings are in accordance with Chen and Yang's (2019) [8] study which revealed that project-based learning has a medium to significant positive effect on students than that conventional instruction on students' academic achievement. Through this technology-integrated PBL method, students arrive at "new" knowledge as a result of their observations, and it provides activities that permit self-direction, exploration, nurturing, satisfaction of curiosity on the parts of students (Gomez-Pablos *et al*., 2017) [13] and influence student achievement in Science by students' demographic backgrounds and unleash multiple intelligences and challenges among students to become versatile and creators of their learning (Alamri, 2021) [4].

In contrast, despite the increase of scores of the Non-PBL group, it was not sufficient to reach an average MPS above 75%; Hence, they remained in the "DNME" after the intervention. The literature cited by Abubakar *et al*. (2020) [1] discovered that the project-based learning approach affected students' academic success in schools, benefitted low-performing students to a greater extent, and decreased the achievement gap. This suggests that integrating technological tools influences students' achievement; Vogler *et al*. (2018) [26] posited that teaching students using PBL enhances their ability to discover and solve problems independently through their teacher's guidance, thereby increasing their abilities in self-discovery and scientific problem-solving methods.

Table 2: Summary of Students' Technological Skills Toward Science

Technological Skills	PBL method				Non-PBL method			
	Pretest		Posttest		Pretest		Posttest	
	MEAN	QI	MEN	QI	MEAN	QI	MEAN	QI
Acquisition of emotional and social skills	4.15	H	4.56	VH	4.03	H	4.14	H
Acquisition of technological skills	4.01	H	4.50	H	3.84	H	3.99	H
Integration of students with special needs	4.13	H	4.48	H	3.94	H	4.14	H
Attention to task	4.12	H	4.45	H	3.93	H	4.06	H
Objectives achieved	4.14	H	4.43	H	3.87	H	4.09	H
Acquisition of Metacognitive skills	3.96	H	4.40	H	3.81	H	4.00	H
Development of creativity	3.98	H	4.40	H	3.71	H	3.96	H
OVERALL MEAN	4.07	H	4.49	H	3.88	H	4.05	H

Rating Scale Qualitative Interpretation
Legend: 4.51 – 5.0 Very High (VH)
3.51 – 4.50 High (H)
2.51 – 3.50 Moderate (M)
1.51 – 2.50 Low (L)
1.00 – 1.50 Very Low (VL)

The findings reflect that both groups generally demonstrated the same level of technological skills, indicating "High" level. Moreover, the PBL group has a remarkably high mean score across all seven domains. The finding is coherent with the study of Dorr (2017) [11], which indicated that students exposed to Project-Based Learning classes are more engaged in the learning process and had develop increased technological skills amongst students toward science. The exposure of students to hands on activities and real-world problems through digitalization allows students to go beyond knowing facts and solutions to routine problems to

succeed in the real world; they learned how to find information, apply knowledge in new ways, develop critical thinking skills, communicate, collaborate, evaluate, and synthesize information–skills (Rubrica, 2018) [22]. In addition, technology and simulations in the classroom allow students to learn by actively engaging in a task that mirrors real-world and personally meaningful tasks (Kiong *et al*., 2022) [16]. Likewise, according to ECLAC (Economic Commission for Latin America and the Caribbean, 2021), digitalization in teaching and learning will likely occupy a much more prominent place as a policy priority because it can maintain access and quality at a lower cost of instruction, raising efficiency (Davidsen *et al*., 2020) [10]. Integrating technology into PBL instruction resulted to positive aspects like optimization of time and resources, the ease of communication, task management, and improved technological skills (Rodrigues *et al*., 2021) [20].

Table 3: Analysis of Covariance (ANCOVA) of Students' Post-test Achievement Scores after Intervention between Classes Exposed to Digital PBL and Non-PBL

GROUP		N	Mean	Standard Deviation	
Project-Based Learning		34	71.10	15.89	
Non- Project-Based Learning		35	48.07	13.85	
Total		69	59.42	18.79	
Source	**Type III Sum of Squares**	**D f**	**Mean Square**	**F-value**	**p-value**
Group	38275.51	1	19137.76	86.17	0.000
Pretest (covariate)	195.57	2	195.57	0.88	0.351^{ns}
Error	14657.89	66	222.10		
Total	267625.00	69			
a. R Squared = 0.996 (Adjusted R Squared = 0.996)					

The results signify a significant increase in PBL groups' academic achievement which obtained a high mean score, which was associated to students' exposure to Problem-based learning. These findings are consistent with Calore (2018) [6], that technology-integrated project-based learning positively impacts students' achievement and skills. In addition, Gomez-Pablos *et al*. (2017) [13] revealed that students attained higher academic achievement, showed significantly higher critical thinking skills, and appreciated peer learning by incorporating technologies in PBL more than Non-PBL. Moreover, student's exposure to digital project-based learning helps them unleash their potential fostering independent learning skills and develop the learning competence required for college, work, and life beyond school (Knoblauch, 2021) [17]. Furthermore, in the digital PBL method, the researchers discovered that digital project-based learning allows students to learn comfortably and be diverse in the learning process, thus developing their potential and skills without being compromised by other students' pace of development in the learning process (Lathram *et al*., 2016) [18]. Other studies revealed that students who experienced digital integration in PBL increased their learning motivation, adopted more positive attitudes toward learning (Elizabath & Sangeetha, 2018) [12], and positively affected student engagement and skills (Sahib Tamimi & Salamin, 2020) [23]. PBL contributes to students' academic achievement by creating an equal learning environment (Johnson & Nino, 2021) [15]. Hence, evidence suggests that using technology in PBL classrooms enables more productive activities and learning processes, thus improving students' academic achievement and technological skills in the Science subject

Table 4: Analysis of Covariance (ANCOVA) of Students' Technological Skills after Intervention between Classes Exposed to Digital PBL and Non-PBL

GROUP		N	Mean	Standard Deviation	
Project-Based Learning		34	4.47	0.27	
Non- Project-Based Learning		35	4.05	0.28	
Total		69	4.26	0.35	
Source	**Type III Sum of Squares**	**D f**	**Mean Square**	**F-value**	**Sig.**
Group	6.60	1	3.30	43.10	0.000**
Pretest (covariate)	0.01	2	0.01	0.11	0.740^{ns}
Error	5.05	66	0.08		
Total	1257.70	69			
a. R Squared = 0.996 (Adjusted R Squared = 0.996)					

The results convey a significant increase in the students' technological skills as exposed to PBL, which imply that intervention effectively promotes increased students' technological in science learning. These results corroborate the study of Al-Abdullatif & Gameil (2021) [3] which confirm that the use of digital technology in PBL facilitates flexible and quick communication (useful), resulting in effective interaction and collaboration between students and their peers and the successful completion of tasks. In addition, the valuable characteristics of digital technologies offer great potential to support students' learning within a PBL environment which confronts the constructivist view that learning by doing activates students' intelligence (Abubakar *et al*., 2020) [1] and adheres to the vision of the Department of Education, which states that students should be equipped with knowledge and skills for ICT education and that students should be technologically skilled and literate that transform students' holistic development into

lifelong learners and values-centered citizens (Almerino *et al*., 2020) [5]. Rodriques *et al*. (2021) [20] supported the importance of technological skills at a professional level in the future, referring to its inevitability, especially considering its relevance in society and the digital world in the future, its demand in the labor market, and the usefulness of technologies. Therefore, evidence suggests that increased student technological skills due to exposure to PBL is correlated with improved academic achievement in post-tests.

Conclusions and recommendations

Based on the findings of the study, the following conclusions were drawn

The academic achievement in Science of the Grade 10 students in terms of pretest for digital PBL and Non-PBL had shown "needs improvement" results. After the intervention, the PBL group improved their academic achievement to a "Satisfactory" level result, while the Non-PBL attained the same achievement level, "Did Not Meet Expectations." The technological skills level of the digital PBL group towards Science before and after the intervention was high. At the same time, the technological skills level of the Non-PBL before and after the intervention was high. Therefore, the student's technological skills level was high. Moreover, those students exposed to digital PBL had significantly higher posttests than those exposed to Non-PBL. Both PBL and Non-PBL attained high technological skills. However, those students exposed to PBL had a higher significant difference in terms of technological skills level than those exposed to Non-PBL.

The study's conclusions lead to the following are the recommendations

1. Teachers may utilize it to allow students to develop their curiosity and interest, be more active in the learning process, improve interaction with science instruction, and offer a flexible learning environment.
2. School administrators, educators and curriculum developers are urged to innovate and plan guidelines and adequately define the use of projects in the learning process and encouraged to allocate appropriate funds for ICT facilities, tools, and software that can be used in the delivery of learning and instruction to help develop and to ensure effective implementation and obstacles are reduced or eliminated for better digital project outputs.
3. Teacher, school administrators, and curriculum developers may include more digital Project-Based Learning in instruction to improve the science curriculum. Moreover, this method might help increase students' conceptual understanding, interest, skills development, and participation in the subject.
4. Teachers may be challenged to incorporate digital PBL as an alternative tool in increasing the academic achievement of students and in enhancing active learning in science since it provides an excellent opportunity to collaborate and maintain positive involvement to achieve the common goal of education and the holistic development of the students.

Lastly, for the future researchers may study this strategy further to address academic gaps as this may provide additional information and baseline knowledge needed to suffice effective instruction and undergo an in-depth study on digital Project-Based Learning for future research.

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