# The Impact of the Integrated Project-Based and 4C-Scaffolding (Pj4CS) Model on Learners' Digital Literacy in Biology

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**Abstract.** The primary objective of higher education is to cultivate graduates who possess a wide range of skills necessary for success in the contemporary job market. Thus, educators must develop the ability to create engaging educational experiences, foster self-directed learning, incorporate the 4C global competences, and promote digital literacy within the classroom setting. Pj4CS is an instructional model that prioritizes the development of learners' critical thinking, communication, teamwork, creativity, and digital literacy skills. The present study examined the impact of the project-based learning approach combined with 4C-scaffolding (Pj4CS) on college students' digital literacy in biology. This study used a quasi-experimental design. The research sample consisted of 22 pre-service biology teachers. Data were collected using a questionnaire on digital literacy in biology and subjected to both descriptive and inferential analysis. The statistical analysis revealed a t-value of 84.068, with a significance level of 0.000. The mean score on the pretest was 35.47 and the mean score on the post-test was 84.08 with an N-Gain score of 0.753, indicating a substantial increase in participants' digital literacy in biology. Based on the findings, it can be inferred that the Pj4CS model had a significant impact on learners' digital literacy in biology. It is anticipated that the utilization of this instructional model will have ramifications for enhancing the quality of higher education

**Keywords:** Digital Literacy in Biology, Instructional Model, Pj4CS.

## 1 Introduction

The integration of technology in education has brought about a beneficial transformation in the conventional and occasionally ineffective methods of teaching and learning [1]. Education requires a framework for integrating information and digital literacy skills into virtual and physical classrooms [2]. The growing accessibility and cost-effectiveness of emerging technologies are facilitating transformative advancements in


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different societal domains [3]. To address the digital divide in Indonesia, it is necessary to provide digital literacy education through various methods of knowledge transfer that involve educators, students, and parents [4]. Educators should be innovative and flexible, meaning they must be capable of adjusting to the requirements brought about by advancements in science and technology [5]. Utilizing technology in education is a pertinent and practical approach to imparting knowledge to students, enabling them to enhance their skills in alignment with the demands of the workforce [6].

Access to technology and digital literacy provides extensive options for future pupils to develop [7]. Students who grasp the benefits of digital literacy will utilize information and communication technologies more intelligently and will be better prepared to regulate their learning [8]. Students' digital literacy can be strengthened by employing technology devices such as computers, smartphones, tablets, internet, and social media in the classroom [9]. Digital literacy is not only crucial for students' involvement in school, work and other elements of social life, but is also useful for learning new knowledge in all sectors of life [10]. Digital literacy applied in the classroom will have a positive impact on the student learning process [8].

The establishment of a solid integration between the technological, pedagogical, and content knowledge of educators can be achieved by aligning it with the learning objectives. This will enable students to acquire the essential skills and comprehension [11]. The technological, pedagogical, and content knowledge integration into the classroom determines the quality of online learning [12]. Pedagogical knowledge enables educators to comprehend the process by which students acquire classroom management skills, devise learning strategies, execute these strategies, and assess student learning outcomes [13]. Enhanced comprehension of technology, pedagogy, content, and their interconnections empowers educators to construct more suitable and effective learning environments [12, 14, 15]. Verbal information is commonly employed to link concepts, enabling students to acquire a comprehensive understanding of theoretical and practical knowledge. Digital literacy enables students to discern the appropriate way to utilize technology for communication [16].

In the digital era, the enhancement of learning quality relies largely on students' digital literacy [17]. Proficient digital literacy skills facilitate students' access to online material and are strongly associated with enhanced learning strategies, heightened cognitive understanding, and improved academic achievements [18]. Digital literacy is essential for accessing diverse and pertinent sources of information over the internet. Thus, digital literacy skills are indispensable in the learning process [19]. Digital literacy necessitates a range of competencies for performing activities in a digital setting, including information processing, cognitive abilities, and social-emotional skills, enabling pupils to effectively utilize the digital environment [20]. Digital literacy skills help students comprehend, scrutinize, and assess diverse information received, as well as evaluate its reliability and credibility [21].

Students will be more interested in studying biology if learning material is presented in an integrated and holistic manner [22]. Project-based learning experiences foster the growth of students' conceptual and technical knowledge. Project-based learning can assist educators in creating a favorable learning environment by promoting self-directed learning and delivering efficient learning support to students [23]. Efficient learning

can be achieved when a teacher effectively implements a well-designed instructional model in the classroom [24]. In fact, issues in science education commonly arise among educators who adhere to conventional teaching methods [25]. Therefore, learning that integrates technology will help students become more creative and effective [26]. Learning must be designed with a multiliteracy pedagogical plan that integrates various competencies including mastery of information technology [27]. In addition to that, educators need to incorporate communication skills and digital literacy components into their teaching to improve students' critical thinking skills [28].

Research indicates that Indonesian students have poor digital literacy [29]. The results of our preliminary observations showed that pre-service biology teachers in Ternate, North Maluku had a low level of digital literacy. Efforts are needed to integrate these skills into the learning process so that students can tackle increasingly rapid global issues. The Pj4CS model has also been proven to improve critical thinking skills, communication skill, collaboration skill, creativity. The current study aimed to examine the impact of the project-based learning approach, combined with 4C-scaffolding (Pj4CS), on college students' digital literacy in biology.

## 2 Methods

The current study employed a one group pretest post-test quasi-experimental design. The study sample comprised 22 pre-service biology teachers from Ternate. The research instruments consisted of observation sheets and a questionnaire to measure participants' digital literacy in biology. The study instruments were constructed based on the digital literacy indicators, including internet searching, hypertextual navigation, content evaluation, knowledge assembly. Data of the study were analyzed using descriptive and inferential statistics. The research hypothesis states that the integrated project-based learning and 4C-Scaffolding (Pj4CS) has an effect on students' digital literacy in biology. The normality test and the homogeneity test were conducted first. Hypothesis testing in this study used paired t-test.

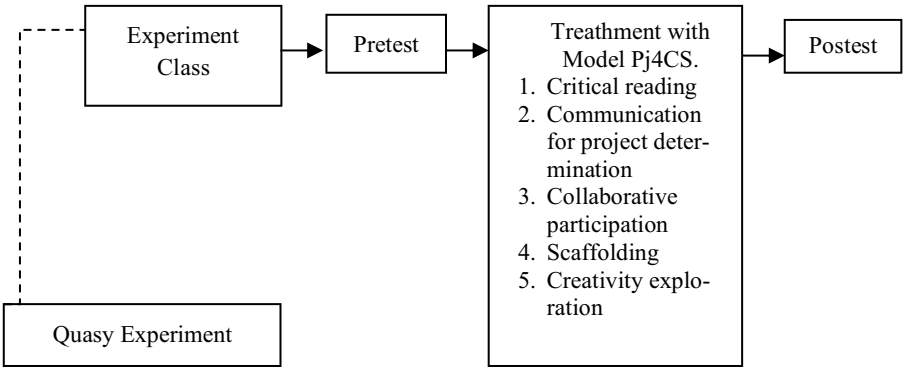


**Fig. 1**. Research flowchart

## 3 Results and Discussion

The pre-service biology teachers' digital literacy was evaluated based on four aspects, namely internet searching, hypertextual navigation, content evaluation, knowledge assembly. Table 1 presents the digital literacy mean score and score increase achieved by the participants following the implementation of the Pj4CS learning model.

**Table 1.** Participants' pretest and post-test mean scores

| No | Instructional Model | Average | | |
|---|---|---|---|---|
| | | Pretest | Post-test | Increase |
| 1. | The Integrated Project-Based learning and 4C-Scaffolding (Pj4CS) | 35.47 | 84.08 | 48.61 |

Table 1 indicates that after learning using the Pj4CS model, the digital mean score of participants increased by 48.61 points from the pretest to the post-test. Figure 1 displays the graph representing the mean scores of digital literacy before and after the instructional model was applied in the classroom.

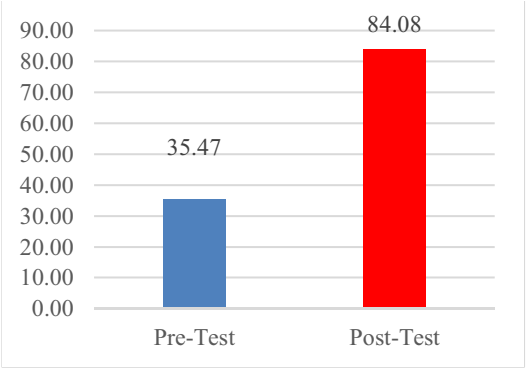


**Fig. 2**. Graph of the mean pretest and post-test scores on digital literacy in biology

The normality test showed a significance value of 0.200 for Pj4CS class, which is bigger than 0.05. This indicated that the digital literacy data in Pj4CS class were distributed normally. The results of the normality and homogeneity tests are presented in Table 2 and Table 3, respectively.

**Table 2.** The normality test results

| | Test | Kolmogorov-Smirnov[a] | | |
|---|---|---|---|---|
| | | Statistic | df | Sig. |
| Digital Literacy in Biology | Pre-Test | .086 | 22 | .200* |
| | Post-Test | .147 | 22 | .200* |

**Table 3.** The homogeneity test results

| | | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| Digital Literacy in Biology | Based on Mean | .887 | 1 | 42 | .352 |
| | Based on Median | .874 | 1 | 42 | .355 |
| | Based on Median and with adjusted df | .874 | 1 | 37.114 | .356 |
| | Based on trimmed mean | .854 | 1 | 42 | .361 |

According to Table 3, the homogeneity test showed a significance value of 0.352 (greater than 0.05). This finding indicated that the data had homogeneous variances. Following the normality and homogeneity tests, hypothesis testing was conducted. Table 4 depicts the hypothesis testing results.

**Table 4.** Results of the paired sample t-test on the model's effect on students' digital literacy

| No | Instructional Model | Mean | | | t-calculated | P value | N-Gain |
|---|---|---|---|---|---|---|---|
| | | Pretest | Posttest | Difference | | | |
| 1 | The Integrated Project-Based Learning and 4C-Scaffolding (Pj4CS) | 35.47 | 84.08 | 48.61 | 84.068 | 0.000 | 0.753 |

The t-test results in Table 4 show a t-calculated value of 84.068 at the 0.000 (less than 0.05) significance level for the model's effect on students' digital literacy. The t-test findings indicated that $H_0$ was rejected; hence, the research hypothesis stating that *"the integrated project-based learning and 4C-Scaffolding (Pj4CS) has an effect on students' digital literacy in biology*" was accepted. Additionally, the N-Gain value of 0.753 (higher than 0.7) suggested that the Pj4CS model was highly effective in improving students' digital literacy in biology. The post-test mean score (84.08) which was higher than the pretest mean score (35.47) also confirmed this conclusion. Digital literacy is needed in all learning activities [30]. Students with adequate digital literacy can discover, access, analyze and use information ethically and properly [31]. With high digital literacy skills, students will rapidly read and access the features inherent in digital technology [32]. The current study results have proven that the Pj4CS learning phases consisting of critical reading, communication for project determination, collaborative participation, scaffolding, creativity exploration could stimulate and develop students' digital literacy in biology class.

An initiative to integrate modern technology in education involves training educators and students to effectively utilize technology, enabling them to engage in global thought and action [33]. Effective integration of digital resources in 21st-century learning can be achieved when students possess both digital literacy and self-regulation skills [34]. According to Jin, students with advanced digital literacy skills also possess the

ability to effectively search, filter, evaluate, and manage digital information and data. For instance, students can ascertain the appropriate keywords to employ in their search for information and evaluate the accuracy of the material obtained [35]. Students typically choose using the internet as a more efficient means of acquiring knowledge, allowing them to enhance their abilities in looking for and organizing digital content [36].

Digital literacy has a significant relationship with learning outcomes, including conceptual understanding [37, 38]. Students often rely on information search engines like Google and video platforms like YouTube to gather a large amount of information. They also use their digital literacy skills to filter this information, ensuring that it enhances their conceptual understanding in the learning process [36]. To effectively attain their learning objectives, students must exercise self-regulated learning abilities to manage the usage of digital gadgets [39]. High self-efficacy enables pupils to employ targeted strategies to obtain reinforcement and consistently approach problem-solving tasks with readiness [40, 41]. Learning with the Pj4CS model provides opportunities for students to learn autonomously and discuss collaboratively to produce authentic work. Educators act as facilitators and directors only in learning, while project design ideas come from the thoughts of each collaborative group. When in difficulty, educators will provide scaffolding according to each need. This is an advantage of the Pj4CS model compared to conventional learning.

## 4 Conclusion

The current study findings dan data analysis revealed that the integrated project-based learning and 4C-Scaffolding (Pj4CS) had an effect on students' digital literacy in biology class. The Pj4CS phases consisting of critical reading, communication for project determination, collaborative participation, scaffolding, and creativity exploration were proven to be effective in stimulating and promoting digital literacy in biology students. The Pj4CS model can be used as an alternative instructional approach to accommodating the development of digital literacy in high schools and universities. It is hoped that this study can make a valuable contribution to the advancement of learning design to address the specific learning requirements of the 21st century. Further research can be conducted on a wider scale with a longer implementation time of the Pj4CS model in classroom learning.

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