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Innovative Project-Based Learning Video Tutorial Media: Development and Its Effect on Students Collaborative Skills

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Abstract

Mastery of the 4C skills (Critical Thinking, Communication, Collaboration, Creativity) is essential for success in 21st-century education. However, the persistent challenges in developing collaboration skills highlight a critical gap in current educational practices. This research seeks to develop a Project-Based Learning (PjBL) video tutorial and assess its impact on enhancing students' collaboration skills in high school biology education. Using a Research and Development (R&D) design based on the Alessi & Trollip model, the study involved two media experts, two content specialists, three teachers, and twenty-nine students as participants. Data were gathered through observations, interviews, and questionnaires, and analyzed using the N-Gain technique to evaluate improvements in collaboration skills, alongside descriptive percentage techniques to assess the feasibility of the video media product. The urgency of this research lies in addressing the limitations of traditional teaching methods, which often fail to foster active collaboration among students. Findings from the planning phase, including interviews with biology teachers, revealed a lack of collaborative interaction in conventional classroom settings. In response, a video tutorial was developed to enhance teamwork and collaboration during project assignments. Expert validation yielded a high feasibility score of 85.3%, and user testing showed excellent results with an average score of 83.7%. The video tutorial achieved an N-Gain value of 0.52, categorized as moderate, indicating a significant improvement in students' collaboration skills. This research is significant as it provides a practical, scalable solution to improve collaborative learning through innovative media in biology education. Further studies are recommended to expand the development of PjBL-based videos for other subjects and to investigate their long-term impact on 21st-century skills.

Keywords: 4C skills, biology, collaboration skills, Project-Based Learning, video tutorial

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INTRODUCTION

The significant transformations in the 21st century, characterized as the era of knowledge and information technology, coupled with the advent of the fourth industrial revolution, necessitate students to acquire essential skills known as the 4Cs: Critical Thinking, Communication, Collaboration, and Creativity (Budiarto et al., 2024; Supena et al., 2021). Saimon et al. (2023) emphasized that these 4C competencies must be integrated into the learning process through innovative strategies fostering active and meaningful learning experiences. One such strategy is the integration of the 4Cs into problem-based learning models, which not only

enhances learning outcomes but also promotes critical thinking and problem-solving skills. This approach has shown effectiveness in diverse contexts, particularly in highlighting the transformative potential of problem-based learning for fostering essential skills.

Critical thinking, creativity, communication, and collaboration skills (4Cs) are not only crucial for improving students' academic performance but also for preparing them to face the challenges of globalization and a knowledge-based economy (Boyles, 2012). These skills can be developed through creative and innovative teaching methods, including the integration of technology (Widarti et al., 2020). Additionally, project-based learning (PjBL) has been proven effective in enhancing soft skills, as evidenced by several studies (Mohamadi, 2018; Ummah et al., 2019). This method allows students to work in teams, tackle real-world challenges, and find creative solutions, significantly improving their collaboration and communication skills (Tahmidaten, 2021). In the context of 21st-century education, developing these skills is essential to ensure that students are not only prepared for academic challenges but also equipped to compete in a dynamic and globally connected workforce.

Considering the many approaches that exist in the learning process, one of the most popular approaches, namely Project-Based Learning (PjBL), is one of the approaches that is often proposed for implementation, which effectively promotes active and meaningful learning (Hujjatusnaini et al., 2022). Additionally, Kardoyo et al. (2020) emphasize that this strategy can assist students in developing critical and creative thinking abilities, as well as enhancing their collaboration and communication skills within contexts that are relevant to real-life situations.

PjBL has been shown to enhance the development of 21st-century skills among students in various educational contexts, including higher education and vocational training (Saimon et al., 2023; Urrutia Pereira et al., 2022). Studies have demonstrated PjBL's effectiveness in improving soft skills, engagement, and core competencies (Dogara et al., 2020; Pawar et al., 2020). The integration of design thinking with PjBL (DT-PBL) has emerged as a promising approach to further enhance creativity and problem-solving capabilities (Jia et al., 2023). Nevertheless, the implementation of PjBL faces significant challenges, including large class sizes and inadequate technological infrastructure.

A significant challenge in education today lies in improving students' collaboration and communication skills. While critical thinking and creativity are widely emphasized by educators, students' communication abilities often remain at a moderate level, such as highlighted by Rusdin (2018) signaling the need for more focused interventions in this area. Furthermore, research conducted by Wati (2018) reveals that variations in school environments also impact students' collaboration skills. This disparity reflects an uneven implementation of strategies designed to foster collaboration across diverse educational contexts. To address these challenges, it becomes imperative to adopt teaching approaches that specifically emphasize the enhancement of both communication and collaboration skills, equipping students to navigate the complexities of global challenges and meet the demands of an increasingly dynamic job market.

Previous discussions have highlighted that differences in school environments significantly impact the development of soft skills. The educational

context, including teaching methodologies and the interpersonal dynamics fostered by school leadership, plays a pivotal role in shaping these competencies. For instance, schools that adopt collaborative learning environments demonstrate enhanced communication skills among students, particularly when utilizing diverse communication tools like discussion forums and instant messaging apps (Oluwagbohunmi & Alonge, 2023). This suggests that the integration of technology in learning can facilitate better communication and collaboration, essential components of the 4C skills framework. Moreover, the leadership style within schools also impacts the development of these skills. emphasizes that effective school leadership, characterized by strong communication and teamwork abilities, directly correlates with improved school quality and student outcomes (Wrahatnolo & Munoto, 2018). This is echoed by Demirtaş & Üstün (2023), found that students participating in music education, which inherently emphasizes collaboration and communication, demonstrate significantly higher levels of social intelligence and communication skills compared to their peers. These findings underscore the critical importance of fostering a supportive school environment that actively promotes interaction and teamwork, essential components for nurturing 4C competencies. Additionally, classroom management strategies adopted by educators significantly influence the cultivation of these skills. Suhendra (2022) discusses how contemporary classroom management practices create opportunities for students to engage in critical thinking and creative problem-solving. Schools that prioritize such pedagogical approaches provide an environment where students are encouraged to collaborate effectively and develop their critical thinking abilities (Supandee & Yachulawetkunakorn, 2023).

Video tutorials, particularly those based on Project-Based Learning (PjBL), have been identified as effective tools for enhancing students' collaboration and communication skills. Research by Hamida & Desnita (2021) demonstrate that context-based educational videos significantly improve soft skills, especially collaboration and communication, by presenting real-life scenarios that make learning more interactive and applicable. The flexibility and visual nature of PjBL-based videos allow for the clear presentation of complex concepts, facilitating students' comprehension of the material (Hamdani & Suherman, 2021). These videos also enable students to learn independently at their own pace, allowing for deeper reflection on the material covered (von Lautz-Cauzanet, 2022). Despite these advantages, video tutorials have limitations, particularly the absence of direct interaction and real-time feedback, which are crucial for addressing immediate questions and fostering active engagement. To overcome these challenges, integrating video tutorials with complementary teaching methods can create a more balanced and interactive learning experience.

The availability of attractive and dynamic content within videos encourages active participation among students. Combining this approach with other methods, such as group discussions or post-video reflections, can be more effective in fostering collaborative and communication skills in a holistic manner (Dogara et al., 2020). In line with this, numerous previous studies indicate that video-based learning provides significant benefits in improving student comprehension due to its inherent flexibility, the possibility of repeated viewing, and the visualization of complex concepts. For instance, highlights that video-based learning media can

effectively improve student learning outcomes, it is indicating its adaptability to various learning contexts (Cheristiyanto, 2021). This flexibility allows students to engage with the material at their own pace, facilitating a deeper understanding of the subject matter. Similarly, assert that videos can stimulate logical and analytical thinking, thereby enhancing students' imaginative capacities and making the learning process more engaging compared to traditional oral instruction (Rahmatika et al., 2021). Moreover, the repeated use of video content enables students to revisit challenging concepts, reinforcing their learning. emphasize the importance of integrating videos into the course structure, which allows students to clarify their understanding and relate video content to course objectives (Gayatri et al., 2018; Djannah et al., 2020). This iterative exposure to visualized concepts can significantly aid comprehension, as students are able to see and hear the material being presented, which is particularly beneficial for visual learners. discuss the use of interactive video-based learning environments, which can effectively illustrate complex ideas that are difficult to convey through text alone, thus enhancing the overall learning experience (Sarwinda et al., 2020). Students can control their learning process by deciding when and how often to engage with video materials, promoting autonomy and self-directed learning, a crucial aspect of modern education where students increasingly tailor their experiences to meet individual needs.

The significance of this research lies in providing educators with comprehensive insights into the effective integration of Project-Based Learning (PjBL) in biology education to enhance students' collaboration and communication skills. In the context of 21st-century education, the PjBL approach offers a pragmatic solution to this challenge (Rochmawati & Ridlo, 2020; Roemintoyo & Budiarto, 2023; Saimon et al., 2023). This study will furnish guidance on how PjBL can be implemented to facilitate students' development of collaborative and communicative competencies, which are essential for addressing the demands of the evolving global and digital workforce.

Furthermore, the implementation of Project-Based Learning (PjBL) in biology education can align students with real-world issues that necessitate critical thinking and robust collaboration. Previous research findings suggest that the integration of PjBL is expected to facilitate more active student participation in learning and deepen their understanding of biological concepts, while simultaneously honing essential collaborative skills vital for their future in the digital age. Consequently, the overarching aim of this research is to develop a project-based learning video resource for biology that enhances collaboration skills, which are among the crucial 21st-century competencies required by students today.

METHODS

This study employs the Research and Development (R&D) methodology, adopting the Alessi and Trollip model, which consists of three primary phases: planning, designing, and development (Alessi & Trollip, 2001). In this research, the focus is on assessing the feasibility of the learning product, which will be evaluated during the beta testing phase of the development stage. As outlined, the

development process in this study follows the Alessi & Trollip model, which includes key steps: (1) Planning, (2) Design, and (3) Development. Below is an overview of the research and development procedures used in this study, which centers on the creation of a video-based Project-Based Learning (PjBL).

The development process of this instructional video involved two media experts, two subject matter experts, three teachers, and one high school student as subjects. Data were collected using non-test techniques (Arikunto, 2010), through observation, interviews, and questionnaires, wherein the questionnaire was adapted to assess the feasibility of this PjBL-based video media (Andriyani & Suniasih, 2021).

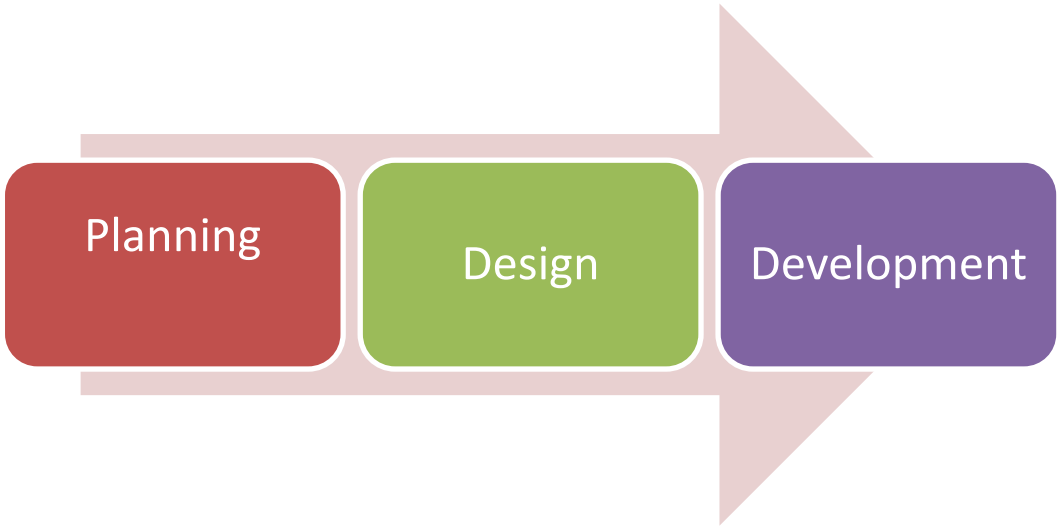

Figure 1. Research design

The instruments used for evaluation by media experts, content experts, and users (teachers and students) encompass several aspects, such as appearance, design, interactivity, and the alignment of content with the curriculum and learning objectives. This media feasibility questionnaire employs a five-point Likert scale (Arisa, 2023). Tables 1, 2, and 3 present the specifications of the media product validation instruments for each validator and user.

Table 1. Media Expert Instrument Grid

Aspect	Indicator
Appearance and Design	Attractive video visual design
	Appropriate use of colors, fonts, and visuals
	Image and video quality
Functionality	Loading speed on YouTube
	Responsive on various devices (smartphone, tablet, laptop)
	No system errors or bugs
Interactivity	Interactive features in the video (e.g., timestamps, comments, polls)
	Clarity of instructions delivered in the video
	Ease of access for users through descriptions or additional links

Adaptation of research Yusuf et al. (2022) and Rahman et al. (2022)

Table 2. Material Expert Instrument Grid

Aspect	Indicator
Material Suitability	Materials are in accordance with the biology curriculum
	Materials are relevant to learning objectives
	Materials are appropriate to students' needs
	Materials are presented in depth
Depth of Material	The level of difficulty of the material is according to the student's level.
	The material covers a variety of perspectives
Clarity and Presentation	The language used is easy to understand
	Systematic presentation of material
	Clear example
	Use of clear illustrations
	Summary or conclusion at the end of each chapter
Evaluation	Practice questions available according to the material
	Practice questions cover various types of questions
	There is feedback for each exercise
	A comprehensive final evaluation is available

Adaptation of research Susantini et al. (2021) and Sary et al. (2023)

Table 3. User Instrument Grid (Teachers and Students)

Aspect	Indicator
Ease of Use	Easy and intuitive navigation
	Clear and easy to understand instructions
	Accessibility on various devices
Interactivity	Availability of interactive features (quizzes, simulations)
	Fast and precise system response
	Interactions that are interesting and motivating
User Satisfaction	Interesting and relevant material
	Attractive visual design
	Enjoyable learning experience

Adaptation of research Rahman et al. (2022) and Motamedi (2019)

Each validator or media feasibility tester undergoes a validation process involving experts. The validation process involves selecting experts for each category of the instrument, such as media experts, content experts, and student representatives. Each expert is then asked to evaluate the quality of the Project-Based Learning (PjBL)-based instructional video, according to their expertise and perspective (Hasyim et al., 2021).

The collected data is then analyzed, particularly from questionnaires administered during the product trials of interactive multimedia. The analysis is carried out using descriptive techniques by calculating the average percentage from the total validation results (Pujawan, 2019). For the PjBL-based instructional video to be deemed feasible as a learning medium, the feasibility analysis must achieve a minimum percentage score of 63% (Bustanil S et al., 2019). Below is a table 4 contain conversion criteria for interactive multimedia feasibility, adapted from various studies (Handayani et al., 2021).

Table 4. Multimedia Interactive eligibility criteria

Percentage	Qualification	Decision
82 – 100%	Very good	Very Eligible
63 – 81%	Good	Eligible
44 – 62%	Enough	Less Eligible
25 – 43%	Deficient	Not Eligible
0 – 24%	Very Deficient	

The effectiveness of video-based learning utilizing Project-Based Learning (PjBL) in this study will be evaluated through the assessment of n-gain scores, which reflect the enhancement of students' collaborative skills. The questionnaire employed to measure these collaborative skills is derived from indicators and aspects identified in several prior studies, including those conducted by Pertiwi et al. (2023), Afelia (2023), and Braathen (2022). Subsequently, the n-gain scores will be classified according to predetermined levels. The categories of n-gain utilized in this research are presented in the table 5.

Table 5. N-Gain Criteria

N-Gain (g)	Interpretation
$g \geq 0,7$	High
$0,3 \leq g < 0,7$	Medium
$g < 0,3$	Low

Adapt from (Wandani et al., 2023)

RESULTS & DISCUSSION

Planning Stages

The planning phase is the initial step in developing a Project-Based Learning (PjBL)-based biology instructional video designed to enhance students' collaboration skills. Based on interviews with several high school biology teachers, it was found that the current teaching methods still rely on traditional approaches such as slide presentations and textbooks. Teachers reported that these methods do not adequately support the development of collaboration skills, as students tend to work individually and are not engaged in activities that foster cooperation among peers.

The interviews also revealed that while students grasp biological concepts well, they rarely participate in group discussions or collaborative activities. This indicates a need for developing instructional media that encourages students to engage in teamwork and problem-solving together. Teachers recognized that PjBL-based video media could offer a solution to this challenge by providing a more interactive learning environment and facilitating team-based learning.

Through the utilization of PjBL-based instructional videos, students are anticipated to engage more actively in biology projects relevant to real-life scenarios. This approach is expected to not only deepen students' understanding of biological concepts but also foster collaborative skills crucial in the modern workplace. Interviews with educators indicate that the implementation of PjBL can enhance students' ability to collaborate effectively, share ideas, and support one

another in completing biology assignments. Overall, the necessity for more interactive and collaborative media in biology education becomes evident based on these interview results. Consequently, PjBL-based instructional videos are considered an effective tool for enhancing students' collaborative skills while simultaneously improving the quality of biology education by connecting theory with practical application.

Design Stage

After identifying field needs through observations and interviews with biology teachers, a solution was conceptualized in the form of an initial product design, namely a Project-Based Learning (PjBL)-based biology instructional video. This product is specifically focused on enhancing students' collaboration skills. Based on interviews with the teachers, the current biology teaching methods are not effective in encouraging collaborative interaction among students, highlighting the need for more interactive instructional media that can facilitate teamwork.

During the development phase, the initial instructional video was designed with clear instructions for project tasks that students must complete in groups. These projects not only allow students to learn biological concepts but also engage intensively with their peers to solve problems related to the biology topics. The aim is to improve students' collaboration skills while deepening their understanding of the subject matter. Below is the initial design of the instructional video media that has been developed.

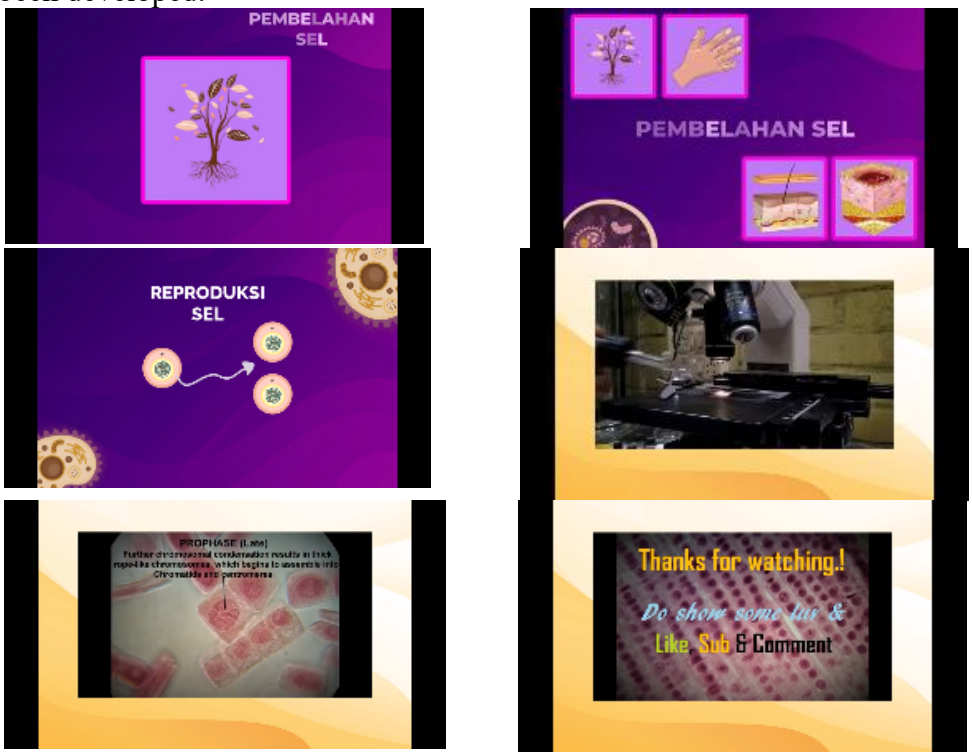

Figure 2. Video Media View

Development Stage

Upon the completion of the development of the educational video product, a validation test was conducted by two media experts and two subject matter experts,

referred to in this development model as the Alpha Test. The purpose of this validation process is to ensure that the product not only meets technical standards but also enhances students' collaborative skills. Below are the results of the initial product validation conducted by the experts.

Table 6. Alpha Test Results

No	Validator	Validation Result Average (%)	Qualification	Decision
1.	Media Expert I	88.9%	Very Good	Very Eligible
2.	Media Expert II	84.4%	Very Good	Very Eligible
3.	Subject Matter Expert I	82.7%	Very Good	Very Eligible
4.	Subject Matter Expert II	85.3%	Very Good	
Average Total Expert Test Results		85.3%	Very Good	Very Eligible

According to Table 6, the alpha test results for the Project-Based Learning (PjBL) video learning product indicate that it has received an excellent evaluation from experts. Media Expert I provided a validation score of 88.9%, categorized as "Very Good," confirming the product's suitability for use. Media Expert II also rated the product with a validation score of 84.4%, classified as "Very Good," and deemed it appropriate for implementation. Furthermore, Subject Matter Expert I recorded a validation score of 82.7%, which falls within the "Very Good" category and was assessed as suitable. Meanwhile, Subject Matter Expert II assigned a validation score of 85.3%, also classified as "Very Good," and concluded that the product is eligbile for use.

The mean total validation score from the four experts is 85.3%, indicating that the product meets a very high standard in terms of media and content. Consequently, this PjBL-based instructional video product is deemed highly suitable for implementation in biology education, particularly as an alternative medium to support the development of students' collaborative skills.

Following the validation of the Project-Based Learning (PjBL) video learning product by experts, the subsequent phase involves conducting user trials, specifically with teachers and students, referred to as Beta Testing in this development model. The objective of these trials is to evaluate the practicality and suitability of the product for student use during biology learning activities. The users involved in the trials comprise education practitioners or teachers and students, categorized into three groups: individual trials, small group trials, and field trials. The assessment results provided by teachers and students, which are included in the beta test series, can be viewed in Table 7 below.

Table 7. Beta Test Results

No	Test Type	Percentage of Validation Results (%)	Qualification	Decision
1.	Practitioner Test I	82.2%	Very good	
2.	Practitioner Test II	80%	Very good	Very Eligible
3.	Practitioner Test III	86.7%	Very good	

4.	Individual Test (3 Students)	84.3%	Very good	Very Eligible
5.	Small Group Test (11 Students)	86.3%	Very good	Very Eligible
6.	Field Trial Test (29 students)	82.8%	Very Good	Very Eligible
Average Result in Beta Test		83.7%	Very Good	Very Eligible

The results of the Project-Based Learning (PjBL)-based instructional video product testing showed excellent outcomes. In Practitioner Test I, the product achieved a validation score of 82.2%, categorized as "Very Good" and deemed feasible. Similarly, Practitioner Test II and Practitioner Test III recorded scores of 80% and 86.7%, respectively, also qualifying as "Very Good" and suitable for use. The individual trial involving 3 students resulted in a validation score of 84.3%, further supporting the product's feasibility in biology learning. The small group trial, involving 11 students, recorded a score of 86.3%, confirming the product's effectiveness in enhancing student collaboration. Additionally, the field trial with 29 students yielded a validation score of 82.8%. Overall, the average user test score reached 83.7%, with a "Very Good" qualification, demonstrating that this product is very eligible as a biology learning medium.

Subsequent to the validation of the Project-Based Learning (PjBL) video learning product by experts and users, the next phase involved direct product testing in the classroom environment. This evaluation encompassed 29 high school students participating in a biology learning class, with a focus on enhancing their collaboration skills through the utilization of PjBL-based video learning.

The testing procedure commenced with the administration of a pre-test to assess the students' initial level of collaboration skills prior to exposure to the video learning material. Subsequently, students engaged in two biology learning sessions employing the PjBL-based video product, during which they worked collaboratively in groups to complete assigned project tasks. Upon conclusion of the learning sessions, a post-test was conducted using the same questions as the pre-test to evaluate the improvement in students' collaboration skills.

In the pre-test and post-test trials, the N-Gain method was used to measure the effectiveness of the Project-Based Learning (PjBL)-based instructional video in enhancing students' collaboration skills. The maximum score that could be achieved in this test was 100. The average pre-test score from 29 students was 73.6, while the average post-test score increased to 86.9 after learning with the PjBL-based instructional video. This indicates an improvement of 13.3 points between the pre-test and post-test scores (86.9 - 73.6). This result is illustrated in Figure 3 below.

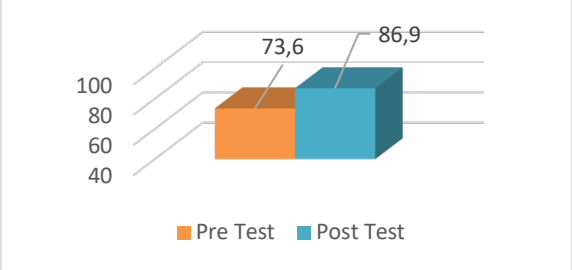

Figure 3. Average Results of Students' Pre-Post Test

Referring to Figure 3, the analysis conducted using the N-Gain method yielded a Gain score of 0.52, which falls within the moderate improvement category ($0.3 < g < 0.7$). This indicates that the video-based learning media grounded in Project-Based Learning (PjBL) has a statistically significant impact on enhancing students' collaboration skills, although the improvement remains within a moderate range. The results suggest that while the developed media is effective in facilitating collaborative work among students, there is still potential for further enhancement to optimize collaborative learning outcomes. Overall, this media sufficiently supports the project-based biology learning process, encouraging students to collaborate in completing their tasks.

The Project-Based Learning (PjBL)-based instructional video developed for biology subjects at the junior and senior high school levels has been proven valid and suitable for use in the learning process. The validity of this video was obtained through a series of validation tests involving experts, teachers, and students as end-users. The instructional video is deemed capable of facilitating an interactive and in-depth understanding of biology material while encouraging active student engagement in collaborative activities. Additionally, the validation results indicate that the video meets the necessary pedagogical and technical standards to support project-based learning, with a primary focus on improving students' collaboration skills.

The uniqueness of this PjBL-based instructional video lies in its distinct approach compared to previous biology learning media. Most prior learning media have typically focused on passive delivery of content, where students receive information without much interaction or active involvement. However, this video is specifically designed to encourage students to actively participate in project tasks related to biology topics. By incorporating visually appealing elements such as animations and infographics tailored to the biology topics, along with clear instructions, the video not only enhances students' comprehension of the material but also increases their engagement in the learning process.

The development of instructional products, such as educational videos in this research, undoubtedly requires validation from various stakeholders to ensure their quality and effectiveness. The study emphasizes the significance of validation by experts, practitioners, and users to enhance the learning experience. Experts play a crucial role in evaluating the content, design, and overall quality of the educational videos, while practitioners provide valuable insights regarding the implementation of the learning materials for students (Prasetyono & Hariyono, 2020). Involving students as potential users in the validation process ensures that the e-modules are engaging, easily comprehensible, and aligned with learners' needs, ultimately improving learning outcomes and student satisfaction (Dewi et al., 2020). For instance, research conducted by Hamida & Desnita (2021) indicates that the involvement of subject matter experts, designers, and media specialists in validating an educational video for physics instruction achieved high scores in media validity, thereby confirming its suitability as a learning medium. Another study conducted by Irtawidjajanti & Azahra (2023) on the development of tutorial videos for fashion design education also took into account feedback from media experts, subject matter specialists, and teachers to evaluate the feasibility of the product prior to its implementation in the learning process. Integrating feedback and validation from

diverse perspectives can enhance the development of Project-Based Learning (PjBL) video resources, ensuring they are more aligned with student needs and effective in addressing challenges encountered. Validation from experts guarantees the accuracy and quality of the media, while insights from practitioners, such as teachers, provide crucial information regarding the application of videos in education, particularly in fostering students' collaborative skills. The perspectives of students as end users ensure that the videos are comprehensible, engaging, and relevant to their needs, thereby increasing their engagement and understanding of the material.

Project-Based Learning (PjBL) has been shown to effectively improve high school students' collaboration skills across various subjects. Multiple studies have reported significant increases in collaboration skills when implementing PjBL compared to conventional teaching methods (Yanti et al., 2012; Widarti et al., 2020). PjBL encourages students to work together, exchange ideas, and respect others' opinions (Purwaningsih et al., 2020), it also enhances students' ability to interact with group members, provide mutual assistance, and take responsibility.

Additionally, Project-Based Learning (PjBL) integrated with video-based resources has demonstrated significant advantages in enhancing high school students' collaboration skills. By engaging students in collaborative projects, PjBL encourages teamwork and communication as they work together towards common goals. Nabila & Putri (2022) emphasize that the use of video media within the PjBL framework makes learning more engaging and relatable, as it often begins with real-world contexts that resonate with students. This relevance not only captures students' attention but also motivates them to collaborate more effectively as they see the practical implications of their projects. This method enhances students' understanding of the subject matter while promoting collaborative efforts, as they must discuss and analyze the video content together. Additionally, the incorporation of video in PjBL not only aids in the visualization of concepts but also encourages students to reflect on their collaborative processes (Anggito et al., 2021). Through projects that require collective input and problem-solving, students learn to negotiate roles, share responsibilities, and support one another, which are key components of effective teamwork. This collaborative environment fosters essential 21st-century skills, preparing students for future academic and professional success.

Effectiveness tests show that the use of Project-Based Learning (PjBL)-based instructional videos significantly enhances students' collaboration skills. The projects presented in the videos encourage students to work together, share ideas, and solve problems collaboratively, thus deepening their understanding of biology while developing essential social skills necessary for team-based learning (Sungkono, 2023). The improvement in collaboration skills demonstrates that PjBL-based learning media is effective in creating an interactive and productive learning environment.

Several studies indicate that Project-Based Learning (PjBL) effectively develops collaboration skills across various subjects, including biology. Multiple studies have demonstrated that PjBL enhances collaborative learning and teamwork activities (Elsamanoudy et al., 2021; Almulla, 2020). The implementation of PjBL has led to significant improvements in students' communication and collaboration

skills (Hasan et al., 2023; Zubaidah, 2018). This approach fosters 21st-century skills, including collaborative and problem-solving abilities (Hujjatusnaini et al., 2022). PjBL has been found to encourage knowledge sharing, discussion, and active participation among students (Elsamanoudy et al., 2021). The integration of PjBL in higher education, particularly in technical fields, has also shown potential in developing soft skills such as teamwork and communication.

It is noteworthy that one of the advantages of the product resulting from this research, in addition to being integrated with a project-based approach, is that it incorporates dynamic and interactive material components through audiovisual presentations and collaborative assignments. This is intended to facilitate students' learning of the material and foster teamwork among students in solving problems or tasks. The findings of this research are corroborated by several studies indicating that media in audiovisual format can serve as a potential solution to enhance students' collaboration skills and teamwork (Hidayatulloh & Ashoumi, 2022; Zhong et al., 2022).

The distinction between this research and previous studies lies in the audio-visual media developed, which takes the form of an educational video accessible through YouTube. Due to its web-based accessibility, this media exhibits a high level of accessibility, as it can ultimately be accessed via both smartphones and laptops, provided there is an internet connection. This research aims to optimize students' collaborative skills through learning and assignments in the Biology subject. Furthermore, it is anticipated that the product, consisting of video media integrated with the Project-Based Learning (PjBL) approach, can be routinely utilized in biology education as one of the efforts to enhance 21st-century 4C skills.

CONCLUSION

The research findings demonstrate that project-based learning (PjBL) videos represent an innovative and effective approach for application in biology education. This method not only creates a more dynamic learning environment but also fosters teamwork among students through collaborative assignments. Prior to implementation, the product received a high feasibility rating, categorized as "very suitable" as a learning medium, providing confidence in the quality and relevance of the media for educational activities. The effectiveness of the PjBL-based video media is further supported by quantitative data; the N-Gain Score analysis reveals a significant improvement in students' computational thinking skills, with an average N-Gain of 0.72, categorized as "high." This aligns with pre-test and post-test results, which show consistent increases in students’ performance across all measured competencies. Consequently, the developed media is highly appropriate for high school biology education, particularly in enhancing students' collaboration and communcation thinking skills. Future research is encouraged to explore the creation of innovative learning media for other subjects and topics while assessing their impact on various 21st-century skills, such as critical thinking, creativity, and communication, to further advance educational practices.

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