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Optimizing Collaboration and Communication Skills of Pre-Service Biology Teachers Based on Cognitive Styles through Scientific Paper Tasks

Imas Cintamulya*
Department of Biology Education, University of PGRI Ronggolawe, Tuban, Indonesia
ORCID: 0000-0001-8852-1481

Iin Murtini
Department of Biology Education, University of PGRI Ronggolawe, Tuban, Indonesia
ORCID: 0009-0008-5822-5794

Warli Warli
Department of Mathematics Education, University of PGRI Ronggolawe, Tuban, Indonesia
ORCID: 0000-0002-5198-2011

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Collaboration and communication have become essential skills in biology learning today. This research aims to describe pre-service biology teacher students' collaboration and communication skills based on reflective and impulsive cognitive styles through scientific paper tasks. This research is designated employing exploratory research using quantitative and qualitative paradigms. The subjects were five reflective and five impulsive students. This study used a familiar figure-matching test to assess cognitive style and an observation sheet to evaluate collaboration and communication skills. The results reveal that impulsive students with high collaboration skills are more than 50%, while reflective students with high collaboration skills are less than 50%. Reflective and impulsive students show distinct strengths in various indicators of communication skills. This research concludes that impulsive students' collaboration skills are superior to those of reflective students. Based on the communication skills indicators, impulsive and reflective students each have different advantages in communication skills. The results have implications for improving the quality of pre-service biology teacher graduates. Pre-service biology teacher students who can write scientific papers will have their 21st-century skills trained. The 21st-century skills trained in writing scientific papers include collaboration and communication, critical thinking, creativity, and digital and information literacy. These 21st-century skills are essential for individuals, including teachers, to face complex problems in the global era.

Introduction

Biology has been a source of exciting and extensive scientific investigation since the invention of the first microscope (Susiyawati & Treagust, 2021; Yadav et al., 2021). As technology advances, more and more scientific knowledge (including Biology) can be

* Correspondency: cintamulya66@gmail.com

accessed regardless of time and place (Aslan, 2021). This condition requires educators to be able to teach biology to provide all information about basic concepts and principles (Muhibbuddin, Safrida, & Hasanuddin, 2018). However, structured tasks, including writing for students using abundant biological knowledge, such as plant anatomy, are still necessary. Sánchez and Sunesson (2023) report that providing structured tasks in written form will impact the complexity, accuracy, and fluency in creating narratives from writing.

Research on biology learning about plant anatomy has empowered many 21st-century skills, such as critical thinking (Andalia, Ridhwan, Roslina, Afni, & Burhanuddin, 2019; Dafrita & Nawawi, 2022; Kustiani, Zaini, & Mulyadi, 2020; Rahayu & Dwiastuti, 2020; Safitri, Sholihat, & Purwanto, 2022), creativity (Agustina, Sholikha, Mas'ud, & Pangsuma, 2022; Suprapto, 2019), and information literacy (Nuraeni & Rahmat, 2019; Susiyawati & Treagust, 2021). However, researchers rarely research collaboration and communication skills in learning biology. Collaboration is part of the 21st-century skills that individuals must have to prepare for their future when entering the world of work (Baran, Baran, Karakoyun, & Maskan, 2021). The success of the collaborative process is determined by interaction and supporting each other in achieving a common goal (Anderson, Guerreiro, & Smith, 2016). In addition, collaborative success in learning occurs when educators are involved in designing activities and students are involved in knowledge construction through tasks. Collaboration in higher education learning aims to enable students to work together to determine the meaning of a concept, find a solution to a problem, or produce a product collaboratively (Mandikonza, 2022).

Collaboration is a recommended method for learning to write. Writing is a communication skill that involves interaction between two or more people in expressing thoughts and sharing knowledge, ideas, or opinions (Fajaryati, Budiyono, Akhyar, & Wiranto, 2020; Nadya, Ismail, Guntur, & Fransori, 2022; Zulfa & Rosyidah, 2020). Sriarunrasmee, Techataweewan, and Mebusaya (2015) defined communication skills as students' ability to express and transfer knowledge through a project, from writing to oral presentations. Therefore, for learning in higher education, students' ability to convey ideas, both orally and in writing, must be emphasized and done collaboratively (Fajaryati et al., 2020). Educators can provide structured tasks to train students' collaboration skills in expressing their thoughts in writing when learning biology. Especially in the era of globalization, collaboration and communication skills are needed in the world of work so that students are motivated to complete tasks and also provide opinions and ideas in solving problems (Bandono, Mukhlis, Susilo, Prabowo, & Maksum, 2023; Baran et al., 2021; Dewi, Erna, Haris, & Kundera, 2021; Fajaryati et al., 2020). Therefore, educators must equip students with these skills.

The student's learning style in completing tasks is another essential aspect of biology learning. Cognitive style influences the student's learning style. Each student has a different cognitive style. One is the reflective-impulsive cognitive style, which refers to differences in individual speed in making decisions in uncertain conditions (Chen, 2021; Masfingatin & Suprapto, 2020; Yuniasari, 2019). Educators use a reflective-impulsive cognitive style in learning when forming groups (Cintamulya, I, Warli & Mawartiningsih, 2019; Muryani & Cintamulya, 2018). Research in the field of mathematics learning has looked at the effective-impulsive cognitive style of students, especially in problem-solving skills (Hidayanto, Permadi, & Lestari, 2022; Hidayati & Kurniasari, 2021; Masfingatin & Suprapto, 2020). However, research on reflective-impulsive cognitive style related to collaboration and communication skills in biology learning is still rare. Collaboration skills related to communication technology, critical thinking, creative thinking, metacognition, writing skills, problem-

solving, and student and teacher perceptions have been widely developed (Alsmadi, Tabieh, Alsaifi, & Al-Nawaiseh, 2023; Asha, Hamengkubuwono, Ruly Morganna, Warsah, & Alfarabi, 2022; Gertrude, 2015; Lupión-Cobos, Girón-Gambero, & García-Ruiz, 2022; Nadya et al., 2022; Ramdani & Susilo, 2022). Researchers examined the beginning of developing communication skills through various models and strategies, including communication strategies, culturally responsive teaching approaches, and Jigsaw cooperative techniques. The implementation of these multiple strategies aims to assist introverted students, minimize the delivery of incorrect messages, develop interprofessional communication, and acquire teamwork skills (Noviyenty, 2022; Reising et al., 2017; Rivet et al., 2022). Next, Özden and Yenice (2022) examine the relationship between communication and scientific inquiry skills in pre-service science teachers.

Based on previous research, the novelty of this research is the collaboration and communication skills of reflective and impulsive pre-service biology teachers through structured tasks, namely writing scientific papers. The research problem formulation is: "How are pre-service biology teacher students' collaboration and communication skills based on reflective and impulsive cognitive styles through scientific paper tasks?" The objectives of the research were (1) to describe the collaboration and communication skills of pre-service biology teachers students' based on reflective and impulsive cognitive styles through scientific paper tasks and (2) to describe the differences in collaboration and communication skills of pre-service biology teachers students' based on reflective and impulsive cognitive styles through scientific paper tasks.

Research Methods

Research Design

This research uses quantitative and qualitative paradigms with exploratory methods, revealing pre-service biology teacher students' collaboration and communication skills based on reflective and impulsive cognitive styles through scientific paper tasks on plant anatomy (Speziale, Streubert, & Carpenter, 2011). This research uses quantitative and qualitative data about pre-service biology teacher students' collaboration and communication skills based on reflective and impulsive cognitive styles collected and analyzed separately (Othman, Steen, & Fleet, 2020). The purpose of collecting qualitative data in this research is to deepen and verify quantitative data.

Research Subject and Data Collection

Researchers conducted this study in the biology education study program at the University PGRI Ronggolawe of Indonesia with 20 students (pre-service biology teachers). Researchers used the MFFT (Matching Familiar Figure Test) instrument to measure the cognitive style of students (Warli, 2010). This measurement aims to determine the research subject. The research subjects comprised five reflective students (WD, RF, DF, DA, and AM) and five impulsive students (AV, NS, AN, MN, and AH). The researcher determined the number of research subjects based on the characteristics of the most reflective and impulsive participants.

The instruments used in this study include (1) a collaboration skills observation sheet, (2) a written communication skills observation sheet, and (3) an MFFT test sheet. Researchers collected data on student collaboration skills during plant anatomy learning. Furthermore, to

assess students' collaboration skills using an observation sheet with indicators adapted from several sources, including (1) discussing tasks well with friends, (2) contributing to the group, (3) listening to others well, (4) respecting and valuing other people's opinions, and (5) working together in solving problems (Hidayat, Hendayana, Supriatna, & Setiaji, 2020; Malik, 2018; Sagala & Simanjuntak, 2019; Winaryati & Munsarif, 2021). The quality of students' collaboration skills is determined based on a rubric of the five indicators.

Students' written communication skills are obtained through non-test techniques using observation sheets based on scientific paper tasks (Rosiani, Parmin, & Taufiq, 2020). The task that students must complete is to write a topic on the concept of plant anatomy from textbooks and research articles. The task components include a title, introduction, material description, summary, evaluation, and references. Students' communication skills are then assessed based on indicators adapted from several sources, including accuracy, interpretation, target audience, organization, quality, and appearance (Al Fatihah, Yennita, & Futra, 2022; Pisano, Crawford, Huffman, Graham, & Kelp, 2021; Rukmini & Saputri, 2017; Saputra & Marfuah, 2022). The quality of students' written communication skills in completing scientific paper tasks is determined using a rubric.

Data on collaboration skills were collected by (1) observing students' collaboration when they completed plant anatomy tasks and (2) observing their collaboration when presenting plant anatomy tasks. Meanwhile, data on communication skills was collected by (1) analyzing writing scientific paper tasks and (2) analyzing writing on PowerPoint when students presented scientific paper tasks. Furthermore, researchers conducted internal validity of the collaboration and communication skills data. The researcher compares the data obtained from the two techniques for collaboration and communication skills. The researcher conducted an internal validity test using the triangulation method, which aims to increase the credibility of the research findings and to ensure the accuracy of the techniques used in collecting data on collaboration and communication skills.

Data on collaboration and communication skills are valid if the observation data of the two techniques are the same. Researchers analyzed the correct and accurate data to obtain conclusions from the research results. Furthermore, after validating the data, researchers assessed data on collaboration and communication skills based on the reflective-impulsive cognitive style. In the study, there were two stages of assessment, namely obtaining achievement scores and weighted scores. The first stage measures the achievement score of collaboration and communication skills of students with reflective-impulsive cognitive styles. The second stage multiplies the achievement score with a weighted score for each indicator of collaboration and communication skills (Tables 1 and 2).

The score weight is determined based on the quality of each indicator of collaboration and communication skills: 1) discussing tasks with friends well (weighted 3); 2) contributing to the group (weighted 3); 3) listening to others well (weighted 2); 4) appreciating and respecting other people's opinions (weighted 2); 5) working together in solving problems (weighted 3); 6) accuracy of scientific content (weighted 3); 7) interpretation of scientific content (weighted 3); 8) target audience (weighted 2); 9) organization (weighted 2); 10) quality of writing (weighted 3); 11) appearance (weighted 2); 12) reference sources (weighted 3).

Table 1. Collaboration skills quality

Collaboration skills quality	Weighted score
High collaboration skills	Ws ≥ 27
Moderate collaboration skills	14 ≤ Ws ≤ 26
Low collaboration skills	6 ≤ Ws ≤ 13
Shallow collaboration skills	0 ≤ Ws ≤ 5

Table 2. Communication skills quality

Communication skill quality	Weighted score
High communication skills	Ws ≥ 41
Moderate communication skills	25 ≤ Ws ≤ 40
Low communication skills	11 ≤ Ws ≤ 24
Shallow communication skills	0 ≤ Ws ≤ 10

Data Analysis

Data analysis aims to systematically organize observation notes, improve understanding, and present findings regarding students' collaboration and communication skills based on reflective-impulsive cognitive styles. This study used qualitative data analysis techniques according to de Casterlé, Gastmans, Bryon, and Danier (2012), which consists of four stages, namely: (1) data collection, (2) data reduction, (3) data presentation, and (4) conclusion drawing and verification. Data collection in this study relates to data sources in words and actions that reflect students' collaboration and communication skills based on reflective-impulsive cognitive styles. Data reduction summarises the data collection results on collaboration and communication skills of students based on reflective-impulsive cognitive style into categories (excellent, good, sufficient, and less). Data will be presented as a result of activities to collect information about collaboration and communication skills based on students' reflective-impulsive cognitive style to provide conclusions. Data presented in this study are in the form of narrative text and graphs.

In addition, to determine the validity of the data in this study, several stages were carried out, namely: (a) credibility test (internal validity), which shows the level of confidence of findings regarding the skills of collaboration and communication of students based on reflective-impulsive cognitive styles as evidenced by using the triangulation method (in this case using two different methods); (b) transferability test (external validity), looking for and collecting empirical events about the skills of collaboration and communication of students based on reflective-impulsive cognitive style in a similar context and then presenting it in the form of descriptive data; (c) reliability test (reliability), conducting a tracking audit of all records of observations, ranging from the process to the results of research; and (d) confirmability test (confirmability), ensuring that the findings on the skills of collaboration and communication of students based on reflective-impulsive cognitive style through scientific paper tasks are really based on data to then draw logical conclusions.

Results

The data consists of (1) collaboration skills of pre-service biology teacher students based on reflective and impulsive cognitive styles in completing scientific paper tasks and (2) communication skills of pre-service biology teacher students based on reflective and impulsive cognitive styles in completing scientific paper tasks.

The collaborative skills of pre-service biology teacher students based on reflective and impulsive cognitive styles in completing scientific paper tasks

Assessment of collaborative skills of pre-service biology teacher students based on reflective and impulsive in completing scientific paper tasks using indicators of collaborative skills, including (1) discussing assignments well with friends, (2) contributing to groups, (3) listening to others well, (4) appreciate and respect other people's opinions, and (5) work together in solving problems. The results of the assessment of the quality of collaborative skills of pre-service biology teacher students based on reflective and impulsive skills in completing scientific paper tasks are in Tables 3 and 4. Furthermore, the results of comparing the quality of collaboration skills between pre-service biology teacher students who are reflective and impulsive in completing scientific paper tasks are in Figure 1.

Table 3. Scores and weight pre-service biology teacher students' collaboration skills who are reflective in completing scientific paper tasks

Collaboration Skill Indicator Score × Weight	**Reflective Students**				
	WD	**DA**	**RF**	**DF**	**AM**
1st Indic (3)	9	9	6	6	6
2nd Indic (3)	9	6	6	6	6
3rd Indic (2)	6	4	4	4	4
4th Indic (2)	6	4	4	4	4
5th Indic (3)	9	9	6	6	6
Total Score x Weight	39 HC	29 HC	26 MC	26 MC	26 MC

Descriptions: HC (high collaboration), MC (moderate collaboration), 1st Indic (Discuss assignments with friends well), 2nd Indic (Contribute to groups), 3rd Indic (Listen to others well), 4th Indic (Appreciate and respect the opinions of other people), and 5th Indic (Work together to solve problems).

Table 4. Scores and weight pre-service biology teacher students' collaboration skills who are impulsive in completing scientific paper tasks

Collaboration Skill Indicator Score × Weight	**Impulsive Students**				
	AV	**NS**	**AN**	**MN**	**AH**
1st Indic (3)	9	9	9	6	6
2nd Indic (3)	9	6	9	6	6
3rd Indic (2)	9	4	6	4	4
4th Indic (2)	6	4	6	4	4
5th Indic (3)	6	9	9	6	6
Total Score x Weight	39 HC	29 HC	39 MC	26 MC	26 MC

Descriptions: HC (high collaboration), MC (moderate collaboration), 1st Indic (Discuss assignments with friends well), 2nd Indic (Contribute to groups), 3rd Indic (Listen to others well), 4th Indic (Appreciate and respect the opinions of other people), and 5th Indic (Work together to solve problems).

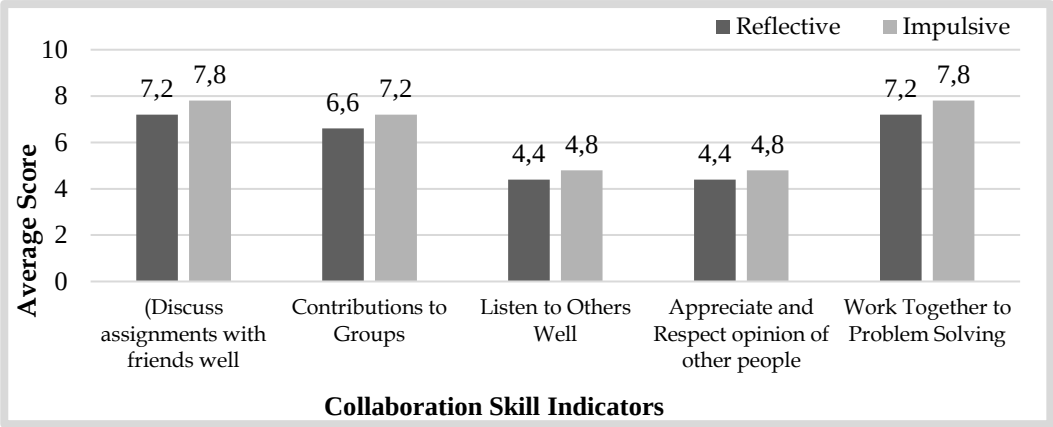

Figure 1. Pre-service biology teachers students' collaboration skills who are reflective and impulsive in completing scientific paper tasks

Figure 1 shows essential findings regarding collaboration skills based on five indicators, namely: 1) pre-service biology teacher students who are impulsive with the high category in collaboration skills totaling more than 50%, and 2) pre-service biology teacher students who are reflective with the high category in collaboration skills totaling less than 50%. These results mean that pre-service biology teacher students who are impulsive are better than pre-service biology teacher students who are reflective in completing scientific paper tasks based on five indicators of collaboration skills.

The communication skills of pre-service biology teacher students based on reflective and impulsive cognitive styles in completing scientific paper tasks

Comparison of communication skills between pre-service biology teacher students who are reflective and impulsive in completing scientific paper tasks based on indicators of accuracy, interpretation, audience targeting, organization, quality, and appearance (Figures 2-7). The scientific paper tasks include a title, introduction, material description, summary, evaluation, and reference components

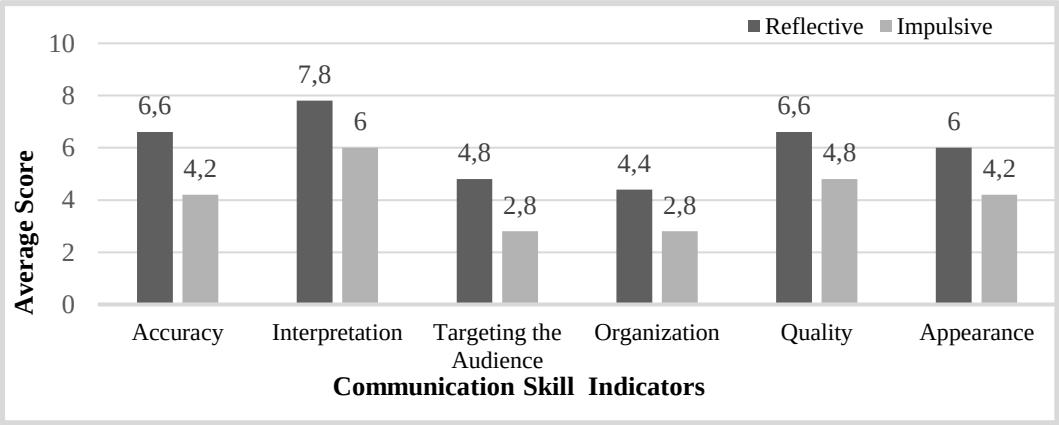

Figure 2. Pre-service biology teachers students' communication skills who are reflective and impulsive in creating the title

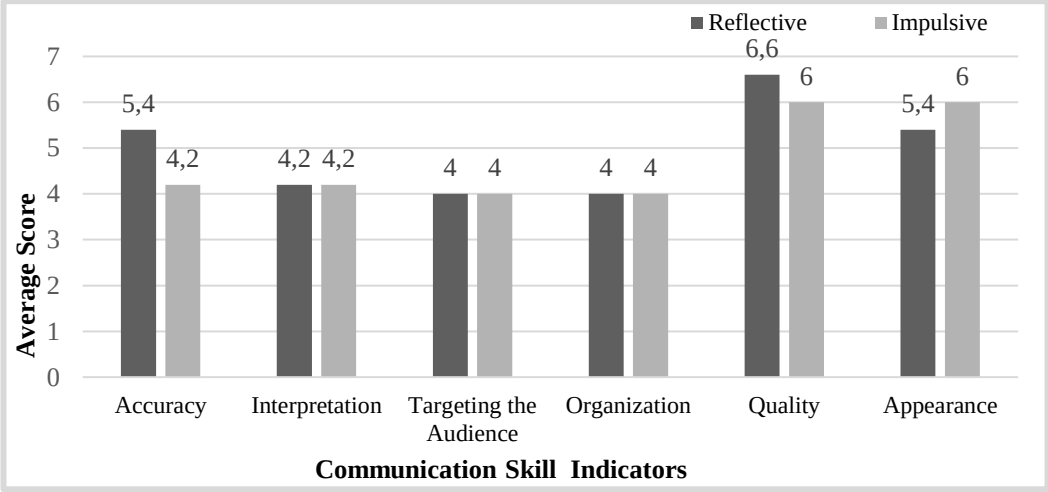

Figure 3. Pre-service biology teachers students' communication skills who are reflective and impulsive in creating the introduction

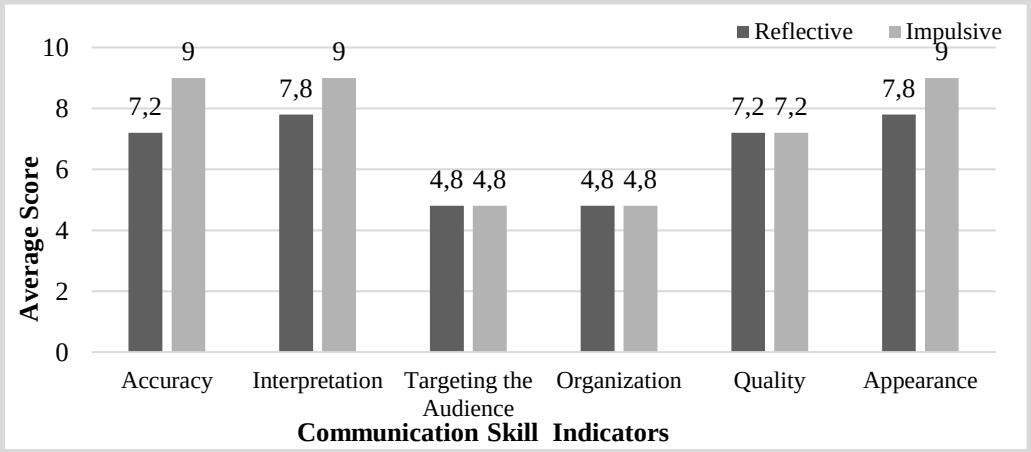

Figure 4. Pre-Sevice biology teachers students' communication skills who are reflective and impulsive in creating the material

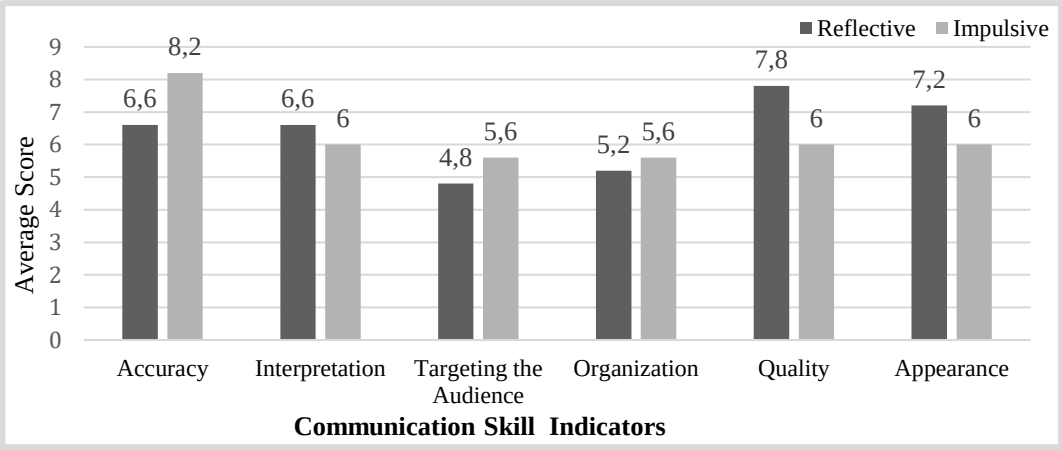

Figure 5. Pre-service biology teachers students' communication skills who are reflective and impulsive in creating the summaries

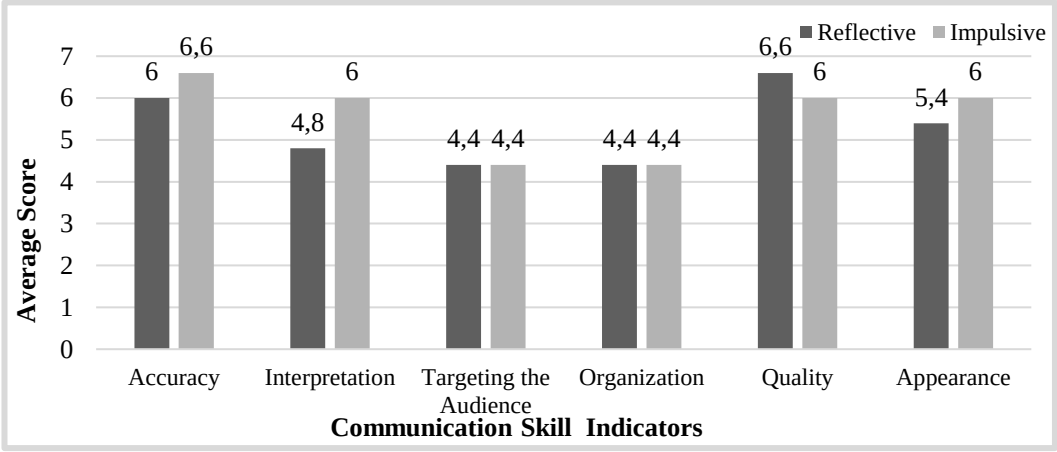

Figure 6. Pre-service biology teachers students' communication skills who are reflective and impulsive in creating the evaluation

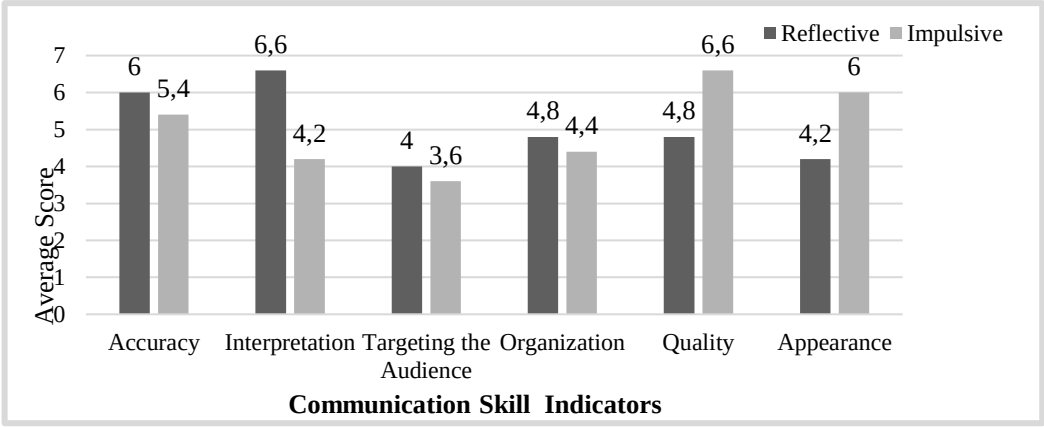

Figure 7. Pre-service biology teachers students' communication skills who are reflective and impulsive in creating the reference

Figure 2-7 shows essential findings regarding communication skills, including:
Reflective students' communication skills are better than impulsive students in creating titles for all communication skill indicators (accuracy, interpretation, target audience, organization, quality, and appearance).

Reflective students' communication skills differ from impulsive students when composing an introduction in terms of 1) reflective students' communication skills are better than impulsive students when composing an introduction based on accuracy and quality indicators; 2) impulsive students' communication skills are better than reflective students when composing an introduction based on performance indicators; and 3) reflective students' communication skills are the same as impulsive students when composing an introduction based on interpretation, target audience, and organization indicators.

Reflective students' communication skills differ from impulsive students when compiling material descriptions in terms of 1) impulsive students' communication skills are better than reflective students when compiling material descriptions based on indicators of accuracy, interpretation, and appearance; and 2) reflective students' communication skills are the same as impulsive students in compiling material descriptions based on indicators of the target audience, organization, and quality.

Reflective students' communication skills differ from impulsive students when compiling summaries in terms of 1) impulsive students' communication skills are better than reflective students when compiling summaries based on indicators of accuracy, target audience, and organization; and 2) reflective students' communication skills are better than impulsive students when compiling summaries based on indicators of interpretation, quality, and appearance.

Reflective students' communication skills are different from impulsive students when evaluating in terms of 1) reflective students' communication skills are better than impulsive students in the evaluation component based on quality indicators; 2) impulsive students' communication skills are better than reflective students in the evaluation component based on accuracy, interpretation, and appearance indicators; and 3) reflective and impulsive students have the same communication skills based on the target audience and organization indicators in the evaluation component.

Reflective students' communication skills differ from impulsive students when compiling references in terms of 1) reflective students have better communication skills than impulsive students in compiling references based on indicators of accuracy, interpretation, target audience, and organization; and 2) impulsive students have better communication skills than reflective students in compiling references based on indicators of quality and appearance.

Discussion

Information about students' collaboration and communication skills is crucial for educators in higher education. Students must have both skills to have a successful career after graduating from an educational institution. Therefore, information about students' collaboration and communication skills is helpful for educators to consider when designing learning models and supporting tools. Furthermore, through reflective and impulsive cognitive styles, learning models and support tools empower these skills . Research on reflective and impulsive cognitive styles in education is rarely done (Chen, 2021), especially regarding collaboration and communication skills. Therefore, the novelty of this research is

the collaborative and communication skills of reflective and impulsive students through the scientific papers tasks.

The collaboration skills of reflective and impulsive biology teacher pre-service students

This finding shows that impulsive students have better collaboration skills than reflective students. This finding contradicts Seçer, Celikoz, Koçyigit, Seçer, and Kayili (2010) research, which explains that reflective students' collaboration skills are better than those of impulsive students. This result also contradicts several studies on problem-solving and critical thinking skills, where reflective students are always superior (Bagheri Masoudzade & Fatehi Rad, 2021; Fitriyani, Setyawan, Hendroanto, & Istihapsari, 2021; Muhtarom, Sugiyanti, Utami, & Indriyana, 2018; Muthmainnah, Subarinah, Amrullah, & Arjudin, 2022). Chen (2021) explains that individuals with reflective and impulsive cognitive styles have advantages. Through collaboration, students can find various opinions and ideas (Seçer et al., 2010). In addition, the cognitive style impacts students' behavior and attitude in the learning environment. Thus, differences in style can affect the results obtained if students search for information and access various information (Simuth & Sarmany-Schuller, 2014). Collaborative learning in completing scientific paper tasks was more supportive of the behaviors and attitudes of impulsive students. Impulsive students completed the scientific paper tasks using more of their knowledge during collaboration. Through collaboration, impulsive students are more active in sharing knowledge to gain more understanding through joint exploration and achieve shared meaning. In addition, collaboration makes impulsive students more involved in the learning process than reflective students, thus improving concept mastery (Eshuis et al., 2019).

Chen (2021) explains that the impulsive style will be advantageous in collaborative activities because it has advantages in terms of language fluency. Impulsive students speak enthusiastically and dare to express their views and opinions in class. Impulsive students often react quickly and thoughtlessly to internal and external stimuli, regardless of the negative consequences of these reactions. In addition, impulsive students respond quickly because their thought process is holistic, even though they are cognitively immature (Cheval, Sarrazin, Isoard-Gautheur, Radel, & Friese, 2016; Rozencwajg & Corroyer, 2010). This characteristic supports them in working collaboratively, thus allowing them to express their opinions when working on scientific paper tasks. Indicators of collaboration skills include (1) discussing tasks with friends well, (2) contributing to the group, (3) listening to others well, (4) appreciating and respecting other people's opinions, and (5) working together in solving problems, which can be done better by impulsive students.

In contrast, reflective students who speak cautiously tend to have advantages regarding language precision (Chen, 2021) and are less supportive of collaborative work in completing scientific paper tasks. Collaborative work requires speed of reaction in conveying opinions or views to the group. Therefore, the characteristics of reflective students who are cognitively mature, always think analytically in solving problems, and have high self-control are less supportive of collaboration skills (Rozencwajg & Corroyer, 2010).

The communication skills of reflective and impulsive biology teacher pre-service students

In creating titles, reflective students' communication skills are better than impulsive students for all indicators of communication skills (accuracy, interpretation, target audience,

organization, quality, and appearance). Ecarnot, Seronde, Chopard, Schiele, and Meneveau (2015) explained that the title is an essential part of an article and should stimulate people's interest in reading it through keywords that reflect its content. This condition benefits reflective students with traits that support title creation, namely the need for analytical thinking (Rozencwajg & Corroyer, 2010) and high accuracy. Although it only consists of a few words, it requires critical thinking skills (Cahyono, Kartono, Waluyo, & Mulyono, 2019; Michalska & Zając-Lamparska, 2015), accuracy and precision in language to be easily understood by readers (Chen, 2021).

Reflective students' communication skills in making introductions are better than impulsive students based on accuracy and quality indicators. Based on appearance indicators, impulsive students' skills are better than reflective students in making introductions. In contrast, based on the indicators of interpretation, audience targeting, and organization, reflective students' skills are the same as impulsive students in making introductions.

Impulsive students' skills are better at making material descriptions than reflective students based on accuracy, interpretation, and appearance indicators. In contrast, reflective students' skills differ from those of impulsive students based on the target audience, organization, and quality indicators. Impulsive students' skills were better at making summaries than reflective students based on accuracy, audience targeting, and organization indicators. Furthermore, reflective students' skills are better than impulsive students based on interpretation, quality, and appearance indicators.

In making evaluations, the communication skills of reflective students are better than those of impulsive students based on quality indicators. Impulsive students' communication skills are better than reflective students' in completing scientific paper tasks based on accuracy, interpretation, and appearance indicators. Reflective and impulsive students have the same communication skills in completing scientific paper tasks based on the target audience and organization indicators.

Reflective students have better communication skills in compiling references than impulsive students in completing plant anatomy tasks based on indicators of accuracy, interpretation, audience targeting, and organization. Impulsive students have better communication skills than reflective students when completing scientific paper tasks based on quality and appearance indicators.

Communication skills of reflective and impulsive students have advantages in the introduction, material description, summary, evaluation, and reference. The results of this study follow Chen's (2021) explanation, which states that individuals with reflective and impulsive cognitive styles have advantages/peculiarities in terms of fluency and accuracy of language. They also have unique thinking processes (analytical vs. holistic)(Rozencwajg & Corroyer, 2010) and differences in the speed of responding to a problem (careful vs. hasty) (Muhtarom et al., 2018; Razmjoo & Mirzaei, 2009). These characteristics result in differences in the communication skills profiles of reflective and impulsive students for each task component. The difference occurs because there is a match between the characteristics of reflective and impulsive cognitive styles with indicators of communication skills (accuracy, interpretation, audience targeting, organization, quality, and appearance).

Conclusion

This research has explained that impulsive biology teacher pre-service students' collaboration skills are better than reflective biology teacher pre-service students in completing scientific paper tasks. The characteristics possessed by impulsive students are more supportive of optimizing collaboration skills in completing scientific paper tasks based on indicators of 1) discussing tasks well with friends, (2) contributing to the group, (3) listening well to others, (4) respecting and valuing other people's opinions, and (5) working together in solving problems. Furthermore, the communication skills of reflective and impulsive biology teacher pre-service students differ in completing scientific paper tasks on the components of titles, introductions, material, evaluations, and references. The difference in communication skills is due to students' reflective and impulsive characteristics, each of which has advantages in communication skills according to the indicators. Reflective students' communication skills are better than impulsive students' for all indicators of communication skills (accuracy, interpretation, target audience, organization, quality, and appearance) when making titles. Reflective students' communication skills differ from impulsive students in completing scientific paper tasks in the aspects of introduction, material descriptions, evaluations, and references. The difference in communication skills between the two style characteristics is because each has advantages according to the communication skills indicators.

The research findings will have implications for improving the quality of prospective biology teacher graduates. Prospective biology teachers must understand and have the skills to empower 21st-century skills for their future students. Therefore, writing scientific papers can be one way to optimize collaboration and communication skills, which are the demands of learning in the 21st century. Collaboration skills have become essential for students and employees in the era of globalization and the rise of technology as skills for achieving meaningful and effective results. The power of modern media and communication technology in all aspects of life makes learning essential to empower communication skills for prospective teachers. Educators' success and professionalism in competition in the global world require innovative capacity, creative spirit, critical thinking, collaboration, and communication. Thus, once they become educators, they will do a much better job teaching and developing skills in the 21st century, indispensable for participation, achievement, and competitiveness in the global economy.

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