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Analysis of Collaboration, Communication, Critical Thinking, and Creative Thinking Ability of Students in Solving Science Problems in Terms of Gender

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Abstract. This research is motivated by the existence of information related to the ability that students must possess today, namely collaboration, communication, critical thinking, and creative thinking ability. The purpose of this study was to analyze in more detail the students' 4C abilities in solving science problems in terms of gender. This research includes quantitative research involving the first-semester of science students of FTK UIN Mataram who are taking introductory physics courses. The participants used in this study were 67 students, of which 32 were male students and 35 were female students. Collaboration and communication ability are measured during the lecture process using observation sheets. Critical thinking and creative thinking were measured using written test questions with a description of 10 questions each. The data obtained were analyzed using descriptive statistics and Rash modeling. The results showed that female students' collaboration and creative thinking abilities were better than male students. The results also showed that male students' communication and critical thinking ability were better than female students. In general, the 4C abilities possessed by female students and male students are not much different.
Keywords: Collaboration, communication, critical thinking, creative thinking

Introduction

Academies, polytechnics, high schools, institutes, and universities are all examples of institutions of higher learning that organize higher education (Ogunode & Musa, 2020). Higher education institutions are required to provide community service, education, and research (Posselt et al., 2019). The purpose of Higher Education is to train students to be community members with academic and/or professional aptitudes who can apply, advance, and/or broaden their knowledge of science, technology, and/or the arts (Saleh & Mujahiddin, 2020). As an educational unit that has an obligation to provide education, it is necessary to prepare an educational curriculum in the lecture process. One of them is the course curriculum for science students.

The science course is one of the subjects that must be taken by science students at universities, including science students at the Faculty of Education and Teacher Training Universitas Islam Negeri Mataram (FTK UIN Mataram). This course studies material related to natural phenomena that can be viewed from physics, chemistry, and biology. Lecturers of science courses (physics, chemistry, and biology) must prepare graduates who are able to live independently and play a role in their environment (Atangana &

Gómez-Aguilar, 2018; Bahtiar & Wasis, 2016). After graduating, they are equipped to handle the difficulties of an increasingly globalized world (Peppoloni & Di Capua, 2021). Students must be equipped with critical, independent, and disciplined ways of thinking (Egege & Vered, 2019). In the lecture process, effective communication is needed in order to be able to solve problems to overcome egocentric attitudes (Renn, 2020; Rosenbaum & Lawrence, 2017). The 21st-century ability that students need is collaboration, communication, critical, and creative thinking (4C) abilities (Handajani & Pratiwi, 2018; Bahtiar, 2023; Widiawati et al., 2018).

Collaboration is a learning process in which collaborating with one another helps complete tasks, is able to work together in groups, and adapt (Sipayung et al., 2018), (Erdoğan, 2019; Li et al., 2022). Someone who has collaboration ability will make it easier to solve problems together (Agauglo & Demir, 2020; Maimun & Bahtiar, 2022b). Collaboration ability relates to students' ability to work together to achieve common goals (Tang et al., 2020). The process of optimizing students' collaboration abilities as one of the important aspects of lifelong learning requires information about the student's collaboration ability profile (Agussuryani et al., 2022). Collaboration in the lecture process is a form of cooperation with each other, helping and complementing each other in carrying out certain tasks in order to obtain a predetermined goal. Have the ability to work in groups and be able to adapt various roles and groups. In addition to collaboration, students also need to have communication abilities (Mariano & Chiappe, 2021; Maimun & Bahtiar, 2022a).

Communication is the process of delivering information, ideas, and emotions using symbols, words, pictures, and others so as to help evoke a response from the recipient (Vithayaporn et al., 2021). The important of students' capacity for communication includes their ability to adapt to a new social environment and more easily establish relationships with other individuals (Claramita et al., 2020), (Kumaro & Barliana, 2022). Communication requires language that is easy to understand, respects the opinions of others, and explains with a logical mind (Chaka, 2020), (Gunawan et al., 2021). Improve communication ability, it can be done by getting used to having the courage to appear to speak in public (Mansor et al., 2020), (Tee et al., 2022). This courage to appear can only be brought out by students from within. Communication can be done verbally or non-verbally, formally and non-formally (Efendi et al., 2020). By communicating, humans can relate to each other, in daily life at home, in institutions, in communities, or wherever humans are (Goyal et al., 2022).

Another ability that students also have is the ability to think critically (Jatmiko et al., 2021). Critical thinking ability is an evaluative thinking ability that shows the human ability to see the gap between reality and truth by referring to ideal things, as well as being able to analyze and evaluate and be able to make stages of problem-solving (Isdianti et al., 2021). Students who usually think critically will go deep or dig up information and understand a problem well so that they can make decisions wisely (Bahtiar & Ibrahim, 2022). Students must be able to think critically, be independent, self-disciplined and improve their own thinking processes. It requires effective communication and problem-solving to overcome egocentrism. Critical thinking means being able to express thoughts and reasons according to the situation, and being able to make decisions and make solutions to solve problems (Vithayaporn et al., 2021).

The ability to think creatively is also one of the 4C components that must be possessed by students (Akyıldız & Çelik, 2020). Creativity is how productive thinking has the creativity of an open and responsive mind (Cai, 2021). The ability to think creatively is closely related to the creative thinking process, and the creative thinking process is related to the process of creating (Yalçın & Erden, 2021). Thinking creatively means being able to express conceptual and practical creative ideas (Wan et al., 2021; Azid et al., 2022). States that students must be able to think creatively in order to be

competitive in the world of work and have new innovations (Cheng, 2019; Bahtiar & Ibrahim, 2022). To be creative, students must: (1) work at the edge of competence, not in the middle; (2) review ideas; (3) do something because of internal impulses and not because of external impulses; (4) divergent/spreading mindset; (5) lateral/imaginative mindset. If you experience failure, get up again and use it as learning and be able to adapt to new situations and make a positive contribution to the surrounding environment (Aytug et al., 2018).

Based on the results of observations and interviews with lecturing activities for natural science students of FTK UIN Mataram, there are several problems, namely, students think learning is only oriented to completeness grades so they look for practical ways, students often have difficulty connecting the previous material with the material being studied even material in everyday life, and students still do not think about the benefits of learning outcomes for their lives. Some of these problems are very contrary to the mental growth of students' awareness and greatly raise the paradigm of thinking that is instantaneous to obtain their ideals or desires. This happens because not all lecturers implement activities that lead to a better interest in 4C abilities, exams that require cognitive dominance of learning completeness are not diagnostics and have not involved the role of the environment as a learning resource such as campus, laboratory, and surrounding communities and there are still students' thoughts that are still cognitively oriented from the end of learning. So that students are still looking for a quick way to get the answer keys to questions that are almost appropriate/equivalent to the questions without discussing, communicating, developing new ideas, and thinking more critically.

In the 21st century, everyone can get information from anywhere, including looking for information about science learning (Bahtiar et al., 2022). There are search technologies such as google, websites, and youtube, as well as non-formal educational institutions that use the internet as a communication tool in discussing science learning. Thus people in the world can come together to solve problems together in the same problem to find solutions. However, not all answers, methods, or opinions given to all problems are the same and correct. Critical thinking is needed to respond to new things that are obtained in the digital world.

Therefore, based on the description above, the purpose of this study was to analyze the collaboration, communication, critical, and creative thinking (4C) abilities of students in solving science questions in terms of gender. There are three things that underlie the importance of this research: (1) to find out the 4C abilities of FTK UIN Mataram Science students; (2) as material/reference for lecturers to pay attention to student characteristics, especially gender in terms of using methods, models, approaches, and learning strategies; (3) as evaluation material for course lecturers to pay attention to the 4C component in the lecture process and the assessment process.

Methods

This research is included in quantitative research. Quantitative research is research that describes and analyzes data using statistical analysis. In this study, researchers describe and analyze data from observations of collaboration and communication ability of science student of FTK UIN Mataram as well as posttest results of critical thinking

ability and creative thinking ability. Participant in this study were first-semester students of the Science Education Study Program FTK UIN Mataram who took basic physics courses 1. The total participants used were 67 students, of which 32 were male and 35 were male. female students, as shown in Figure 1

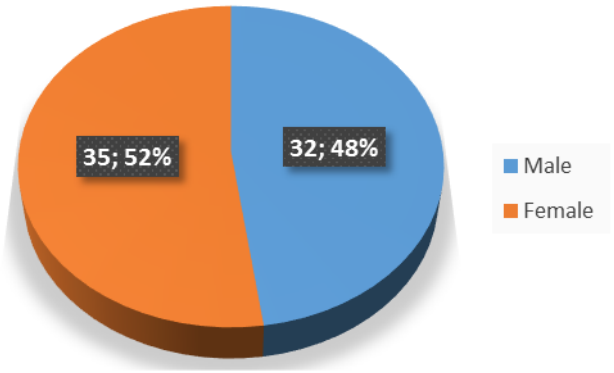


Figure 1. Research Participant

This research was conducted for 4 months, from June 2022 to October 2022. The implementation procedure is presented in the form of Figure 2.

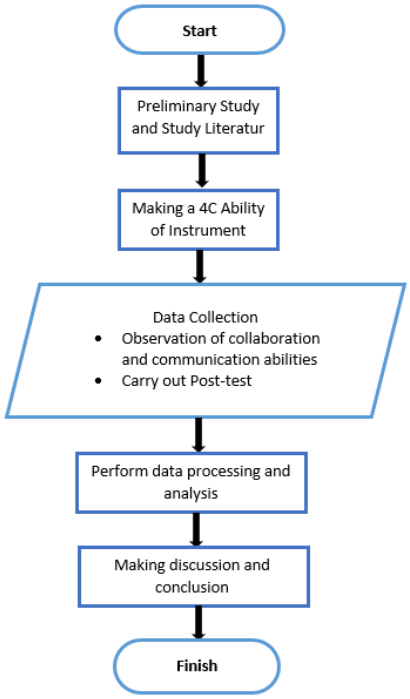


Figure 2. Research Procedures (Bahtiar et al., 2022)

The research instrument was made according to the research variables, which consisted of four components, namely collaboration ability, communication ability, critical thinking abilities, and creative thinking abilities. The 4C research instrument grid is presented in Table 1.

Table 1. 4C Capability Instrument Grid

No.	Component of 4C Ability	Code	Indicator	No. Item
1	Collaboration	CLB	1. Work productively with others (**CLB1**) 2. Participate and contribute actively (**CLB2**) 3. Take joint responsibility to complete the work (**CLB3**) 4. Participate respectfully in discussions, debates, and disagreements (**CLB4**) 5. Always compromise with the team to solve problems (**CLB5**)	S1, S2, S3, S4, and S5
2	Communication	COM	1. Speaking Ability (**COM1**) 2. Listening Ability (**COM2**) 3. 3. Nonverbal Communication Ability (**COM3**)	S1, S2, and S3
3	Critical Thinking Ability	CriTA	1. Elementary Clarification (**CriTA1**) 2. Basic Support (**CriTA2**) 3. Inference (**CriTA3**) 4. Advance Clarification (**CriTA4**) 5. Strategy and Tactics (**CriTA5**)	Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q9, and Q10
4	Creativity Thinking Ability	CreTA	1. Fluency (**CreTA1**) 2. Flexibility (**CreTA2**) 3. Originality (**CreTA3**) 4. Elaboration (**CreTA4**)	Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q9, and Q10

Data analysis in this study used descriptive statistics and Rash Model analysis. Rash modeling used mathematically is presented in the following equation.

$$P_{ni}\left(x_{ni}=\frac{1}{\beta_n},\delta_i\right)=\frac{e^{(\beta_n-\delta_i)}}{1+e^{(\beta_n-\delta_i)}} \qquad 1$$

Results and Discussion

Science education students who were used as research samples were first-semester students of physics education, chemistry education, and biology education who were taking basic physics courses 1. The measurement of the 4C ability of science students was carried out by observing during the learning process for collaboration and communication ability, as well as taking tests to determine students' critical and creative thinking ability. The results of the analysis of the 4C ability of the science students of FTK UIN Mataram are explained as follows.

Collaboration Ability

Collaborative ability is a process of working together to generate ideas and solve scientific problems together toward a common vision (Yu et al., 2022). When the science learning process is interconnected, collaboration ability are the main key to solving science problems in discussion activities. Collaboration ability are important for achieving the best results when solving complex problems (Graesser et al., 2018). To determine the ability of students to collaborate, measurements were made with indicators (1) Work productively with others (CLB1); (2) Participant science and contribute actively (CLB2); (3) Take joint responsibility to complete the work (CLB3); (4) Participant science respectfully in discussions, debates, and disagreements (CLB4); and (5) Always

compromise with the team to solve problems (CLB5). Collaboration ability is measured during the discussion process in class. Lecturers who act as facilitators also observe students' collaboration abilities. The results of the observations are presented in the form of the following analysis results.

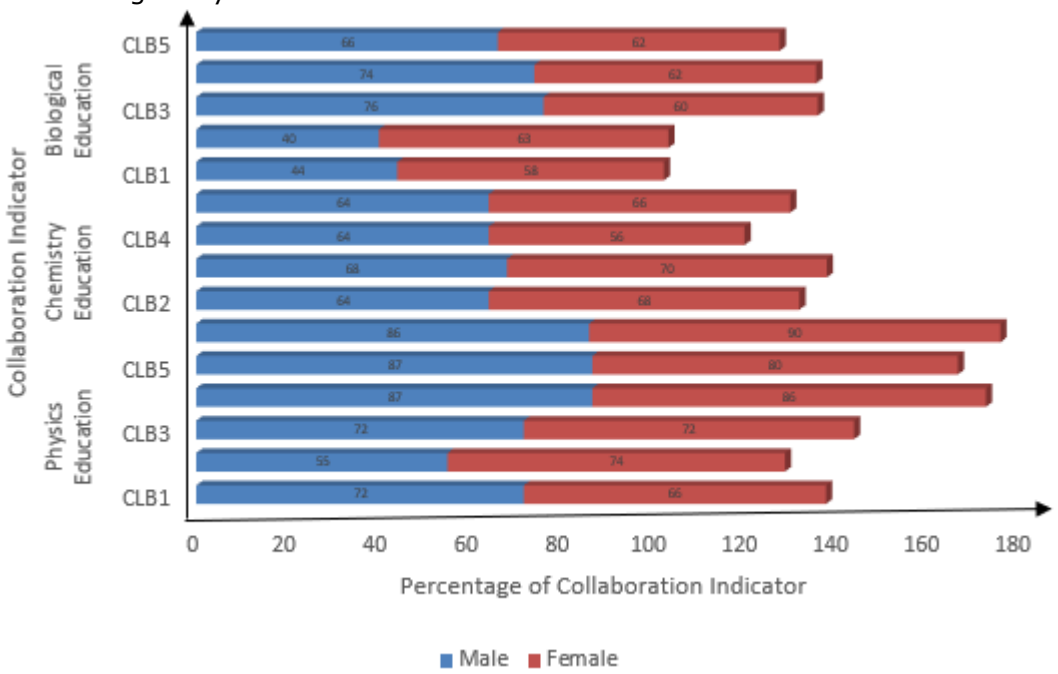


Figure 3. Science Students' Collaborative Ability Based on Gender in terms of Indicators

Figure 3 shows that the collaboration ability of science students of FTK UIN Mataram during the learning process is more dominant by female students than male students. This can be seen from the percentage obtained by female students is higher than male students. In addition, each indicator of the collaboration ability of female students is more dominant than male students. However, in some indicators, male students are more dominant than female students, such as indicators CLB1, CLB4, and CLB5 in physics education students; CLB4 in chemistry education students; and CLB3, CLB4, and CLB5 in biology education students. The high number of indicators for male students was because during the discussion male students in the study program showed a willingness to cooperate among their discussion partners, and provided active caricature sciencetion in the discussion process.

These factors have a good impact on students' collaboration ability in science course lectures which are exact learning (White, 2018), (Nortvig et al., 2018). Osborne et al., stated that collaboration can be seen clearly when students carry out practical activities and discussions (Osborne et al., 2018). The same thing was conveyed by Malik & Ubaidillah, (2021)which stated that female students in group discussions tend to prefer to solve science problems. The results of the analysis of collaboration capabilities can also be seen more clearly in Figure 4.

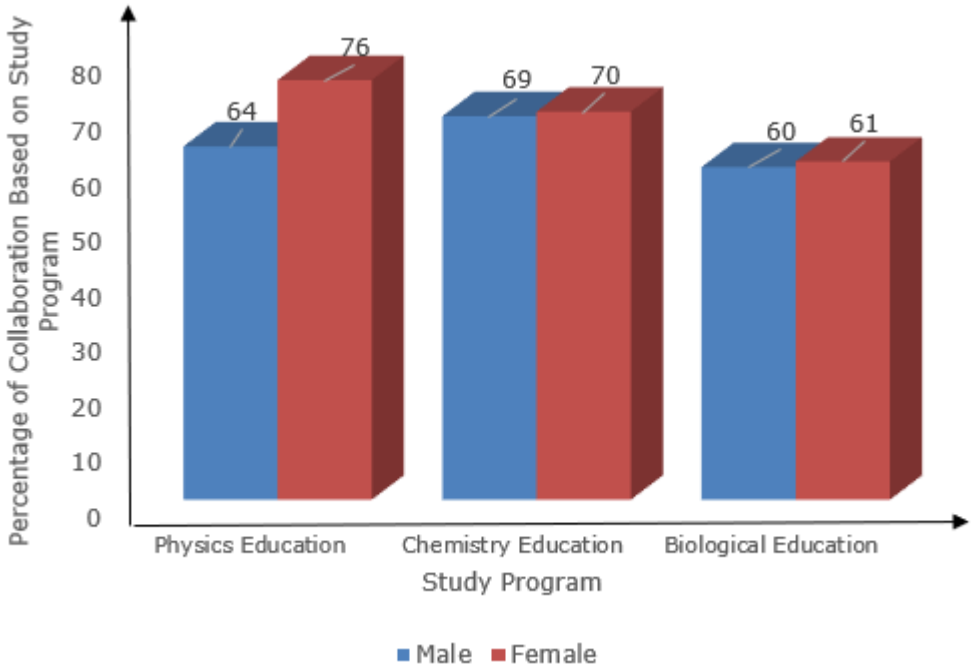


Figure 4. Student Collaboration Ability Based on Gender in View from Study Program

Based on Figure 4, it is known that the collaboration ability of science students of FTK UIN Mataram is more dominant than female students in all study programs. This can be seen from the percentage obtained by female students is higher than male students. The highest collaboration ability is in the physics education study program, followed by the chemistry education study program students, and the lowest is in the biology education study program, students. Based on the results of the analysis, the ability of students to collaborate has a very good achievement.

This is because most of the indicators of this ability are categorized as high. Through learning activities with the discussion method, there is an expectation that students can work together, especially on indicators of caricature sciencing in solving science problems, working productively with others, and being responsible for completing group work. The results of this study are also in line with research conducted by Herro et al., which states that students' collaboration abilities are seen during discussion activities (Herro et al., 2017). The theory of personality and social development of female and male expressed by Block, in which female tend to score higher on socializing behaviors, such as dependence, social desire, obedience, general anxiety, and living near friends, and men tend to score higher on agency behaviors, such as aggression, confidence in task performance, dominance, and activity level (Block, 1976).

Communication Ability

Communication ability is the level of ability to deliver messages from one person to another to inform and change attitudes, opinions, or overall behavior either directly or indirectly (Coffelt et al., 2019). Communication ability helps students to develop good social relationships. Good communication ability can help students to understand others, be understood by others, and also form the trust that forms the basis of a relationship (Stein et al., 2019). Students' communication ability can be known by looking at the

indicators of communication ability when the learning process takes place. The results of measuring the communication ability of science students of FTK UIN Mataram are presented in Figure 5.

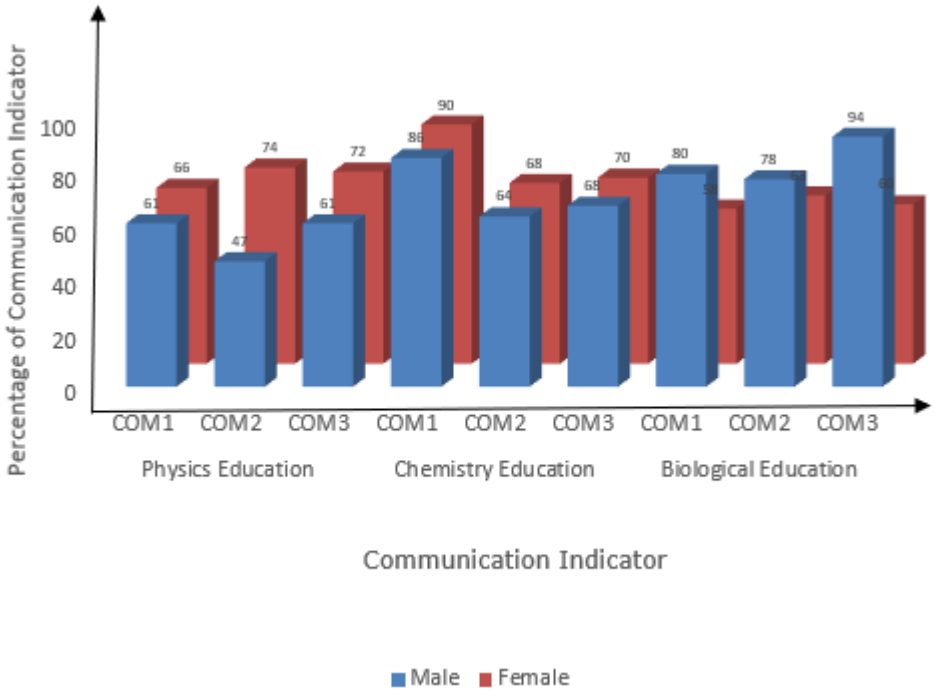


Figure 5. Communication Ability Based on Gender in terms of Indicators

The communication ability of science students of FTK UIN Mataram shown in Figure 5 shows that all indicators COM1, COM2, and COM3 are dominated by female students, this can be seen from the percentage obtained by female students which are higher than male students. The results of this study indicate that female of science student of FTK UIN Mataram are actively involved in building dialogue with discussion partners, conveying ideas or questions clearly and easily to understand, listening attentively and politely to the other person, and showing good body language when communicating.

The results of this study are in line with research conducted by Hakim et al., which states that the communication ability of male students are more accurate and detailed, while female students are more critical in various interpretations (Hakim et al., 2021). The communication process is essentially the process of conveying thoughts or feelings by someone (the communicator) to another person (the communicant) (Sari & Hermansyah, 2022), (Minarni et al., 2020). The following also presents the communication ability of science students of FTK UIN Mataram based on gender based on their study program.

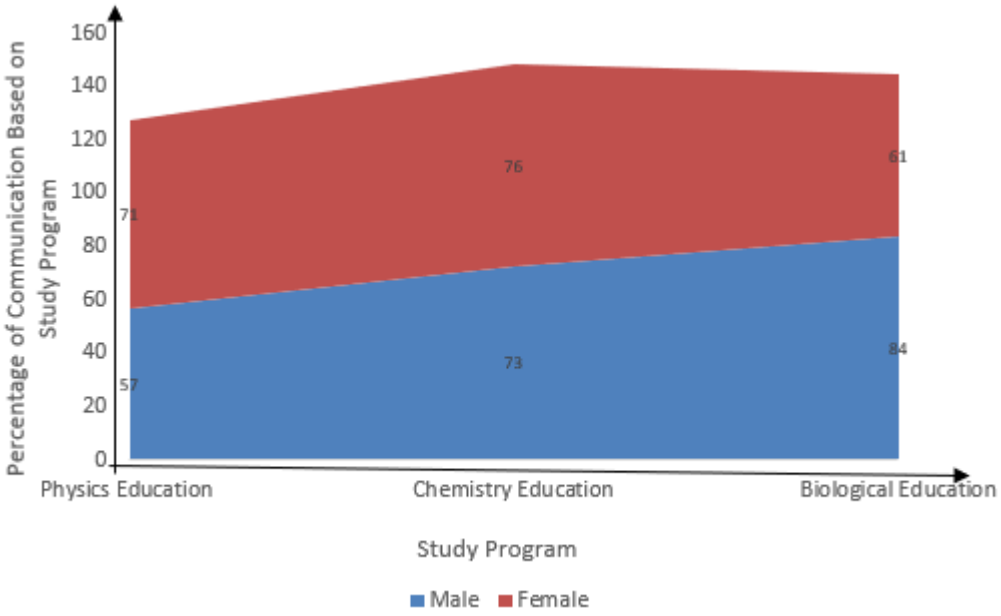


Figure 6. Communication Ability Based on Gender in terms of Study Programs

Figure 6 shows that female students have better communication abilities than male students. Figure 6 also shows that female students' communication abilities are better in physics education and chemistry education study programs. This is because when the discussion process takes place in the physics and chemistry education study program, female students are more active in conveying ideas/ideas related to solving the problems being discussed. In addition to the active role of female students, it can also be seen when the way to convey ideas/ideas is more polite and clear. However, for students in the biology study program, communication abilities are dominated by male students compared to female students. This is because, at the time of discussion, male students dared to express their ideas even though they could not match the actual concept of the material. Male students have a way of communication that is to the point in the biology education study program compared to female students in the study program.

This is in line with research conducted by Rohid & Rusmawati which states that students have different communication abilities during the discussion (Rohid & Rusmawati, 2019). This is in accordance with the theory of cognitive development based on hormones in male and female, where the testosterone hormone in men makes them happy about challenges, likes to compete, competes with ideas and concepts, so they are happy (at home) in discussions or meetings (Sherrod, 2018), (Zilioli & Bird, 2017). Female also like to gather, but because their hormones are dominated by estrogen and progesterone, they prefer peace, relaxation, and so on so that when they gather, what they enjoy is "gathering" not material or substance gathering because when they gather they gather information (Collins et al., 2022; Catenaccio et al., 2016).

Critical Thinking Ability

Critical thinking ability is the ability to think reflectively and reasoning in making decisions (Saphira & Prahani, 2022). The ability to think critically makes students become people of character. Students' critical thinking ability can be identified by conducting tests

using critical thinking-based questions consisting of five main indicators (Rijal, 2021). The results of the analysis of the critical thinking ability of science students of FTK UIN Mataram are presented in Figure 7.

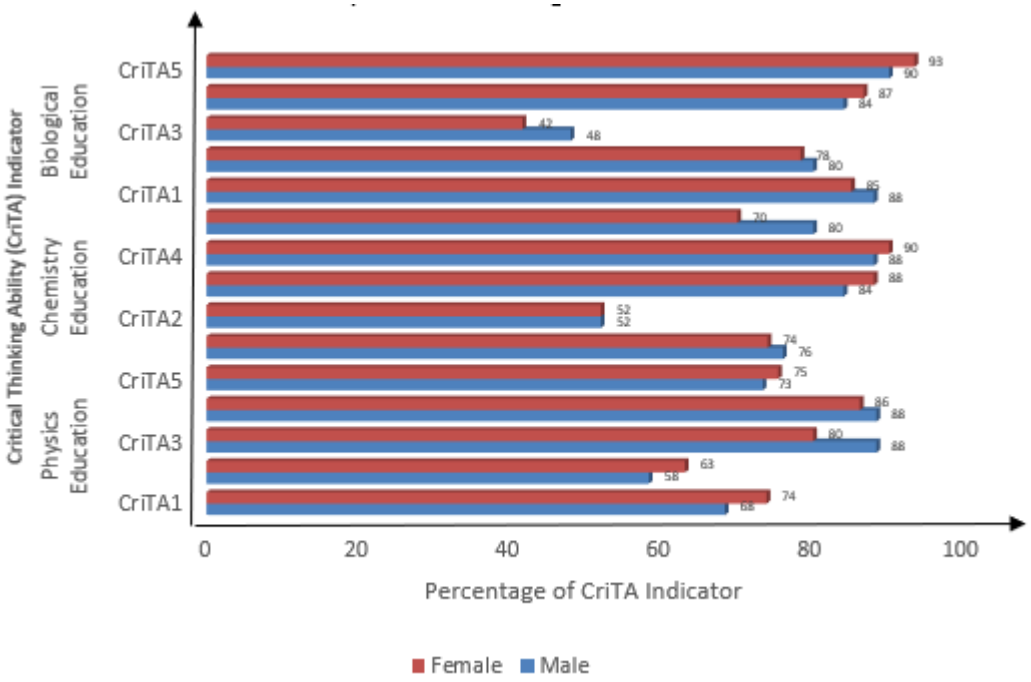


Figure 7. Students' Critical Thinking Ability Based on Gender-Based Indicators

Figure 7 shows that the critical thinking ability of science students of FTK UIN Mataram is different for each indicator. Female students have critical thinking ability on indicators CriTA1 (77.62%), CriTA2 (64.47%), and CriTA4 (87.61%); while male students were more dominant in the CriTA3 (73.44%) and CriTA5 (81.11%) indicators. This indicates that female students can identify and formulate problems, identify causal reasons that are asked in solving science problems, and can define terms or concepts, principles, and theories related to solved science problems.

Male students can make and consider decisions in solving problems and can consider the results of observations. Ma et al., stated that the decision-making process is a rational effort of the administrator to achieve the goals that have been set in the early part of the planning function (Ma et al., 2020). The process begins and ends with consideration. Critical thinking includes analyzing and interpreting data in scientific inquiry activities (Mueller et al., 2020), (Maknun, 2020). Students in critical thinking use reasonable thinking to decide what to do according to their intellectual abilities (Paul & Elder, 2019), (Wang, 2017).The following also presents students' critical thinking ability based on gender in terms of the study program.

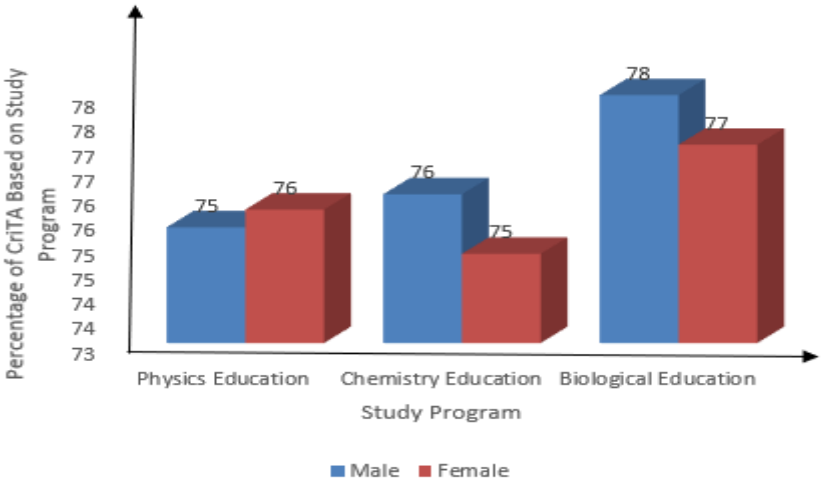


Figure 8. Students' Critical Thinking Ability Based on Gender given Study Program

Figure 8 shows that the critical thinking ability of male students of the biology education study program is the highest at 78.00%, while the critical thinking ability of female students of the chemical education study program is the lowest at 74.80%. This is because male students, especially in the biology education study program, are more understanding and critical of the answers to the problems given. Male students tend to detect bias with a different and critical point of view. The following is also presented in Figure 9 which is the distribution of critical thinking ability of science students of FTK UIN Mataram.

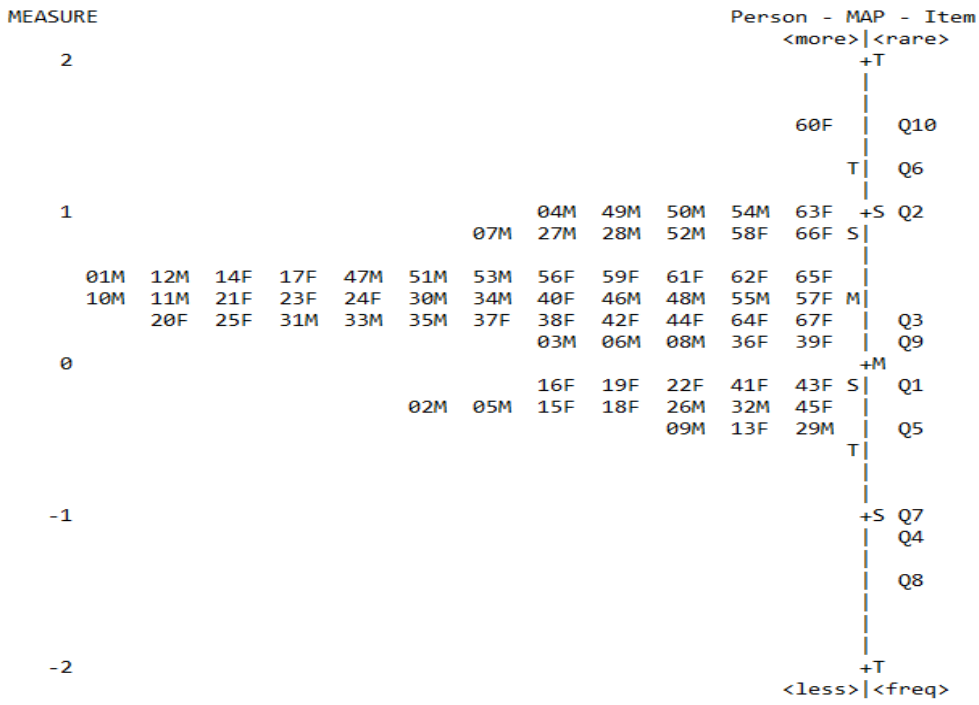


Figure 9. Wright Map of Critical Thinking Ability

The distribution of the ability to think critically of science students of FTK UIN Mataram, which is shown in Figure 9, varies. The average critical thinking ability of students is above the logit value of 0.00. Students who have the highest critical thinking ability are science students with a code of 60F, which means female students from the biology education study program.

Students who have low critical thinking ability are students who have logit values below 0.00, namely students with codes 16F, 19F, 22F, 41F, 43F, 02M, 05M, 15F, 26M, 32M, 45F, 09M, 13F, and 29M. This is due to the learning habits possessed by students. Students only want to solve science problems that match the examples without requiring higher thinking ability (Willingham, 2021).

Creative Thinking Ability

Creative thinking ability is the ability to analyze something based on data or information to generate new ideas in understanding something (Romli & Riyadi, 2018). The ability to think creatively can not only help students in facing the challenges of the world of work, but can also shape students into productive, empathetic individuals, and become better every day. Students are said to have the ability to think creatively if they have original thinking, curiosity, hard work, agility and flexibility in thinking, and independence. In the following, data on the analysis of the creative thinking ability of science students of FTK UIN Mataram is presented.

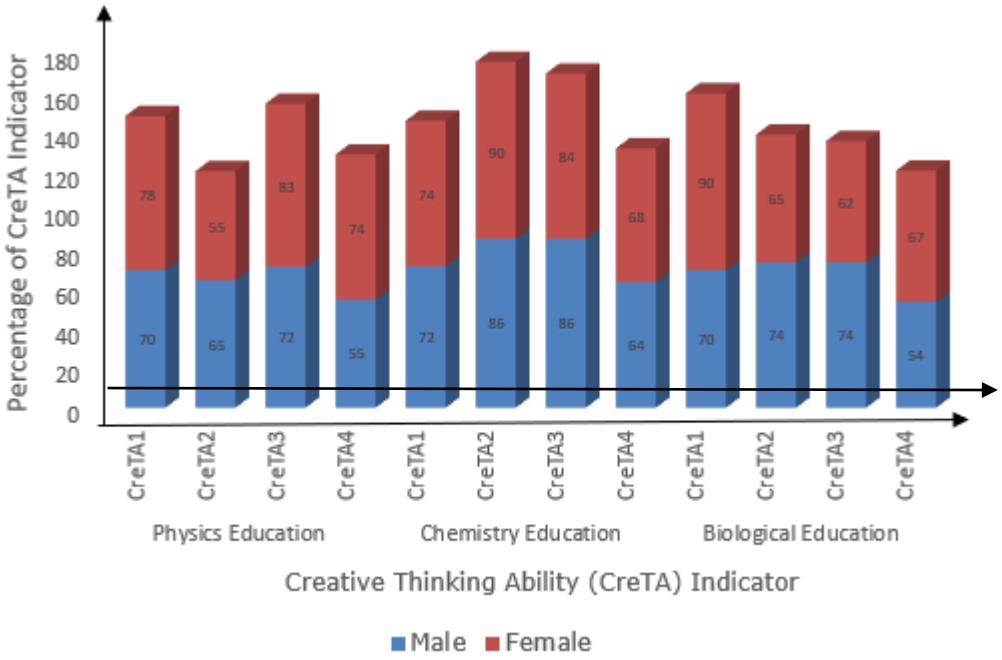


Figure 10. Students' Creative Thinking Ability Based on Gender in terms of Indicators

Figure 10 shows that the creative thinking abilities of male and female students are different. In the CreTA1 and CreTA4 indicators, the percentages obtained by female students were higher than male students, namely 80.82% and 69.50%, while on the CreTA2 and CreTA3 indicators the percentages obtained by male students were higher than female students, namely 75% and 77.22%, respectively. The high creative thinking

ability of female students on the CreTA1 and CreTA4 indicators indicates that female students can answer with several answers in solving science problems, can quickly see the errors and weaknesses of a given science problem, and can find deeper meanings in answers or answers. problem by doing scientific steps.

The high creative thinking ability of male students on the CreTA2 and CreTA3 indicators indicates that male students can provide various interpretations of a given problem, and can solve problems with new ideas. This means that students have flexible thinking ability that can create diverse answers, can see a problem from different perspectives, look for several different alternative solutions, and can change strategies (Vale et al., 2018), (Grohs et al., 2018). In the following, the data from the analysis of the creative thinking ability of science students of FTK UIN Mataram based on gender is also presented in terms of the study program.

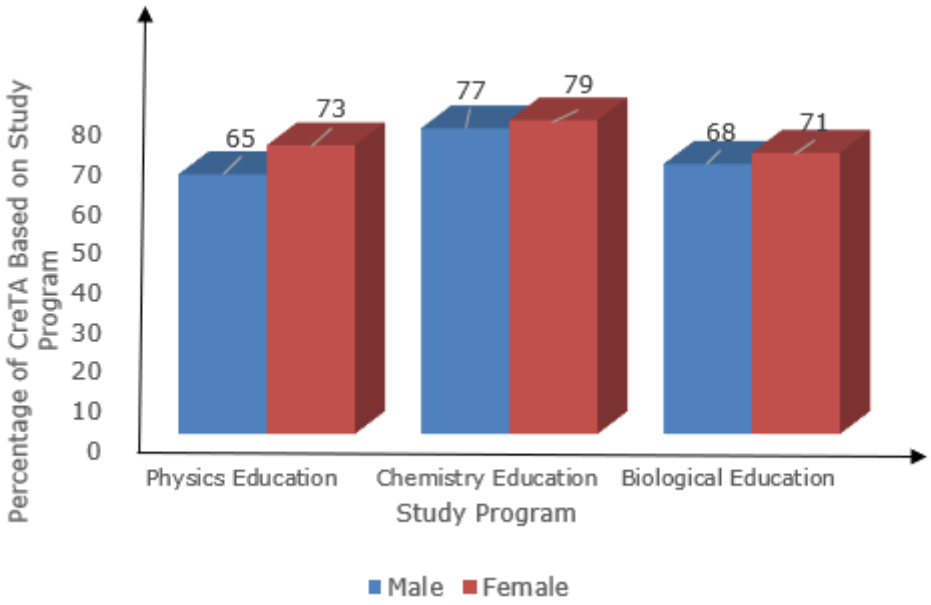
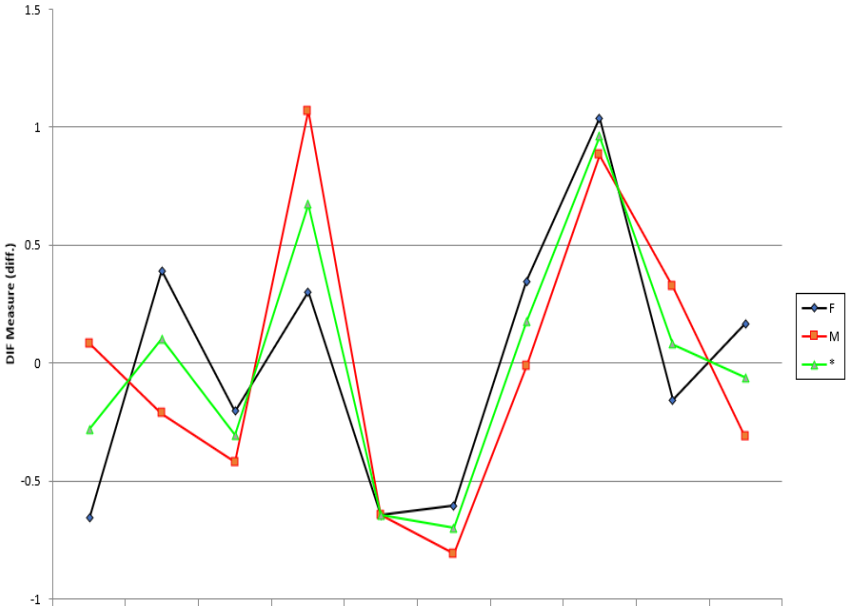


Figure 11. Students' Creative Thinking Ability Based on Gender in View from Study Program

Based on Figure 11, it can be seen that the highest creative thinking ability of students is female students in the chemistry education study program with a percentage of 79.00%, while the lowest creative thinking ability is male students in the physics education study program with a percentage of 65.42%. The high creative thinking ability of female students in the chemistry education study program is due to chemistry education students during the learning process always providing ideas that can solve the problems discussed. The low creative thinking ability of male students in the physics education study program is caused because they only focus on the problems presented without developing new ideas in solving them. Developing new ideas, looking for deep meanings, providing several interpretations, and classifying things according to divisions needs to be done and owned by all students (Sandika & Fitrihidajati, 2018). Referring to the developmental phase and differences in brain structure, male students in learning something or solving a problem they will be happier when they find something new or challenging, especially those that require them to be hands-on (Nemorin, 2017). This

behavior appears as an effect of his good left brain performance and is also influenced by the testosterone hormone in him (Steimer, 2022). In addition to referring to the structure of the inferior parietal lobe, the ability to imagine and construct an imaginary three-dimensional model of a movement, position and so on is better developed in males than females (Stoodley et al., 2017). In detail, the creative thinking ability of science students of FTK UIN Mataram are presented in Figure 12



	1	2	3	4	5	6	7	8	9	10
F	-0.6556	0.3906	-0.203	0.3025	-0.6448	-0.6032	0.3467	1.0383	-0.1552	0.1682
M	0.0833	-0.2134	-0.4201	1.0688	-0.6448	-0.807	-0.0138	0.8821	0.3226	-0.3158
*	-0.2815	0.1043	-0.3065	0.6724	-0.6448	-0.6993	0.1741	0.9618	0.0808	-0.0615

Figure 12. Person DIF Students' Creative Thinking Ability Based on Gender

Figure 12 shows the distribution of creative thinking abilities of science students of FTK UIN Mataram, where there are still many science students of FTK UIN Mataram who get a logic score below 0.00. This indicates that there are still many students who have below-standard creative thinking ability. This is because most of the indicators of creative thinking competence are still categorized as adequate, especially in the CreTA3 indicator, namely originality (Q5 and Q6). This is in line with research conducted by Wijayati et al., (2019) which states that students' creative thinking abilities are not maximized.

This is to observations made during learning, students are accustomed to answering questions by focusing on reading books without developing new ideas, students learning are only oriented to complete values so that they look for practical ways, and students still do not think about the benefits of learning outcomes for their lives. Some of these problems are in stark contrast to the mental growth of awareness to work better among students and very far from developing 4C competencies (critical thinking, creative and innovative, communication ability, collaboration) that are 21st-century ability. Research conducted by Insan (2019) also states that in student learning there are still obstacles to thinking creatively both in solving problems and in the learning process taking place.

Conclusion

Based on the results of the research and discussion, it can be concluded that the 4C abilities possessed by the science students of FTK UIN Mataram have different percentages between male students and female students. The collaboration ability of female students is better than male students, namely 68.90% of female students, and 64.30% of male students. The ability of science students of FTK UIN Mataram in communicating was higher for male students than female students, namely 71.11% male students, and 69.11% female students. The critical thinking ability of male students is higher than female students, namely 76.44% for male students and 75.83% for female students. The creative thinking ability of female students is higher than that of male students, namely 74.18% of female students and 70.14% of male students.

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