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Analysis of 4C Skills (Critical Thinking, Creativity and Innovation, Collaboration, and Communication) of Physics Education Students in Facing the Industrial Revolution 4.0

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Abstract: This research is a qualitative research with a case study design. The instruments used will be prepared based on the indicators of each 4C skill. The data collected will be analyzed through the stages of data reduction, data presentation and conclusions. The research results show students' critical thinking skills on indicator 1 reasoning have an achievement percentage of 34%; indicator 2 thinking as hypothesis testing has an achievement percentage of 47%; indicator 3 analyzing arguments has an achievement percentage of 49%; indicator 4 analysis of possibilities and uncertainties has a percentage of 68% and indicator 5 problem solving and decision making has a percentage of 73%. The results of students' creative and innovative thinking abilities on indicator 1 of fluency thinking skills have an achievement percentage of 28%; indicator 2 elaboration skill has an achievement percentage of 52%; indicator 3 of flexible thinking skills (flexibility) has an achievement percentage of 26%; and indicator 4 Original thinking skills (originality) has a percentage of 17%. The results of student collaboration skills in indicator 1 contributed to the percentage of achievement of 49%; indicator 2 time management has an achievement percentage of 54%; indicator 3focus on taskhas an achievement percentage of 63%; indicator 4 working with other people has a percentage of 71%; and indicator 5 responsibility has a percentage of 67%.

Keywords: Collaboration; Communication; Creative innovation; Critical thinking; 4C

Introduction

The globalization and the 21st century industrial revolution have brought major changes to almost all aspects of life due to advances in science and information technology. This rapid progress is inseparable from quality and competitive human resources (HR). Qualified and competitive human resources are human resources who have skills in accordance with the needs of the 21st century or what are known as 21st century skills (21st century skills).

These skills include: digital literacy, intensive (critical) thinking, effective communication, high productivity, good collaboration (both personal and social), as well as spiritual and moral values (soft skills). These skills are a must for HR to be able to face the job market in Industry 4.0. World Economic Forum (2020) mentions the 10 main skills most needed in facing the world of work until 2025, namely: analytical and innovative thinking, active learning and learning strategies, complex problem solving, critical thinking and analysis, creativity, originality and initiative, leadership and social influence, use of technology, monitoring and control, technology design and programming, resilience, stress tolerance and flexibility and ideas, problem solving and ideas.

The five main domains of 21st century skills are digital literacy, intensive thinking, effective communication, high productivity and spiritual and moral values (Osman et al., 2013). Griffin et al. (2015) classifies 21st century skills and attitudes as ways to think (knowledge, critical and creative thinking), ways

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to learn (literacy and soft skills), and ways to learn with other (personal, social, and civic responsibilities).

Several experts have defined critical thinking. Facione (2011) states that critical thinking is self-regulation in deciding (judging) something produce interpretation, analysis, evaluation, and inference, as well as presentation of use a piece of evidence, concept, methodology, criteria, or contextual considerations on which it is based decisions are made... . The definition of critical thinking according to Proulx (2004) is a process according to steps for analyzing, testing, and evaluating arguments. Skills Critical thinking is a cognitive skill related to the mind (Cotrell, 2005; Polat et al., 2020; Saputri et al., 2019). Trilling et al. (2010) define critical thinking as the ability to analyze, interpret, evaluate, summarize, and gather information. According to Ennis (1996) Critical thinking is a reflective way of thinking that makes sense or is based on reason focused on determining what to believe and do.

4C Skills (Critical Thinking, Creativity and Innovation, Collaboration, and Communication) is a soft skill which in its daily implementation is far more useful than mastering hard skills (Thornhill-Miller et al., 2023). Arief (2012) states that in addition to having hard skills, graduates from tertiary institutions are also required to have soft skills in order to be successful in their work.

Most universities in Indonesia, in preparing their graduates for skills in the 21st century, have made various efforts to achieve this goal. One of the efforts being made is to renovate the curriculum, such as providing opportunities for students to take various elective courses both within the university itself and outside the university. The aim is to improve their soft skills, especially mastery of 4C skills. Besides that, the most important thing is to change the implementation of education and teaching so that students besides mastering hard skills are also appropriate for mastering soft skills in the form of 4C skills. This is a challenge for teachers to innovate in conducting learning. Finken et al. (1993) categorized critical thinking skills into six components, namely: 1) focus, 2) supporting reasons, 3) reasoning, 4) organization, 5) conventions and, 6) integration.

The Indonesian Ministry of Education and Culture has adopted the concept of 21st century education into the national education curriculum. Where learning is reflected into four learning objectives called the 4C skills (Critical Thinking, Creativity and Innovation, Collaboration, and Communication) (Astuti et al., 2019; Susilo, 2015; Zubaidah, 2020). Therefore, learning is not only limited to the ability to master the concepts of a field of science such as mastering physics concepts, but also requires the development of abilities such as critical thinking so that students are able to analyze problems and make decisions to solve problems (Sipayung et al., 2018).

As the main competency needed in the 21st century, 4C skills need to receive good guidance in education at tertiary institutions, as well as education at the high school level (Pasquinelli et al., 2021). In this research, a case study will be carried out to obtain the 4C profile of FKIP Unigha Physics education students. The results of this study can be used as a form of evaluation of higher education learning in an effort to prepare professional teacher candidates, as well as a baseline for improving 4C abilities with more innovative and effective learning models so that students become graduates with competencies that are in line with the demands of the 21st century. In accordance with the focus and Research Master Plan of Jabal Ghafur University for 2020-2024.

Based on the description above, 4C Skills (Critical Thinking, Creativity and Innovation, Collaboration, and Communication) is very urgent to be learned in college. Therefore in this paper discuss about Analysis of 4C Skills (Critical Thinking' Creativity and Innovation; Collaboration; and Communication) of Physics Education Students in Facing the Industrial Revolution 4.0.

Method

The variables in this study are critical thinking skills, creativity and innovation, collaboration skills and communication skills (4C). To obtain the 4C profile, a case study design was used in this qualitative research. Meanwhile, the subjects in this study were students of the Physics education study program, the Faculty of Teaching and Education, Jabal Ghafur University.

The instruments used will be prepared based on the indicators of each 4C skill. The instrument used to measure critical thinking skills refers to the Cambridge critical thinking skills indicator (Black, 2012; Harjo et al., 2019). Creativity and innovation instruments refer to the new heuristic framework (Hughes et al., 2018; Plummer et al., 2022; Scuttari et al., 2021; Sternberg et al., 2022). The collaboration instrument refers to Scoular et al. (2020). The communication instrument refers to Yakob's science communication skills.

Table 1. Percentage Category

rcentage Achievement (%)	Percentage Achievement (%)
< PK ≤ 100	Very high
< PK ≤ 80	Tall
< PK ≤ 60	Currently
< PK ≤ 40	Low
: PK ≤ 20	Very low

The grouping of students' critical thinking skills, creativity and innovation, collaboration skills and communication skills (4C) is classified into five categories, namely very low, low, medium, high and very high categories. The percentage of critical thinking skills is shown in Table 1.

Result and Discussion

4C skills (Critical Thinking, Creativity and Innovation, Collaboration, and Communication) are skills that are considered important in today's digital era (Siregar et al., 2023). These skills include the ability to think critically, think creatively and innovate, work with others, and communicate well. To build 4C skills, more are built through learning activities such as: using learning models that are more demanding of student activities, proposing authentic problems to be solved cooperatively or collaboratively, independent assignments that demand creativity and innovation, online learning, and presenting papers in scientific forums and published in scientific journals. The skills that are trained will be brought by graduates when they work.

The results of research in Europe show that a person's success in the business world is 80% determined by his soft skills and only 20% is determined by his hard skills. This is in line with the US-based Partnership for 21st Century Skills (P21) which states that the competencies that must be possessed by human resources in the 21st century are: critical thinking skills Critical Thinking Skills, Creative Thinking Skills, communication skills, and collaboration skills.

Critical thinking skills measured in this study consist of indicators which include: reasoning, thinking as hypothesis testing, analyzing arguments, analysis of possibilities and uncertainties, problem solving and decision making.

Table 2. Results of Critical Thinking Ability

Thinking Indicator Critical	Percentage Achievement
Reasoning	34%
Think as Hypothesis test	47%
Analyze argument	49%
Probability analysis and uncertainty	68%
Solution to problem and retrieval decision	73%

Table 2 above shows the results of students' critical thinking skills. In indicator 1 reasoning has an achievement percentage of 34%, indicator 2 thinking as hypothesis testing has an achievement percentage of 47%, indicator 3 analyzing arguments has an achievement percentage of 49%, indicator 4 analysis of possibilities and uncertainties has a percentage of 68%. and indicator 5 problem solving and decision making has a percentage of 73%.

The results of critical thinking skills in indicator 1 regarding reasoning have an achievement percentage of 34% included in the medium category. In this aspect, the researcher analyzes students' abilities in reasoning, that is, any object whose density is greater than the density of water will surely sink when immersed in the water. Students were asked to drop a stone into the river while playing the otok-otok boat on the bank of the river. After that students are asked to define sinking and floating.

When an object is under gravity the object experiences a buoyant force in the opposite direction. So that the state of the object in the liquid is related to the difference in gravity and buoyancy (Besson, 2004; Wibowo et al., 2023). The definitional mistake mentioned by the students is that density does not always cause objects to sink or float. The floating otok-otok ship gets a buoyant force greater than its weight, at the same time, if the otok-otok ship is placed vertically into the water, the ship will sink. So the location of the mistake is that not all sinking or floating conditions are caused by density, but more precisely caused by the difference in gravity and buoyancy.students' critical thinking abilities can only be identified if they are first introduced to these abilities through the implementation of an appropriate learning model, which can lead students to intelligent thinking (Halpern et al., 2021).

Critical thinking skills in indicator 2 about thinking as hypothesis testing which has a percentage of 47% in the medium category. In this aspect the researcher analyzes the abilitystudentinnotice that the block of wood stays floating in the same position in the cup. The phenomenon written in the problem isa cup of water with a small wooden block floats into an elevator. Then, studentasked toshows that the

acceleration of the lift does not affect the buoyant force. Better understanding of the nature of learning and creating academic situations where learning leads to analytical, critical and creative skills (Sudarisman, 2015).

Critical thinking skills on indicator 3 analyze arguments which have an achievement percentage of 49% in the very moderate category. In this aspect the researcher analyzes the abilitystudentin terms ofconducted trials after adding a paper clip in the middle of the plane by giving the same speed using his hands so that the paper plane could fly. The phenomenon written in the problem is when a paper airplane starts hovering in the air, what determines how long the airplane flies in the air is the amount of air lift on the plane's wings, the greater the lift on the wings of the plane, the longer the plane will fly. Students are then asked to concludeThe difference in airflow velocity at the top and bottom of the airplane wing will produce different pressures at the top and bottom of the airplane wing. The ability to conclude can be trained by applying the concepts, principles and skills they have learned to solve the problems they face or conclude them (Fakhriyah, 2014).

The ability to think critically on indicator 4 of the possibility and uncertainty analysis has an achievement percentage of 68% belonging to the high category. this aspectstudenttoldput a load in a toy boat as shown in the picture and mark the water level.Studentasked to provide an explanationwhat happens to the surface of the water if the weight in the toy boat is moved into the water.The student's explanation in this case is that when the load is transferred to the water, the volume of the boat that is immersed becomes smaller, and the volume of the load that sinks is smaller than the volume of the load and the boat so that the water level is lower/falls. This can be done by learning with an active debate strategy that can train students' critical thinking skills (Pramesswari et al., 2016).

Critical thinking skills on indicator 5 regarding problem solving and decision making with an achievement percentage of 73% in the high category. Students' mastery of concepts in measuring the volume of chess pieces made of wood is in the high category. To get accurate and valid results, students use Archimedes' concept, namely by dipping and pressing all chess pieces with wire (as shown in the picture) into a container filled with water, so that the volume of water spilled is equal to the volume of the chess pieces. Critical thinking is the ability to assess epistemic knowledge from available information so that subjects are confident in making decisions or actions based on this information (Pasquinelli et al., 2021).

The result of this research is that students 4Css skills using collaborative inquiry learning model are better than students 4Cs skills using conventional learning at SMA Negeri 14 Medan. Then, it is hoped that they will be able to produce humans who are in accordance with the demands of the industrial era 4.0. With 4Cs skills, they can gain and increase cooperation in a group to solve certain problems, increase their tolerance for peer opinions, try to think critically and creatively to solve problems related to something. Keyword: 4Cs skills, industrial revolution era 4.0 (Daulay et al., 2021).

Table 3. Results of Creative and Innovative Thinking

Thinking Indicator Creative and Innovative	Percentage Achievement
Fluent thinking skills	28%
Detailing skills (elaboration)	52%
Flexible thinking skills (flexibility)	26%
Original thinking skills (originality)	17%

Table 3 shows the results of students' creative and innovative thinking abilities in indicator 1 fluency thinking skills with an achievement percentage of 28%; indicator 2 elaboration skill has an achievement percentage of 52%; indicator 3 of flexible thinking skills (flexibility) has an achievement percentage of 26%; and indicator 4 Original thinking skills (originality) has a percentage of 17%.

The results of the ability to think creatively and innovatively in indicator 1 regarding fluency thinking skills have an achievement percentage of 28% which is included in the low category. In this aspect, the researcher analyzes the students' ability to try to find a way to get across to the KJA so they can witness the release of 1000 lanterns which are similar to small hot air balloons and made of oil paper and a simple fire source. After searching for a solution, they found two empty tin drums, a pile of rope, and three sticks of wood. Students are trying to design a device that can float to make it easier for them to cross to the KJA.

To make flying lanterns, start with: (1-6 elaborations, 7 originals), namely: Preparing the tools and materials needed such as oil paper, aluminum foil, cotton, straws, kerosene, copper wire, etc.),Prepare the incendiary part from aluminum foil and cotton, Prepare the shape of the lantern from oil paper, Prepare the frame for the burner, Assemble the body of the lantern with the burner frame, Fly the lantern by burning the cotton, then release it to air, and So that the light of the lanterns can be enjoyed longer in the KJA as night lights and saving energy, the lanterns can be tied with ropes and then installed at the ends of the KJA so that they become a substitute for lamps from electrical energy. Fluent thinking skills have the following

characteristics: spark many ideas in solving problems; provide many ways or suggestions for doing various things; work faster and do more than others (Munandar, 2014).

Thinking abilitycreative and innovativeon indicatorselaboration skills have an achievement percentage of 52% medium category. In this aspect the researcher analyzes the abilitystudentinmake a Lantern design when you have successfully crossed the KJA while enjoying the night of releasing 1000 Lanterns.

To make flying lanterns, start with: (1-6 elaborations, 7 originals), namely: Preparing the tools and materials needed such as oil paper, aluminum foil, cotton, straws, kerosene, copper wire, etc.), Prepare the incendiary part from aluminum foil and cotton, Prepare the shape of the lantern from oil paper, Prepare the frame for the burner, Assemble the body of the lantern with the burner frame, Fly the lantern by burning the cotton, then release it to air, and So that the light of the lanterns can be enjoyed longer in the KJA as night lights and saving energy, the lanterns can be tied with ropes and then installed at the ends of the KJA so that they become a substitute for lamps from electrical energy. The elaboration or detailed thinking aspect is the student's ability to detail and find various approaches to problem solving (Rubenstein et al., 2020).

Thinking ability creative and innovative on indicator 3 analyze flexible thinking skills (flexibility) has an achievement percentage of 26%very low category. In this aspect the researcher analyzes the ability student in terms of designing a tool to cross the lake to Floating Net Cages (KJA) instead of a boat, they started designing by connecting two can drums with three wooden sticks using a rope. After it has been designed, the tool is placed on the surface of the lake water and is ready to be used as a crossing tool. However, the students had a problem, they could not find wood to pedal to push the raft towards the KJA.

Removing or lifting a paddle that has sunk to the bottom of the lake is: Hooking a rope on a 6-meter long bamboo stick and then hooking it to the paddle at the bottom of the lake and then pulling it slowly, Using a submarine robot to attach the buoy to the paddle at a depth of 5 meters, and waiting for the lake water to dry, so that it can reach it easily. Flexible thinking (flexibility) is a person's ability to produce ideas that consist of various categories or the ability to see various objects or problems from various points of view (Munandar, 2014).

Thinking ability creative and innovative on indicator 4original thinking skills (originality) has an achievement percentage of 17%with low category. In this aspect the researcher analyzes the ability student in answering an alternative solution so that you can still cross to the KJA even if you don't find wood for rowing.

Alternative solutions, so that they can still cross, namely: Using a dynamo to rotate the propeller that has been prepared so that it pushes the assembled boat, and Using the KJA rope to the edge of the lake, students get on the raft, then hold the rope then moves the boat towards the KJA. Originality is the ability of students to give unusual answers that are different from others where answers are rarely given by most people and the answers are original from the thoughts of each student (Munandar, 2014).

Table 4. Skill Results Collaboration

Indicator Collaboration	Percentage Achievement
concontribution	49%
Wherejemen Time	54%
Focus on the task	63%
Working with Originality	71%
Responsibility	67%

Table 4 above shows the results of student collaboration skills in indicator 1, the percentage contribution to achievement is 49%; indicator 2 time management has an achievement percentage of 54%; indicator 3 focus on taskhas an achievement percentage of 63%; indicator 4 working with other people has a percentage of 71%; and indicator 5 responsibility has a percentage of 67%.

Results Student collaboration skills in indicator 1 regarding the contribution of the achievement percentage of 49% are included in the medium category. In this aspect the researcher analyzes mahastudents in conducting group discussions in giving ideas and participating. Collaboration skills are the skills of working together, synergizing with each other, adapting to various roles and responsibilities, and respecting differences. In collaborating there will be mutual filling in of deficiencies with the strengths of the other so that the problems encountered can be resolved properly in an atmosphere of togetherness.

A person is said to have the ability to collaborate, if he fulfills the three components of collaboration ability (three dimensions of collaboration), namely: demonstrates the ability to work effectively and respect the diversity of team members; Demonstrating flexibility and willingness to accept other people's opinions in achieving common goals, and taking on shared responsibility in working collaboratively and appreciating the contribution of each team member (Trilling et al., 2010).

The results of student collaboration skills on indicator 2 regarding time management have an achievement percentage of 54% which is included in the medium category. In this aspect the researcher

analyzes how mahastudents in completing assignments, but late beyond the allotted time, causing group assignments to extend the time limit for their work. Collaborative learning is carried out based on a model which explains that knowledge can be created in a population whose members actively interact with one another, share experiences, and take on asymmetric roles or different roles (Mustadi, 2014).

The results of student collaboration skills on indicator 3 aboutfocus on taskhas an achievement percentage of 63% included in the high category. In this aspect the researcher analyzes how mahastudent fthe focus is mostly on what needs to be done and most of the tasks are well done. Collaboration skills are the ability to participate in every activity to build relationships with others, respect relationships and teamwork to achieve the same goals. Students are responsible for being shown by consistently attending group meetings on time (Diana et al., 2021).

The results of student collaboration skills in indicator 4 about working with others have a percentage of 71% included in the high category. In this aspect the researcher analyzes how mahastudents often (3 times) listen to other people's opinions well and often (3 times) help others, but it doesn't make it easy in group work. Collaboration skills are the ability of individuals to interact with individuals or individuals with groups to achieve goals by working together, respecting each other, being involved in tasks, and being able to produce ideas collaboration as a learning process to plan and work together, to consider different and to participate in discussions by brainstorming, listening, and supporting others (Greenstein, 2012).

The results of student collaboration skills on indicator 5 regarding responsibility have a percentage of 67% included in the high category. In this aspect the researcher analyzes how mahastudentoften active in helping groups and often independent of others to do assigned work. Collaboration skills are actively contributing, working productively, showing flexibility and compromise, showing responsibility, and showing respect (Grenstein, 2012).

The research results show that the 4C skills which include critical thinking, communication, collaboration and creativity have been included in the textbook. 4C skills are integrated in textbooks in pre-learning, student activities, materials, and evaluation. Textbooks are used as learning resources in learning activities, namely discussions (critical thinking skills), written assignments (communication and creativity), and group assignments (collaboration). The obstacles to the use of textbooks that contain 4C skills in learning at Islamic high schools are that the number of textbooks is insufficient, there is less emphasis on integration of 4C skills through textbook learning, and the appearance of textbooks is less attractive (Sholekha, 2023).

Table 5. Skill Results Communication

Percentage Achievement (%) Indicator Communication	Percentage Achievement
Koral communication skills	74%
Kscientific communication skills	41%

Table 5 above shows the results of student communication skills on indicator 1 koral communication skillspercentage of achievement of 74%; and indicator 2 scientific communication skillshas an achievement percentage of 41%. The results of student communication skills on indicator 1 koral communication skills the percentage of achievement of 74% is included in the high category. In this aspect the researcher analyzes how kabilitygreatstudentin presenting practical results. Oral communication skills are a person's ability to communicate through speaking and feedback that can be given directly. Oral communication skills include skills in job interviews, seminars, workshops, public speaking, formal speeches and presentations. Communication skills are skills needed by teachers in speaking, listening, overcoming verbal communication barriers, understanding nonverbal communication from students and being able to solve conflicts constructively (Santrock, 2007).

The results of student communication skills on indicator 2 kscientific communication skillshas an achievement percentage of 41% included in the medium category. In this aspect the researcher analyzes how kabilitygreatstudentin presenting practical reports. Scientific communication skills are physical activities that are usually seen in physical activities such as writing, typing, sports, and so on. Skills can be realized if students are aware of motor movements that require coordination in them (Muhibin, 2003).

Conclusion

The research results show students' critical thinking skills on indicator 1 reasoning have an achievement percentage of 34%; indicator 2 thinking as hypothesis testing has an achievement percentage of 47%; indicator 3 analyzing arguments has an achievement percentage of 49%; indicator 4 analysis of possibilities and uncertainties has a percentage of 68% and indicator 5 problem solving and decision making has a percentage of 73%. The results of students' creative and innovative thinking abilities on indicator 1 of fluency thinking skills have an achievement percentage of 28%; indicator 2 elaboration skill has an achievement percentage of 52%; indicator 3 of flexible thinking skills (flexibility) has an achievement

percentage of 26%; and indicator 4 Original thinking skills (originality) has a percentage of 17%. The results of student collaboration skills in indicator 1 contributed to the percentage of achievement of 49%; indicator 2 time management has an achievement percentage of 54%; indicator 3focus on task has an achievement percentage of 63%; indicator 4 working with other people has a percentage of 71%; and indicator 5 responsibility has a percentage of 67%. The results of student communication skills on indicator 1 koral communication skills percentage of achievement of 74%; and indicator 2kscientific communication skills has an achievement percentage of 41%. The research results obtained are relevant for the research, who stated that the greatest 4c skill contained in the student's worksheet was critical thinking. In addition, the highest 4C skills contained in the student's worksheet where critical thinking skills, and the lowest was collaboration skills. This indicates that critical thinking skills have been applied to the student worksheet, but overall, 4C skills have not been fully implemented.

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Author Contributions
Safrijal contributes to conceptualizing the research idea, developing products, analyzing data, and writing articles. Mulia Rahmi, a supervisor in research activities to article writing, reviewed and edited.

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Conflicts of Interest
The authors declare that there is no conflict of interest regarding the publication of this paper.

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