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21st CENTURY DIGITAL SKILLS: COMMUNICATION, COLLABORATION, CREATIVITY, CRITICAL THINKING IN PRE-SERVICE PHYSICS TEACHER

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ABSTRACT

Information and Communication Technology (ICT) development impacts the need for skills in daily life, education, or work. Everyone needs the 4C skills associated with digital skills. Based on the literature review results, there is not much information about the concept of 4C digital skills. So this research will examine what aspects are needed in 4C digital skills. Another objective of this research is to analyze the 4C digital skills of a pre-service physics teacher. This research uses a literature review and survey methods. The subjects in this study were students of the UNSIQ Physics Education Study Program in the 2022/2023 academic year. There are two collection techniques, namely, literature study and questionnaires. Data from the questionnaire will be analyzed by calculating the percentage of each aspect and then determining the categories divided into five, namely very high, high, medium, low, and very low. The findings in this study are that the 4C skills in a digital context can be divided into 4 (four) aspects: critical thinking digital skills, creative digital skills, collaboration digital skills, communication digital skills. These skills are super skills individuals need to succeed in work and education. The results of a survey by the Department of Physics Education, UNSIQ, found creative digital skills as the lowest aspect with a value of 57.35% (low category). In comparison, collaboration digital skills became the highest aspect with a value of 72.20% (high category). Another aspect, namely critical thinking digital skills (61.66%) and communication digital skills (69.24%), are in the medium category.

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1. INTRODUCTION

The current era is the era of the industrial revolution 4.0 in the 21st century or the disruptive innovation phenomenon where there are three important things: data literacy, technology literacy and human literacy. Every individual must be able to prepare themselves for the trend of implementing Industry 4.0, which is growing rapidly. The tendency of the factory industry today is to switch to the digital technology industry, where there has been a change in the information system to become a data/online system. This change in literacy will significantly impact the world of education, so the world of education today must be able to keep up with changes in social patterns so as not to experience a significant "gap" of inequality. In line with this, the research

results from Lubis (2019) explain that in this disruptive era, there are changing rules in the world of education, and there is increasing pressure on universities to be able to evolve, adapt or even stop.

Education as a provider of human resources must be able to see this change as a challenge, where there has been a change from the old paradigm to a new one, namely from reading, writing and computing literacy to data, technology and human literacy. Eggen & D. Kauchak (2012) also stated that technological literacy is a very important basic skill after reading, writing and calculating. Suppose education is not ready to face the changes that are taking place. In that case, it is feared that many graduates will not be able to compete in the disruptive/21st-century era because the skills or competencies prepared by higher education are not linked to and match with the world of work. Based on data from the Central Statistics Agency (BPS) for February 2018, the unemployment rate reached 6.9 million people or 5.13% of the total working-age population. This shows that the absorption of graduates from schools or tertiary institutions is still lacking in entering the world of work.

Based on the demands above, it is necessary to have an educational direction that can accommodate them. The direction of 21st-century education is related to national education goals as stipulated in SISDIKNAS Law No. 20 of 2003; "National Education functions to develop capabilities and shape noble character and national civilization in order to educate the life of the nation, aims to develop the potential of students to become human beings who believe and fear the Almighty God, have a noble character, are healthy, knowledgeable, competent, creative, independent, and become a democratic and responsible citizen". In teaching and learning activities, it is necessary to integrate the development of 21st-century skills into content learning in various disciplines (Asrizal et al., 2018). Countries need to integrate 21st-century skills in learning to increase the country's competitiveness at the global level.

In order to develop an understanding of how best to teach, pre-service physics teachers need to be prepared to understand and have the skills needed to empower 21st-century skills in their students. John Dewey revealed "Education as a social function". Society in education is not only a place and intermediary for the interaction of one's character with the environment but the whole activity of a person, especially in carrying out a physical activity which will experience gradual changes (Phillips, 2016). Changes that refer to gradual changes are educational effects. Furthermore, each individual has a purpose or participation in several activities.

Voogt & Roblin (2012) explained that the 21st century or disruptive era requires skills such as Communication, Collaboration, Creativity, dan Critical thinking, often shortened to 4C. These skills represent the synchronization of needs between higher education and the world of work. Creativity enables students to produce innovative ideas that can contribute to and challenge further learning through new original learning with others (Bekteshi, 2017). Students' critical thinking skills can be used to make decisions to solve problems in various situations through ideas or ideas (inductive or deductive) (Joynes et al., 2019). Good communication skills are expected to enable students to express themselves effectively, both in productive skills in oral or written form and in receptive skills such as listening and reading (Bekteshi, 2017). The collaboration skills possessed by students can be used by them to work together with other members in carrying out an activity (Joynes et al., 2019).

Information and Communication Technology (ICT) development impacts the need for skills in daily life, education, or work. Everyone needs the 4C skills associated with digital skills. The demands of content-related digital skills are becoming increasingly important in 4C skills.

Integrating the two is a skill required in today's world of education and work for everyone to function effectively as a student, worker, and citizen (Griffin et al., 2012). Only a few experts define the relationship between 4C and digital skills. Van Laar et al. (2019) define digital 4C skills as skills that define what students or workers can do with ICT to support a wider spectrum of 4C skills and essentially make full use of ICT.

Based on studies related to 4C skills, only a little information has been found regarding integrating 4C skills and digital skills. Research conducted by Hidayatullah et al. (2021) relating to the synthesis of 4C skills in Indonesia revealed that from 2015–2020 there were around 300 articles that examined the 4C skills in learning physics. In this study, it has not been explained that there is research that integrates 4C skills with digital skills.

There is still little information about 4C skills integrated with digital skills. Even though these skills are important to be imparted to students, studying the concept of 4C skills is necessary. This study aims to examine what aspects are needed in the 4C digital skills and analyze the 4C digital skills of a pre-service physics teachers.

2. METHOD

The research used is library research and surveys. The research focus of this study is the 4C digital skills: digital communication, digital collaboration, digital creativity, and digital critical thinking. The population in this study were all students of the UNSIQ Physics Education Study Program in the 2022/2023 academic year; as many as 129 students were taken using a stratified random sampling technique. In this study, the techniques used in collecting data were literature studies and questionnaires. Literature study is a data collection technique by reading information from print or online sources such as books, scientific articles, and newspapers about 4C digital skills (Tranfield et al., 2003). Questionnaires are lists of questions given to others willing to respond (respondents) according to user requests (Roopa & Rani, 2012). The questionnaire used in this study was closed. In a closed point of view, the respondent is asked to choose an answer according to his characteristics by giving a cross or a checklist. The questionnaire is used to measure digital 4C skills. The steps for analyzing the includes: 1) checking and calculating the score on the questionnaire from each answer chosen by the student, 2) recapitulating the scores obtained by each student, 3) calculating the proportion of scores for each item, 4) determining the criteria for interpreting the scores shown from the questionnaire, 5) interpretation according to the interpretation of the scores presented in table 1 below.

Table 1. 4C digital skill categories (Arikunto, 2016)

No	Percentage	Category
1	80 – 100	Very High
2	70 – 79	High
3	60 – 69	Medium
4	50 – 59	Low
5	0 – 49	Very Low

Calculation of the percentage of students' 4C digital skills is formulated as follows:

$$\text{Percentage} = \frac{\text{Number answered}}{\text{The maximum number of scores}} \times 100\% \quad (1)$$

3. RESULTS AND DISCUSSION

3.1. 4C Digital Skills

Various institutions such as The Partnership for 21st Century Skills, Assessment and Teaching of 21st Century Skills (ATC21S), and the Organization for Economic Co-operation and Development (OECD) bring up a skilled concept that is urgently needed for education and the workplace today, namely 21st-century skills. Each institution provides different definitions and characteristics of 21st Century skills. However, there are four skills mentioned by most of these institutions, namely Creativity, Critical thinking, Communication, and Collaboration or 4C as super skills (Voogt & Roblin, 2012). With the progress of ICT, not only are 4C skills needed, but digital skills need to be integrated into every element of the 4C skills. The following are the results of a literature study on digital 4C skills.

3.1.1. Communication Digital Skills

Communication activities are facilitated by the development of ICT, such as communication can be done at a distance in a short time and with many people. Everyone can express themselves, establish relationships, and interact with others at any distance in space and time (Yu et al., 2010). ICT-based communication is a means to generate social interaction and strengthen social relations (Antonucci et al., 2017). A worker must understand proper and effective communication methods such as email, social networking sites and instant messaging services (Fusi & Zhang, 2020). Students also need communication skills in the learning process, such as online discussions, teleconferences and the Learning Management System (LMS). Individuals are encouraged to share ideas or ideas through online forums in the context of work or study. Students need skills to contact other members, discuss projects, and evaluate together regarding the progress of the project to be completed.

Many experts have built communication skills frameworks. Binkley et al. (2012) built a framework for communication skills, including presenting information, utilizing various media and technology, listening actively, articulating thoughts and ideas effectively, using communication for various purposes, and communicating effectively. The research report from The Joint Task Force on Undergraduate Physics Programs provides a communication skills framework as follows (Heron & McNeil, 2016)): (1) Communicating with many people with different knowledge backgrounds, understanding the needs of each person, has provides a good impact on others. (2) Evaluate all incoming information through reading, listening, and discussing. (3) Be persuasive in conveying information and ideas to others. (4) Communicating in writing about scientific concepts with scientific and logical arguments. (5) Communicate using words, graphs, tables, equations and other visualizations. (6) Using feedback to evaluate the information being discussed.

A communication skills framework can also refer to a scientific communication skills framework that includes information seeking, scientific reading, scientific writing, listening and observing, information representation, and knowledge presentation (Binkley et al., 2012). This disclosure is very relevant to the framework put forward by The Joint Task Force on Undergraduate Physics Programs. The framework is integrated with the use of technology when students communicate. This framework is based on an authentic scientific framework that includes the complexity of scientific information, the need to analyze scientific data with multiple representations and the understanding of the unique structure of scientific articles (Spektor-Levy

et al., 2009). Digital communication skills in science can be described as communicating scientific information with technological support through LMS, teleconferencing, social media, and e-mail (Herman & Hilton, 2017).

3.1.2. Collaboration Digital Skills

The process of collaboration or interdependence activities between individuals to achieve common goals is increasingly supported by ICT. ICT is especially useful when teams have to share information and make decisions while in different areas (Lukic, 2014). Teams can instantly exchange ideas, information and experiences by using technology as a venue for discussion (e.g. zoom meetings, Skype, WhatsApp, LMS). Therefore, students need skills to connect and collaborate with others in different places (Thornhill-Miller et al., 2023). In addition, teams can work on the same document together using technology (e.g. Google Documents and Spreadsheets). Thus, students need skills to work together on documents and joint projects beyond the boundaries of time and place (Srivastava, 2016). The emergence of various platforms that can be used to collaborate online has an impact on the importance of understanding and managing information together to achieve common goals.

There are five types of collaborative assessments, including (a) independent reports or group work reports, (b) scales of cooperation, (c) subjective assessments, (d) observations, and (e) performance assessments (Cox et al., 2019). This type of collaborative assessment generally ranges from less standardized to more standardized, and the level of standardization is related to the intended use of the assessment information. For example, less standardized types of assessment, such as self-reports or peer reports. In contrast, standard assessments, for example, subjective assessment tests and observations. Observational assessment is carried out through the observer assessing individuals who work in a group. The benefit of using this type of assessment is that it is based on actual student behavior, either verbal or non-verbal.

Previous research has defined the construct of collaboration skills. For example, the Organization for Economic Co-Operation and Development developed a collaboration skills framework. PISA identifies a collaboration skills framework consisting of three core competencies: building and maintaining shared understanding, taking appropriate action to solve problems, and building and maintaining team organizations. According to (Binkley et al., 2012), collaboration is a way of working consisting of knowledge, skills, attitudes/values/ethics with four sub-skills, namely (1) interacting effectively with others, (2) working effectively in diverse teams, (3) managing projects, and (4) mentoring and leading others; respond to others.

Other research divides collaboration into three dimensions: social interdependence, interpersonal skills, and task-related processes. Precisely, collaboration consists of knowledge, skills, and attitudes. (1) Interact with others and communicate clearly. (2) Having social self-regulation, namely knowing when to speak or listen. (3) Working together in a team (team management). (4) Convey original ideas or ideas. (5) Ability to provide input to the team to achieve common goals. (6) Ability to be responsible. (7) Perspective taking. (8) Evaluating tasks and responsibilities within the team (Care et al., 2018). The framework above is also relevant to the collaboration framework built by Herro et al. (2017), which explains that there are five main aspects of collaboration skills: group interaction, positive communication, lots of questions/solutions, authentic approaches and assignments, and transdisciplinary thinking. The explanation above is a framework for traditional collaboration skills that have been researched. As for digital collaboration skills, the difference is the use of ICT in collaborative activities.

3.1.3. Creative Digital Skills

ICT can support creativity in various ways, including by developing and creating or realizing ideas (Nikolopoulou, 2018). The digital environment allows students to assess various design concepts, experiences and ideas. Online content creation uses online spaces to create learning content, including blogging and sharing photos and videos. Creating content that supports understanding in learning is a common creative practice, where creativity determines whether others successfully receive content created online. Creativity can also be raised by using digital applications in science learning, such as PHET and scratch. Students with good digital creativity can explore these digital applications independently to build their understanding.

Experts explain several definitions of creativity. Creativity has been seen as the ability to generate valuable ideas (Agbowuro et al., 2017), divergent thinking (Dollinger et al., 2004), the ability to find new problems (Csikszentmihalyi, 1988), novelty and practicality (Amabile & Pratt, 2016), and the emergence of new ideas through experimentation (Jones & Townley, 2016). Despite language debates, there is general agreement that creativity involves the production of new and valuable ideas and products. The aspects of originality and effectiveness have a long history which can also be referred to as standard definitions of creativity (Runco & Jaeger, 2012). Most modern research relies on the novelty and usefulness of ideas as a measure of creativity (Mumford, 2003). Novelty refers to originality, namely the production of something new, and usefulness refers to the suitability of ideas in solving the problem under consideration (Hennessey & Amabile, 2010).

Creative students possess several characteristics of creativity. Guilford distinguished between cognitive characteristics (aptitude) and affective characteristics (non-aptitude) related to creativity (Guilford, 1957). Cognitive characteristics (aptitude) are related to cognition and thinking processes whose indicators include fluency, flexibility, originality in thinking and elaboration (development, enrichment, detailing) of an idea. At the same time, affective characteristics (non-aptitude) are more related to attitudes or feelings whose indicators include curiosity, being imaginative, feeling challenged by pluralism, being willing to take risks and being respectful. These two characteristics of creativity are needed to to realize students' creative behavior. The Partnership for the 21st Century also identified indicators of creativity, including generating alternative solutions, generating clear ideas, evaluating ideas, developing ideas, being open and responsive to new and diverse perspectives, and generating original ideas (Binkley et al., 2012).

3.1.4. Critical Thinking Digital Skills

Critical thinking has been identified as a critical skill in the global digital environment. Students acquiring knowledge can search independently through the internet. However, not all online content contains the correct information, so students must be able to assess the information circulating critically. Students need to understand its nature and sources. The focus is on the quality of information relevant to the problems. It is essential for college students to filter incoming information online quickly and to extract valuable information (Kurt & Emiroğlu, 2018). Students must be able to encourage critical reflection on points being discussed online and provide ongoing arguments that lead to online discussions.

Based on the Cambridge Assessment taxonomy, critical thinking skills consist of five indicators: analysis, evaluation, inference, synthesis, and self-regulation (Black, 2012). Sub-indicators of the analysis: using inductive and deductive reasoning, identifying arguments, analyzing arguments, identifying the structure of information or argument, analyzing incomplete arguments, and clarifying. Sub-indicators of evaluation: assessing the adequacy of an argument or information, assessing the level of meaningfulness, assessing reliability, assessing feasibility,

assessing analogies, identifying errors in arguments, assessing the truth of arguments, and considering the impact of an argument. Sub-indicators of inference: Consider the implications of the arguments and draw conclusions correctly. Sub-indicators of synthesis: selecting material relevant to the argument, compiling arguments according to the information received, determining further arguments, making decisions based on objective assessments, responding to a problem, and justifying or making the right decision. Self-regulation has the sub-skills of questioning one's preconceptions and careful and persistent evaluation of one's reasoning.

The Partnership for the 21st Century also identified indicators of critical thinking skills, including using various types of reasoning, analyzing interactions between variables, analyzing arguments, assessing, examining ideas, interpreting information, drawing conclusions, clarifying information, synthesizing, building arguments, and reflecting critically to an input (Binkley et al., 2012).

3.2. Analysis of 4C Digital Skills for Department of Physics Education UNSIQ

Based on the results of a survey of students in the UNSIQ Physics Education department, the 4C digital skill results were obtained, which are presented in Table 2 below.

Table 2. Result of 4C digital skills

No	4C digital skills	Indicator	Score
1	Critical Thinking Digital Skills	Analysis	70,5%
		Synthesis	64,2%
		Inference	62,8%
		Evaluation	60,4%
		Self regulation	50,4%
2	Creative Digital Skills	fluency	68,2%
		flexibility	62,9%
		Originality	45,7%
		Elaboration	52,6%
3	Collaboration Digital Skills	Group Interaction	75,4%
		Positive Communication	72,7%
		Many Questions/ Solutions	72,5%
		Authentic Approaches and Tasks	74,8%
		Transdisciplinary Thinking	65,6%
4	Communication Digital Skills	Information search	72,4%
		Listen and observe	71,5%
		Scientific writing	60,2%
		Information representation	71,6%
		Knowledge presentation	70,5%

A recap of each of the 4C digital skills, namely critical thinking digital skills, creative digital skills, collaboration digital skills, communication digital skills, is presented in diagrammatic form in Figure 1 below.

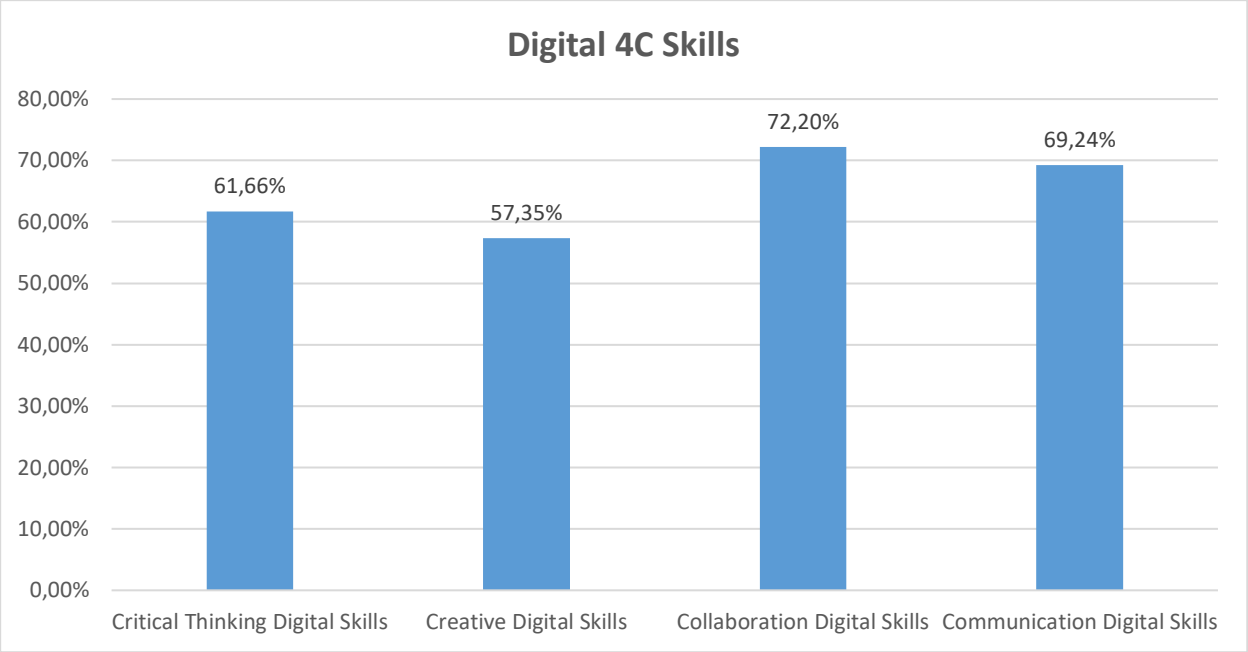


Figure 1. Result of 4C digital skills

Based on Figure 1, it can be seen that of the four skills, the aspects of critical thinking digital skills, creative digital skills, and communication digital skills are lower than the aspects of collaboration digital skills. Creative digital skills get a percentage of 57.35% in the low category. Likewise, the aspect of communication digital skills gets a percentage of 69.24%, and critical thinking digital skills get a percentage of 61.66% which is also in the medium category. Meanwhile, the collaboration digital skills aspect is the aspect with the highest percentage, namely 72.20% in the high category.

Creative digital skills are the lowest aspect compared to other aspects. This can be seen from the indicators regarding the criteria for creative digital skills related to creating new original works, that are very much different from previous works, the lowest criterion, with a score of 45.7%. Even though students with good creative digital skills will obtain one's success. Creative digital skills positively correlate with the quality of one's work (Dawood et al., 2022). In order to improve students' creative digital skills, learning needs to be directed so that they can develop their creativity, one of which is to be able to convey ideas or ideas that are new and different from previous works.

In the aspect of digital communication skills, the lowest criterion is found in the scientific writing indicator. Communicating can be done verbally or in writing. These two aspects are important to be provided to students so that they have the ability to communicate both orally and in writing. Communication skills include the ability to convey thoughts clearly orally and in writing (East, 2015). Communication ability is an important skill considering the era of communication technology, which is developing rapidly. The ability to convey ideas or ideas clearly to others is an essential skill to be trained in learning. Various methods that involve students interacting and communicating ideas or ideas are very important to develop.

In the critical thinking digital skills aspect, the self-regulation indicator is the criterion with the lowest percentage, namely 50.4%. Self-regulation is the ability to regulate yourself, examine yourself and correct yourself. Digital information that is widespread online related to subject

matter or general information can be used to support the learning process. Critical thinking digital skills as indicators of self-regulation are necessary and owned by students. Students can independently plan, help, and evaluate themselves in learning activities such as managing time, repeating lessons, and setting study schedules to achieve predetermined goals or targets (Moohr et al., 2021). Students need to be equipped with good critical thinking skills, one of which comes through learning. Critical thinking skills can be developed through reciprocal teaching strategies (Mafarja et al., 2022), online flipped classrooms (Widodo, 2022), guided inquiry learning models (Maknun, 2020), and the STEM approach (Yaki, 2022).

Skills that get high categories are collaboration digital skills. Collaborative digital skills must be developed to be applied in education or work. With good collaborative skills, students can work in pairs or small groups to complete assignments with friends of different backgrounds (academic abilities, gender, culture). Students can also work flexibly and are willing to compromise with others to achieve common goals, and can show responsibility as team members to complete assigned tasks (Larson & Miller, 2011).

4. CONCLUSION

4C skills in a digital context can be divided into critical thinking digital skills, creative digital skills, collaboration digital skills, digital communication skills. These skills are super skills individuals need to succeed in work and education. The survey results of UNSIQ Physics Education Study Program students found creative digital skills as the lowest aspect, with a value of 57.35% (low category) of digital 4C skills. In comparison, collaboration digital skills became the highest aspect with a value of 72.20% (high category). Another aspect, critical thinking digital skills (61.66%) and communication digital skills (69.24%), are in the medium category. 4C digital skills are urgently needed by students and workers in this era, so striving to develop these skills in education is necessary. The constructivism and connectivism approaches can be adopted in physics learning as an effort to improve the 4C digital skills of a pre-service physics teacher. This approach integrates scientific activities supported by the use of ICT in learning.

REFERENCES

Agbowuro, C., Saidu, S., & Jimwan, C. S. (2017). Creative and Functional Education: The Challenges and Prospects in a Comatose Economy. *Journal of Education and Practice*, *8*(8), 37–40. http://ezproxy.lib.uconn.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1138934&site=ehost-live

Amabile, T. M., & Pratt, M. G. (2016). The dynamic componential model of creativity and innovation in organizations: Making progress, making meaning. *Research in Organizational Behavior*, *36*, 157–183. https://doi.org/10.1016/j.riob.2016.10.001

Antonucci, T. C., Ajrouch, K. J., & Manalel, J. A. (2017). Social Relations and Technology: Continuity, Context, and Change. *Innovation in Aging*, *1*(3), 1–9. https://doi.org/10.1093/geroni/igx029

Arikunto, S. (2016). *Prosedur Penelitian: Suatu Pendekatan Praktik*. Rineka Cipta.

Asrizal, Amran, A., Ananda, A., Festiyed, F., & Sumarmin, R. (2018). The development of integrated science instructional materials to improve students' digital literacy in scientific approach. *Jurnal Pendidikan IPA Indonesia*, *7*(4), 442–450. https://doi.org/10.15294/jpii.v7i4.13613

Bekteshi, E. (2017). The 'fours cs - collaboration, communication, critical thinking and creativity at the faculty of arts (flup), university of porto, porto, portugal. *Journal of International Social*

Research, *10*(50), 56–62. https://doi.org/10.17719/jisr.2017.1638

Binkley, M., Erstad, O., Herman, J., Ripley, M., Rumble, M., & Miller-Ricci, M. (2012). Assessment and Teaching of 21st Century Skills (ATC21S). In *Griffin, P., McGaw, B., Care, E. (eds) Assessment and Teaching of 21st Century Skills*. Springer.

Black, B. (2012). An overview of a programme of research to support the assessment of Critical Thinking. *Thinking Skills and Creativity*, *7*(2), 122–133. https://doi.org/10.1016/j.tsc.2012.04.003

Care, E., Kim, H., Vista, A., & Anderson, K. (2018). Education system alignment for 21st century skills: Focus on assessment. In *Center for Universal Education at the Brookings Institution.* Brookings Institute. https://onlinelibrary.wiley.com/doi/10.1111/cdev.13673

Cox, J., Foster, B., & Bamat, D. (2019). *A Review of Instruments for Measuring Social and Emotional Learning Skills among Secondary School Students. REL 2020-010*. U.S. Department of Education, Institute of Education Sciences, National Center for Edu - cation Evaluation and Regional Assistance, Regional Educational Laboratory Northeast & Islands.

Csikszentmihalyi, M. (1988). Motivation and creativity: Toward a synthesis of structural and energistic approaches to cognition. *New Ideas in Psychology*, *6*(2), 159–176. https://doi.org/10.1016/0732-118X(88)90001-3

Dawood, A. Q., Shaalan, U. H., & Nsaif, A. K. (2022). The influence relationship of creative thinking on the quality of work life, an analytical study on people's officials in the General Directorate of Education of Baghdad Governorate, Rusafa / second. *Technium Social Sciences Journal*, *31*. www.techniumscience.com

Dollinger, S. J., Urban, K. K., & James, T. A. (2004). Creativity and Openness: Further Validation of Two Creative Product Measures. *Creativity Research Journal*, *16*(1), 35–47. https://doi.org/10.1207/s15326934crj1601_4

East, M. (2015). Taking communication to task – again: what difference does a decade make? *Language Learning Journal*, *43*(1), 6–19. https://doi.org/10.1080/09571736.2012.723729

Eggen, P., & D. Kauchak. (2012). *Strategi dan Model Pembelajaran, Mengajar Konten dan Keterampilan Berpikir* (6th ed.). Indeks.

Fusi, F., & Zhang, F. (2020). Social Media Communication in the Workplace: Evidence From Public Employees' Networks. *Review of Public Personnel Administration*, *40*(2), 245–271. https://doi.org/10.1177/0734371X18804016

Griffin, P., McGaw, B., & Care, E. (2012). *Assessment and Teaching of 21st Century Skills*. Springer.

Guilford, J. P. (1957). Creative abilities in the arts. *Psychological Review*, *64*(2), 110–118.

Hennessey, B. A., & Amabile, T. M. (2010). Creativity. *Annual Review of Psychology*, *61*, 569–598. https://doi.org/10.1146/annurev.psych.093008.100416

Herman, J., & Hilton, M. (2017). *Supporting students' college success: The role of assessment of intrapersonal and interpersonal competencies*. The National Academies Press.

Heron, P., & McNeil, L. (2016). Phys21: Preparing Physics Students for 21st-Century Careers. In *American Physical Society, American Association of Physics Teachers*. American Physical Society.

Herro, D., Quigley, C., Andrews, J., & Delacruz, G. (2017). Co-Measure: developing an assessment for student collaboration in STEAM activities. *International Journal of STEM Education*, *4*(1). https://doi.org/10.1186/s40594-017-0094-z

Hidayatullah, Z., Wilujeng, I., Nurhasanah, N., Gusemanto, T. G., & Makhrus, M. (2021). Synthesis of the 21st Century Skills (4C) Based Physics Education Research In Indonesia. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *6*(1), 88. https://doi.org/10.26737/jipf.v6i1.1889

Jones, C., & Townley, B. (2016). Misfits, Mavericks and Mainstreams: Drivers of Innovation in the Creative Industries. *Organization Studies*, *37*(6), 751–768. https://doi.org/10.1177/0170840616647671

Joynes, C., Rossignoli, S., & Fenyiwa Amonoo-Kuofi, E. (2019). *21st Century Skills: Evidence of*

issues in definition, demand and delivery for development contexts. Institute of Development Studies.

Kurt, A. A., & Emiroğlu, B. G. (2018). Analysis of students' online information searching strategies, exposure to internet information pollution and cognitive absorption levels based on various variables. *Malaysia Online Journal of Educational Techology*, *6*(1), 18–29.

Laar, E. Van, Deursen, A. J. A. M. Van, & Dijk, J. A. G. M. Van. (2019). The Sequential and Conditional Nature of 21st-Century Digital Skills. *International Journal of Communication*, *13*(409), 3462–3487. http://ijoc.org.

Larson, L. C., & Miller, T. N. (2011). 21st Century Skills: Prepare Students for the Future. *Kappa Delta Pi Record*, *47*(3), 121–123. https://doi.org/10.1080/00228958.2011.10516575

Lubis, F. (2019). Education in the Disruption Era. *Britain International of Linguistics Arts and Education (BIoLAE) Journal*, *1*(2), 183–188. https://doi.org/https://doi.org/10.33258/biolae.v1i2.85

Lukic, J. (2014). The impact of information and communication technology on decision making process in the big data era. *Megatrend Revija*, *11*(2), 221–234. https://doi.org/10.5937/megrev14022211

Mafarja, N., Zulnaidi, H., & Mohd. Fadzil, H. (2022). Using Reciprocal Teaching Strategy to Improve Physics Students' Critical Thinking Ability. *Eurasia Journal of Mathematics, Science and Technology Education*, *18*(1), 1–14. https://doi.org/10.29333/EJMSTE/11506

Maknun, J. (2020). Implementation of Guided Inquiry Learning Model to Improve Understanding Physics Concepts and Critical Thinking Skill of Vocational High School Students. *International Education Studies*, *13*(6), 117. https://doi.org/10.5539/ies.v13n6p117

Moohr, M. L., Balint-Langel, K., Taylor, J. C., & Rizzo, K. L. (2021). Practicing Academic Independence: Self-Regulation Strategies for Students with Emotional and Behavioral Disorders. *Beyond Behavior*, *30*(2), 85–96. https://doi.org/10.1177/10742956211020666

Mumford, M. D. (2003). Where Have We Been, Where Are We Going? Taking Stock in Creativity Research. *Creativity Research Journal*, *15*(2–3), 107–120. https://doi.org/10.1080/10400419.2003.9651403

Nikolopoulou, K. (2018). Creativity and ICT: Theoretical Approaches and Perspectives in School Education. In *Research on e-Learning and ICT in Education*. Springer. https://doi.org/10.1007/978-3-319-95059-4

Phillips, D. (2016). *Companion to John Dewey's "Democracy and Education."* University of Chicago Press. https://doi.org/https://doi.org/10.7208/9780226408408

Roopa, S., & Rani, M. (2012). Questionnaire Designing for a Survey. *The Journal of Indian Orthodontic Society*, *46*(December), 273–277. https://doi.org/10.5005/jp-journals-10021-1104

Runco, M. A., & Jaeger, G. J. (2012). The Standard Definition of Creativity. *Creativity Research Journal*, *24*(1), 92–96. https://doi.org/10.1080/10400419.2012.650092

Spektor-Levy, O., Eylon, B. S., & Scherz, Z. (2009). Teaching scientific communication skills in science studies: Does it make a difference? *International Journal of Science and Mathematics Education*, *7*(5), 875–903. https://doi.org/10.1007/s10763-009-9150-6

Srivastava, S. (2016). ICT implementation for Education and Learning. *IOSR Journal of Research & Method in Education Ver. IV*, *6*(4), 2320–7388. https://doi.org/10.9790/7388-0604044044

Thornhill-Miller, B., Camarda, A., Mercier, M., Burkhardt, J.-M., Morisseau, T., Bourgeois-Bougrine, S., Vinchon, F., El Hayek, S., Augereau-Landais, M., Mourey, F., Feybesse, C., Sundquist, D., & Lubart, T. (2023). Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education. *Journal of Intelligence*, *11*(3), 54. https://doi.org/10.3390/jintelligence11030054

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of*

Management, *14*, 207–222. https://doi.org/10.1007/978-3-030-92836-0_28

Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21 st century competences: Implications for national curriculum policies. *Journal of Curriculum Studies*, *44*(3), 299–321. https://doi.org/10.1080/00220272.2012.668938

Widodo, W. (2022). Online Flipped Classroom: Developing Postgraduate Science Education Students ' Critical Thinking Skills. *Journal of Science Learning*, *5*(2). https://doi.org/10.17509/jsl.v5i3.43107

Yaki, A. A. (2022). Fostering Critical Thinking Skills Using Integrated STEM Approach among Secondary School Biology Students. *European Journal of STEM Education*, *7*(1), 06. https://doi.org/10.20897/ejsteme/12481

Yu, A. Y., Tian, S. W., Vogel, D., & Chi-Wai Kwok, R. (2010). Can learning be virtually boosted? An investigation of online social networking impacts. *Computers and Education*, *55*(4), 1494–1503. https://doi.org/10.1016/j.compedu.2010.06.015