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Synthesis of the 21st Century Skills (4C) Based Physics Education Research In Indonesia

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ABSTRACT

The development of life in the 21st century requires a variety of skills that one must master. Physics learning in schools has a central role in providing 21st-century skills to students. Physics learning is an integrated field that facilitates 21st-century skills and much research is being done in this field. The purpose of this research is to provide a review or general overview related to 21st-century skills-based physics learning research (Communication, Collaboration, Critical Thinking, and Problem Solving, and Creativity and Innovation) in Indonesia. This type of research is a literature study. The articles analyzed are articles published in Sinta-accredited national journals with publication years ranging from 2015-2020 and Scopus indexed international journals, as well as journal research fields focusing on evaluation and learning physics. The number of articles analyzed was 300 articles from national and international journals. From 2015 to 2020, critical thinking skills were the most researched topic with a percentage of 12% and 27% of researchers did not mention the physics topic studied in their research. A lot of learning research, especially physics learning, focuses on a quantitative approach in solving problems in the field of physics education in this case related to 21st-century skills. Most of the 4C skills-based physics learning research uses a relatively small sample of under 100 samples with the majority of the research locations being found mostly focused on Bali-Nusra and Java. The research subjects most frequently researched regarding 21st-century skills are high school level (SMA/SMK/MA).

INTRODUCTION

Education has become the main mechanism that provides individuals with the knowledge, skills, and competencies that are needed by society today. But education provision usually lags behind emerging

needs [1]. Many authorities who have drawn comparisons between past and present classrooms have shown some changes in classroom design and management. Education is one of the fields that is expected to produce human resources who have 21st-century skills or competencies [2]. These skills are obtained from the process of learning, practice, and experience. The era of knowledge in the 21st century is characterized by a comprehensive linkage in science [3].

The 21st century is called the knowledge century, the knowledge-based economy century, the information technology century, the 4.0 revolution, and so on [4]. The 21st century is marked as openness or the century of globalization, meaning that life in the 21st century has undergone fundamental changes that affect many aspects. The development of life in the 21st century requires a variety of skills that one must master. All the skills that a person needs to succeed in facing challenges in an increasingly complex life and succeed in life and career in the world of work are called 21st-century skills [4].

21st-century skills are one of the most widely used terms in education today. Partnership for 21st-century learning (P21) develops a framework for 21st-century learning [5]. The framework describes the skills, knowledge, and expertise students need to succeed in a social and work environment. Student learning outcomes include 1) core subjects and 21st-century themes; 2) learning and innovation skills; 3) information, media and technology skills; and 4) life and work skills [6]. Innovation and learning skills are what students must prepare for the development of increasingly complex life and work environments in today's world. Partnership for 21st-century learning (P21) states that skills in this field include: creativity and innovation, critical thinking and problem solving, communication, and collaboration.

The 21st-century learning paradigm emphasizes students' ability to find out from various sources, formulate problems, think analytically, and collaborate in solving problems. The achievement of 21st-century skills is done by updating the quality of learning, adapting personalization of learning, encouraging communication and collaboration, emphasizing problem-based or project-based learning, using appropriate learning instructions, designing learning activities that are relevant to the real world. There are many ways to look at the exact content and definition of 21st-century skills. Generally, all emphasize what students can do with knowledge and how they apply what is learned in an authentic context. The essence of 21st-century skills involves strong communication and collaboration skills, expertise in technology, and innovation. When a school, region, or country builds on this foundation, it combines knowledge and skills with the support systems necessary for standards, curriculum and teaching, assessment, professional development, and learning environments. Students are more involved in the learning process and graduates will be better equipped to thrive in today's digitally and globally connected world. The world is changing rapidly, and educators must respond by preparing their students for the society in which they will work and live. Teaching 21st-century skills is essential and cannot be ignored. Teachers mustn't view 21st-century skills as additional "subjects", but rather as skills that must be integrated into all subjects. Today's teachers must build a vision for educators by developing students' communication and collaboration skills, integrating technology and problem-solving skills, and encouraging innovative and creative thinking. 21st-century learning has the main principle that the role of society and teachers in implementing 21st-century learning is very important in realizing a better future for the nation. Therefore, the education system must be oriented towards equipping and developing 21st-century skills. Physics learning in schools has a central role in providing 21st-century skills to students. In line with the competencies that students must have after learning physics, among others: The ability to analyze the principles, physical events, and mathematical reasons for these events, the ability to apply knowledge of physics in everyday life, the ability to solve problems, the ability to carry out investigations using scientific methods, the ability to work together, the ability to communicate research results through scientific writing, presentations, and other explanations in front of scientists and the general public, the ability to use technology and information. Therefore, physics learning is an integrated field that simultaneously facilitates 21st-century skills and much research has been done on this topic.

The purpose of this study is to provide a review or general overview related to 21st century (4C) skills-based physics learning research in Indonesia. It is important to know the distribution and description of

21st-century skills research in physics learning that has been carried out so that it is expected to provide direction in conducting further research, improvement, and policies in the world of education.

METHOD

This type of research is a literature study. The criteria for the articles analyzed were articles published in national journals accredited by Sinta with publication years ranging from 2015-2020 and international journals indexed by Scopus, as well as the field of journal research focusing on evaluation and learning of physics related to 21st-century skills (Communication, Collaboration, Critical Thinking, and Problems Solving, and Creativity and Innovation). The number of articles analyzed was 300 articles from national journals (Sinta 1 until Sinta 6). The categories of article content analyzed were research topics related to 21st-century skills, the physics material being researched, the types/approaches in the research used, the number of samples used, and the research location. Furthermore, the data are analyzed and interpreted in tables or graphs.

RESULTS AND DISCUSSIONS

Distribution of Research about 4C in Indonesia

Along with the development of information and technology, the world of education has undergone many changes. Learning is now leading to 21st-century skills which are commonly called 4C (Communication, Collaboration, Critical Thinking and Problem Solving, and Creativity and Innovation). This is following the demands of 21st-century learning which expects 4C competence in students to be able to compete in the 21st century. In recent years, Indonesia as a country that has participated in developing 21st-century learning has focused its learning and research on this field. Based on the results of the analysis of several published articles, data on the distribution of research topics from 2015-2020 regarding 4C skills were obtained as follows.

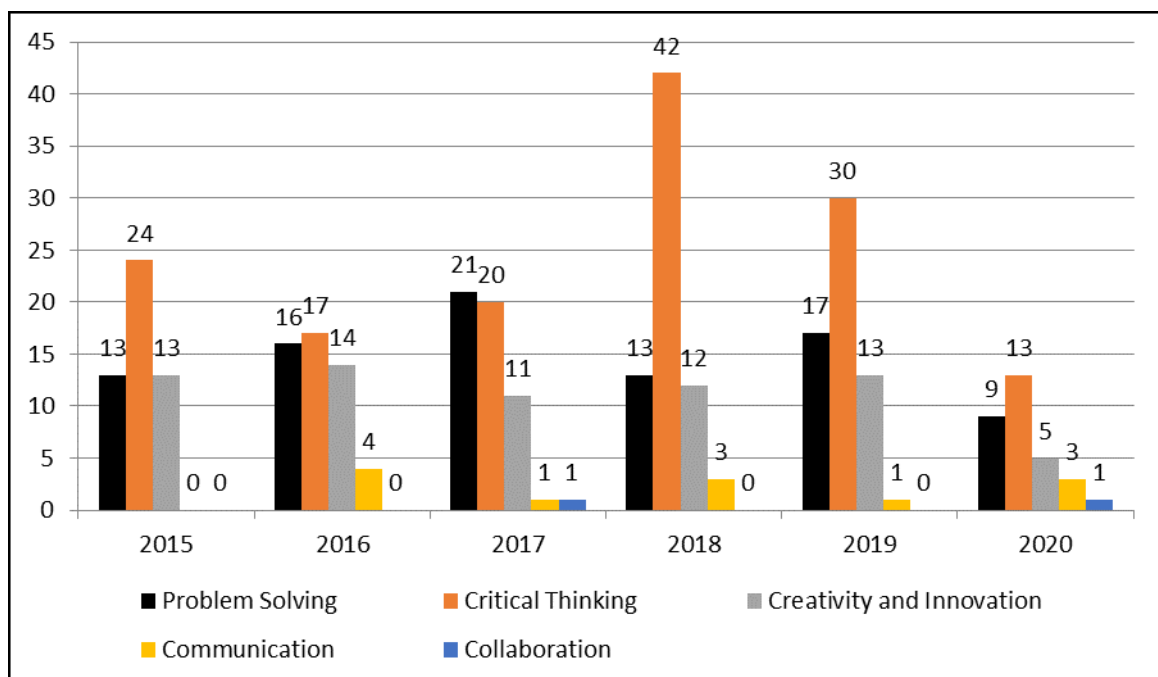


Fig 1. *Distribution of Research and Learning about 4C Skills from 2015-2020*

Figure 1 above shows that problem-solving skills and critical thinking skills are the most frequently researched topics related to 4C abilities. Of the 300 articles on 21st-century skills-based physics learning

research, 89 articles examined problem-solving abilities and 146 articles examined critical thinking. Both of these abilities are things that are often studied because these abilities are directly related to physics subject matter. Physics problems require problem-solving and critical thinking skills to solve them. This problem-solving and critical thinking ability needs to be researched and improved, especially in Indonesia. This is important because the students' problem-solving ability and critical thinking ability are classified as low [7] [8]. Lack of training related to problem-solving abilities is also a contributing factor to low problem-solving abilities. Problem-solving ability is not only influenced by mindset but also by work and training [9] [10]. Problem-solving skills indicator in physics includes the ability to argue, identify problems and evaluate problem-solving solutions [11]. Problem-solving skills are also related to critical thinking skills [12]. Low problem-solving ability because students are less critical in finding solutions to physics problems and their mastery of concepts is also low [13].

Several solutions are often used to improve problem-solving skills and improve critical thinking skills such as developing and applying learning instructions based on problem-solving and critical thinking skills, developing and implementing interactive learning media, developing and implementing physics modules based on 4C abilities, even developing and implementing a test instrument to measure the 4C's skills. Apart from critical thinking and problem-solving skills, creativity has also become a topic that has been frequently researched in recent years. Judging from the data, as many as 68 articles out of 300 articles researching creativity. Creativity is important because with this ability a person can solve physics problems in various ways, of course, is a logical way, and according to the right procedures. Even this ability is useful in finding creative, efficient, and effective solutions in solving real-life problems. Creativity is the ability to come up with ideas or ideas in developing his imagination for various situations or circumstances. This creativity will bring up innovative ideas [14]. Creativity is the ability to generate ideas, alternative solutions, or possibilities that can be used to solve a problem. The components of creativity are fluidity, flexibility, originality, and elaboration [15] [16]. Creativity is important because it is included in the demands of 21st-century learning. There are several problems related to creativity, namely: 1) students cannot think creatively because previous learning activities did not facilitate this; 2) The learning process does not stimulate students in developing these abilities [17]. This proves that the implementation of learning still focuses on low-level abilities, has not been able to foster creative thinking habits in students.

No less important than problem-solving skills, critical thinking, and creativity, communication, and collaboration skills are also important to develop because they are part of the demands of 21st-century learning. However, it can be seen from the data that there are only 12 articles that examine communication skills and only 1 article is written. discuss collaboration skills. This shows that these two abilities are not given enough attention. This communication and collaboration skill is very useful in dealing with real life. These two abilities also help solve problems. Good communication and collaboration with friends in learning physics will be able to provide many new ideas and knowledge to yourself. Some studies make it a habit to train creativity and critical thinking skills, but communication and collaboration skills are not used to be trained [18]. The ability to collaborate is very important for students as a provision to face diversity or provision when working in different groups to face the era of globalization [19]. There are 5 indicators of ability to collaborate, namely: 1) contribution; 2) time management; 3) problem solving; 4) working with others, and 5) investigative techniques [20]. Likewise, communication skills should be trained from an early age because this ability is important and is related to the way a person interacts with his surroundings. However, the fact is that students' communication skills are rarely trained so that their communication skills are low [20]. This communication skill is very important in the learning process. There are 4 important indicators in communication skills, namely: 1) Presentation of ideas; 2) discussion in groups; 3) the ability to ask questions; and 4) the ability to answer questions [21]. Future research is expected to lead to communication and collaboration skills.

Type/Approaches and Number of Research Samples Used

The analysis of the research approach is divided into 4 in general, namely the quantitative, qualitative, development (RnD), and mixed methods approach. The types/research approaches commonly used in

researching 21st-century skills are presented in the following figure.

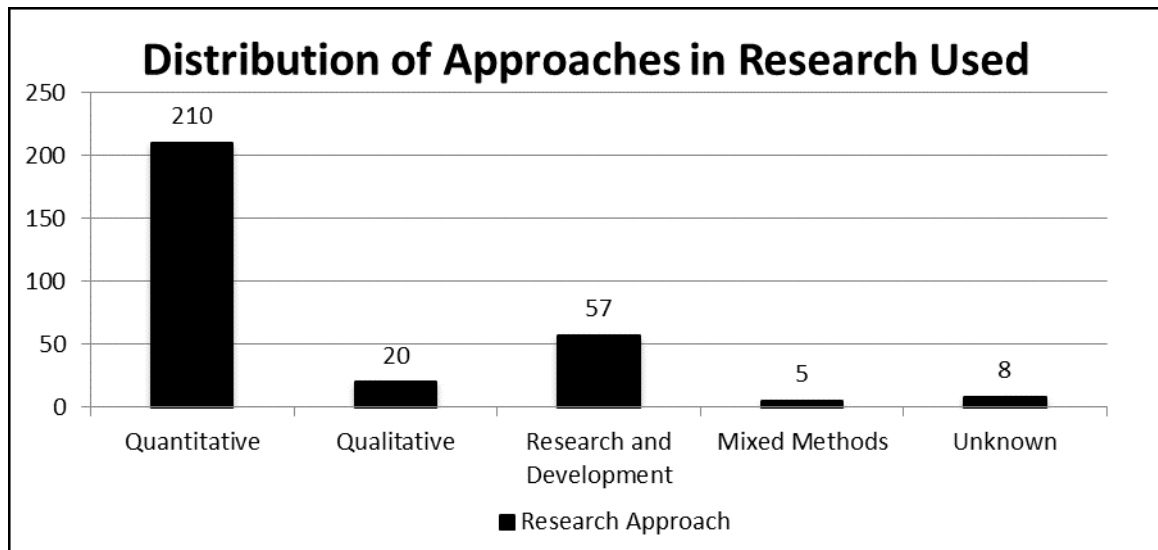


Fig 2. Distribution of research approaches

From Figure 2 above, it is obtained data that most of the research uses a quantitative approach. This quantitative research is often used because it has such wide coverage, the level of variation is quite complex, but only covers the surface area. It is different from qualitative research which covers a relatively narrow area, does not vary too much but the discussion is not limited and deep enough [22]. Therefore, a lot of learning research, especially physics learning, focuses on a quantitative approach in solving problems in the field of physics education in this case related to the ability of the 21st century (4C). Another reason for using a quantitative approach is related to the validity of data collection. The quantitative approach has standard instruments that are well-ordered and structured, while the qualitative approach uses the researcher himself as the instrument. So that the validity of the data is questioned [22]. From the data, it was found that 210 articles (70%) used a quantitative type/approach as their research method and 20 articles (6.67%) used a qualitative type/approach. Several research methods based on quantitative approaches are used such as quasi-experimental, classroom action research, pre-experiment, descriptive-quantitative, and so on. Meanwhile, qualitative research uses surveys or descriptive-qualitative methods.

The quantitative research approach in physics learning research is often used to apply learning models, instructional media, and test instruments to measure and even improve 4C skills. Meanwhile, a qualitative approach to learning physics is often used to deepen or find out more about the causes of problems related to 4C skills. Apart from these two approaches, there is also a type of development research (RnD), seen from the data of 57 articles from a total of 300 articles (19%) using the type of development. This development research is usually related to designing, developing, and even implementing products that support physics learning such as developing learning methods/models, developing interactive media, developing certain model-based learning instructions, and so on. The remaining 5 articles used mixed methods (16.67%), and 8 articles (26.67%) did not mention the research approach used.

Regarding the number of samples used, most of the samples used, 21st-century skills research is still a small-scale sample size and is divided into each region. Only 11 research articles used a sample of more than 100 samples. There are still many research articles that do not tell the number of samples used. The distribution of the number of samples used is presented in Figure 2 below.

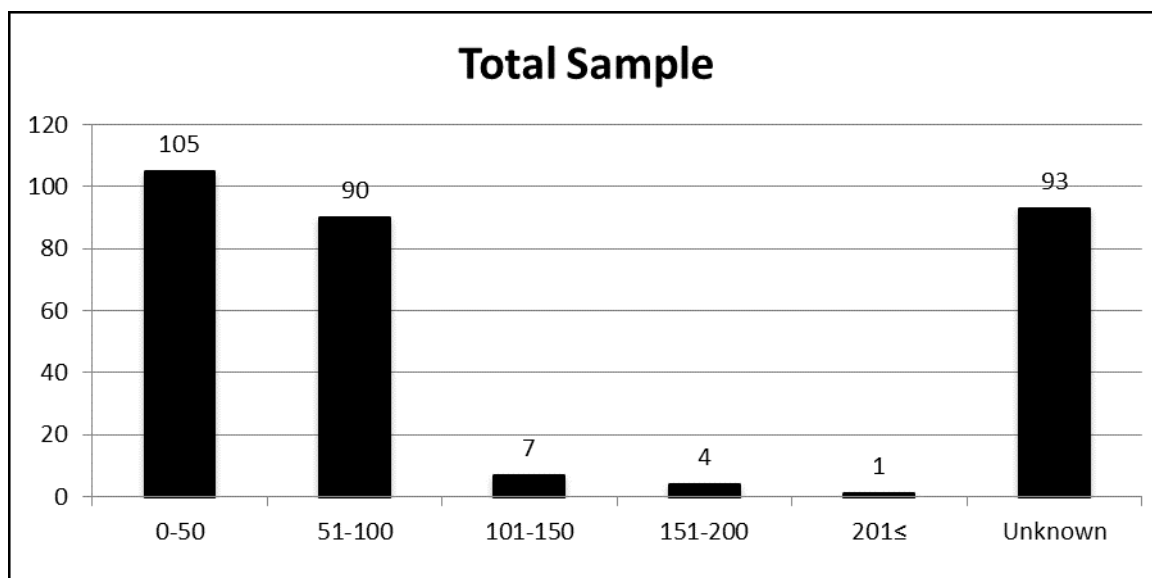


Fig 3. Distribution of the number of samples used

Most of the 4C skills-based physics learning research uses a relatively small sample. 65% of physics learning research uses a sample below 100 samples and only 4% uses a sample over 100 samples. One article uses a sample of more than 200 samples, this is because the type of research used is the development of a test instrument. Testing the test instrument with modern theory (Item Response Theory) requires a minimum sample of 250 for one parameter being measured.

Research Location and Education Level Researched.

The research location is divided into 6 major regions in Indonesia. This is to map the distribution of physics learning research locations related to 4C skills. It can be seen in Figure 3 that most of the research focuses on Bali-Nusra and Java. Meanwhile, in other areas, it is still very minimal. It can be seen that in Papua there is only 1 study on 21st-century skills. This will have an impact on the distribution of education quality.

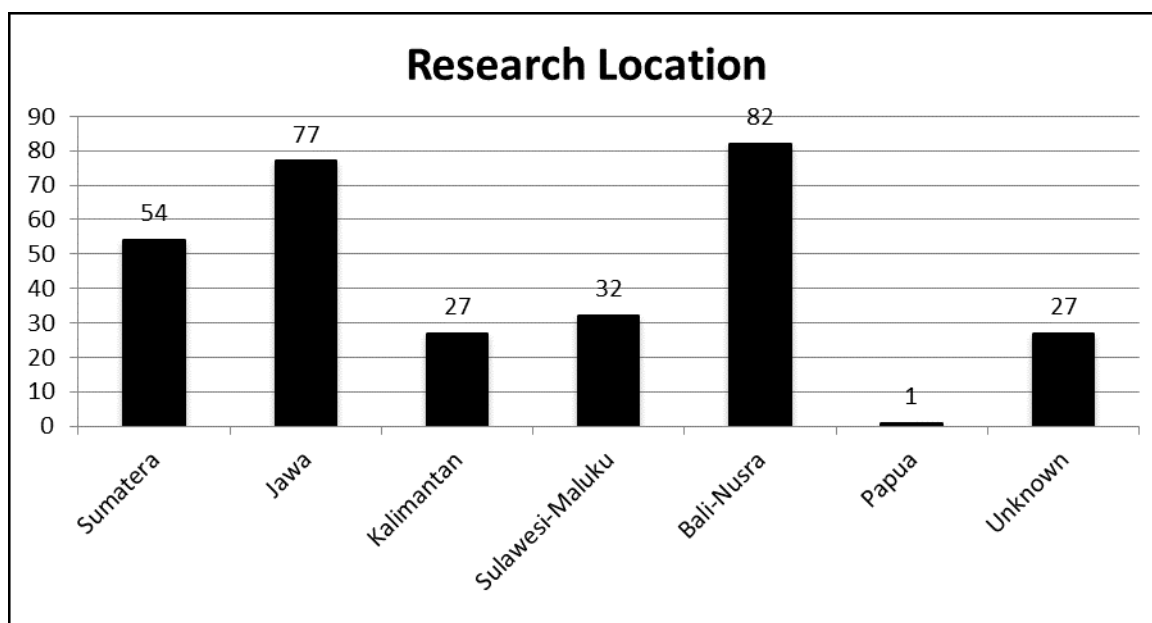


Fig 4. Distribution of Research Location in Indonesia

Equitable distribution of education quality can be started with equal distribution of research locations to improve 21st-century skills (4C). This is because students who are treated in the form of research by applying learning models, instructional media, and other learning aids will enable them to further improve 21st-century skills-based abilities. Based on the data in Figure 3 it is found that 54 articles (18%) researched in the Sumatra region, 77 articles (25.67%) researched in the Java region, 27 articles (9%) in the Kalimantan region, 32 articles (10.67%) in the Sulawesi-Maluku region, 82 articles (27.33%) in the Bali-Nusra, and only 1 article (0.33%) researched the Papua region.

Also, related to the level of education that is usually studied, most physics learning research focuses on the high school level (SMA/SMK/MA), because physics learning experiences many difficulties at that level. Although it cannot be denied that at the junior high school level (SMP/MTs) there is already physics material covered by science lessons. It would be great if 21st-century skills in learning physics were trained from an early age from the SMP/MTs level. It is also necessary to get used to practicing 4C skills at the university level even for physics teachers. Teachers who want to practice 4C skills in their students should also have this 4C ability. This needs to be researched to later provide provisions and training for prospective teacher students to have 4C skills. Another factor that becomes the reason for researching students' 4C abilities is that there are still many student-teacher candidates with low 4C skills. The critical thinking ability of prospective teacher students on dynamic electricity material is classified as low/very less critical [23]. Students' creative thinking abilities in basic physics courses are in a low category [24]. In detail, the levels of education that are often studied are presented in Figure 5 below.

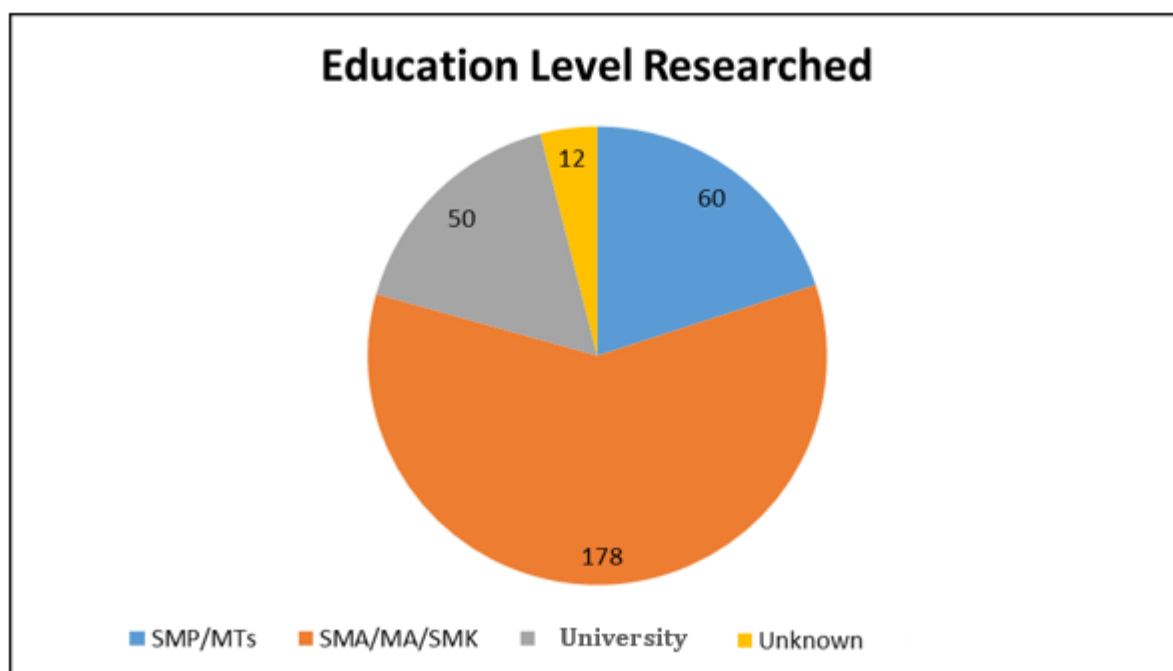


Fig 5. Distribution of Education Levels Researched

As can be seen in Figure 5, the SMA level most often researched related to 21st-century skills is the senior high school level (SMA/SMK/MA) because at that level it has focused on physics lessons instead of integrated science. Of the 300 articles synthesized, 60 articles (20%) focused on the SMP/MTs level, as many as 178 articles (59.33%) focused on the SMA/MA/SMK levels, as many as 50 articles (16.67%) focused on the university level (Students and Teachers), as well as only 12 articles (4%) that did not write down the research level studied.

Material/Physics Topics Research

Figure 6 shows the distribution of physics material selected by the researcher for research.

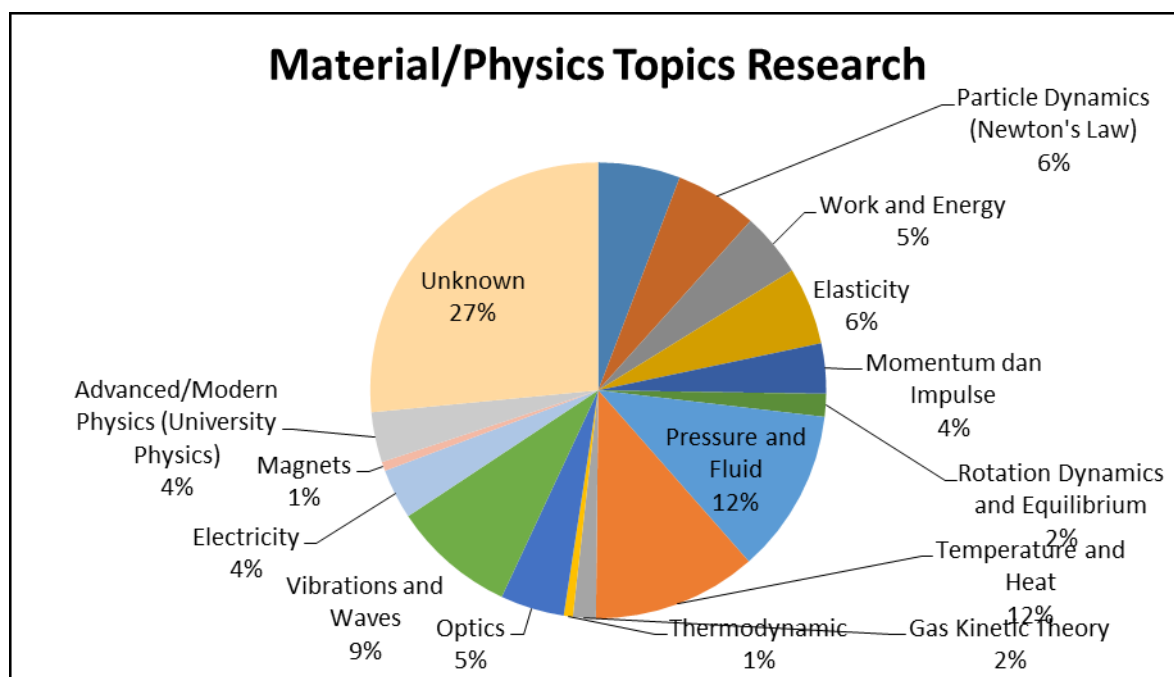


Fig 6. Distribution of the material/topics Physics Research

Based on Figure 6, the material of pressure and fluid as well as temperature and heat which are the topics of physics are the topics most often researched with a percentage of as much as 12% in many studies. Furthermore, Vibration and waves (9%), motion kinematics (6%), particle dynamics (6%), elasticity (6%), work and energy (5%), light and optics (5%), momentum and impulses (4%), electricity (4%), advanced physics (4%), kinetic theory of gas (2%), dynamics of rotation and rigid body equilibrium (2%), thermodynamics (1%), and magnetism (1%). As many as 27% of the research did not mention the physics topic being studied. It is important to know this physics material to assist future researchers in conducting research related to 21st-century skills with different physics materials. Every study should include this component. This is to assist future researchers in focusing their research, especially related to 4C skills.

CONCLUSION AND SUGGESTION

A lot of learning research, especially physics learning, focuses on quantitative approaches in solving problems in the field of physics education in this case related to the abilities of the 21st century (4C). Critical thinking and problem-solving skills have become the most researched topics for the past few years. The quantitative research approach in physics learning research is often used to apply learning models, instructional media, and test instruments to measure and even improve 4C skills. Most of the samples used in 21st-century skills research are still relatively small and divided into each region in Indonesia.

The research locations were found mostly focused on Bali-Nusra and Java. Meanwhile, in other areas, it is still very minimal. The research subject most frequently researched related to 21st-century skills is the senior high school (SMA/SMK/MA) because at that level it has focused on physics lessons instead of integrated science. Matter of pressure and fluid as well as temperature and heat are the most researched topics of physics.

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