Analysis of Needs for Development of Android-Based Socioscientific Issues Teaching Materials on the Topic of Climate Change to Improve Students' Decision-Making Ability

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Abstract: Teaching materials are vital recources for students in their learning process. Decision-making skills are one of the essential competencies that students have to possess in the 21st century. The global dilemmas being faced today and will get worse is climate change. The challenges caused by climate change that is occurring need to involve students looking for the best decisions as well as through these problems students will be able to train their decision-making abilities. This study aimed to analyze the importance of developing socio-scientific issues teaching materials to train decision-making skills so that later it will be improved. Data were collected through questionnaires filled out by 30 students to gauge their current decision-making abilities, revealing a tendency to rely on personal feelings. Additionally, 10 teachers were surveyed about their methods for enhancing students' decision-making skills. This data was analyzed using descriptive analysis. The results of the study found that the level of students' ability to make decisions is still low and based on their personal feelings. Also, there were no teaching materials containing socioscientific-issues to train students' decision-making skill. Thus, it is important to develop android-based socioscientific-issues teaching materials on the topic of climate change to improve students' decision-making skills.

Keywords: Climate change; Decision-making; Socioscientific-issues; Teaching materials

Introduction

One essential educational resource employed by students in school involves the creation of teaching materials, a task often undertaken by their own educators. These teaching materials encompass a comprehensive compilation of information, tools, and text thoughtfully organized to outline the specific competencies students will acquire. They serve as a vital resource for planning, executing, and assessing the learning process (Prastowo, 2014). Such teaching material facilitate teaching staff in conducting effective instructional sessions and empower students to attain their intended learning objectives and competencies. Furthermore, these materials aid students in independently preparing for and grasping the study materials. A meticulously structured set of teaching materials simplifies the acquisition of every competency outlined within them. It is imperative that students utilize teaching materials aligned with the curriculum in use to ensure the realization of their expected learning outcomes. On occasion, educators may customize teaching materials to suit the unique competencies their students are expected to achieve during the learning process.

The Indonesian government has issued a policy to transform the country's traditional education system into a distance education system that can be conducted online (Kepmendikbud, 2020). Various education sectors have been significantly affected by this transformation of the education system. One of them is that electronic media such as distance learning

applications, and learning resources that can be accessed anywhere and anytime can be used as learning resources so that all teachers and students must be able to adapt to use them.

In distance learning, mobile internet communication devices are currently gaining popularity. Mobile technology-based learning facilitates the rapid acquisition of knowledge and instructional resources, significantly increasing student competency (Papadakis et al., 2018). Mobile technology combined with an interdisciplinary approach to knowledge and the organization of meaningful learning experiences for children can create a creative and interactive learning environment different from traditional teaching (Papadakis et al., 2018). On the other hand, the use of this type of learning gives teachers the freedom to manage information, resources, and exams whenever and wherever they want. Technology is advancing so quickly that it is now more important to emphasize how something can be learned than what is learned.

The rapid development of technology and information is also predicted to boost teaching materials used in classrooms. With the emergence of 21st-century learning, it is hoped that learning resources used in classrooms will also integrate information technology, enabling fast, accurate, and effective access to be used as learning resources.

In 2020, 54% of Indonesia's population accessed the Internet, according to Indonesian telecommunications statistics. It has been noted that 91% of homes in Indonesia currently have at least one mobile phone number, an increase of three percent from the statistical data recorded in 2017. Meanwhile, landline telephone connections have decreased to 2%(BPS, 2020). This shows that the majority of Indonesian people have internet access and often use cell phones because they are easy to carry and easy to use.

This technological development also has an impact on the world of education, because currently learning is expected to be able to keep up with the times by using the latest technology. Technology is essential to modern life and influences the education system both directly and indirectly (Yılmaz, 2021). Online learning, simulations, virtual laboratories, online learning applications, and many other conditions related to technology (Brito et al., 2018). Thus, it is hoped that every teaching material used in schools as a learning aid will also be technologically literate.

Technology-based teaching materials can be in the form of Android applications, where teaching materials in the form of Android applications will greatly assist students in accessing learning resources quickly. According to data from (Statcounter, 2022) that the percentage of Android users in Indonesia is 89% in the range from August 2021 to August 2022. This is because Android has characteristics that make it easier for users, namely: 1) Android is open source so that anyone can develop it freely without having to go through the approval of Android Inc.; 2) has no restrictions for non-official application developers; 3) can solve bottlenecks in applications; 4) Android has wide access for developers to develop their applications (Safaat, 2011). So, with the convenience of developing Android, it is an option for Indonesian people, including students.

It is noted that 98% of children over the age of 5 have accessed the internet via smartphones. While the rest use laptops, computers, and others. Their purpose in accessing the internet varies. As many as 66% of children access the Internet to get information and news, and 63% access the Internet for entertainment purposes only. Only 33% of children use the Internet for school work (BPS, 2020). Based on these statistical data, it can be seen that the majority of students already use the internet and most use it for entertainment purposes. Therefore, there is great potential for the world of education to utilize smartphones to support children's education and learning. This is a good step to increase the use of the Internet as an educational tool. It is hoped that with the development of media and applications that can be accessed using the internet on cell phones, students will be more assisted in learning and can use smartphones to develop their skills and competencies.

The ability to make decisions is one of the skills that students need to master to face the challenges of the 21st century, in addition to the use of 21st-century technology in learning. Information is a significant decision-making tool in the digital age because it is so easily accessible and abundantly available (The Organization for Economic Cooperation and Development, 2022). However, some problems arise, and finding accurate and useful information can be difficult even with this quick and easy access. Thus, it is very important to provide students with instruction in decision-making exercises that test their ability to sift through correct, appropriate, and reliable information.

The same idea is also found in the 21st-century learning framework created by Partnership for 21st-Century Learning (2015) to make it easier for educators to include the skills needed to be developed through the learning process. Students must have an important ability they need to succeed in today's world, namely the ability to make judgments and decisions. This ability should be taught to students as part of their education.

In this age of advanced and interconnected technology, it is very important to prepare a future society that can make fair decisions about how to resolve various difficulties on a local or global scale, as well as be effective in preventing unwanted events at the

individual level (Fang et al., 2019). The thought process of identifying and selecting options from a variety of accessible options is a decision-making process. Decision-making capacity enables one to methodically assess the factual and morally feasible actions in complex scenarios involving current events and issues and to make systematic decisions (Tawil & LIliasari, 2013).

Making decisions requires sophisticated skills and techniques that not everyone can acquire naturally (Hsu & Lin, 2017). Because there are so many problems in the 21st century that demand quick decisions and are followed by in-depth consideration, decision-making skills are crucial to students' attention and important to be trained from an early age.

Finding a problem, integrating lots of information, and choosing the best solution from available options are all steps in the decision-making process (Luan et al., 2022). Higher-order thinking skills are required for this decision-making capacity (Bayram-Jacobs et al., 2019; Kinslow et al., 2019). To solve problems with solutions, decision-making demands the ability to acquire accurate knowledge about problems or phenomena as well as critical and creative thinking skills. To prepare students to face future problems that demand the capacity to be able to make the right decisions when facing a problem, it is very important to pay attention to and practice decision-making skills from a young age.

Science is an important topic for children to study in the 21st century(Partnership for 21st Century Learning, 2015). By practicing decision-making on socioscientific issues, decision-making skills can be trained in science learning. According to Anagün & Özden (2010), socioscientific problems (SSI) is a description of social problems in society related to natural science. Students are allowed to think like scientists when solving social problems in society through socioscientific dilemmas. Socioscientific issues (SSI) are complex scientific topics that are also significant to society, require moral judgment when making decisions, and have multiple solutions (Emery et al., 2017; Garrecht et al., 2020). Socioscientific issues that are scientifically, and socially relevant, as well as problems in society itself can help students practice their decision-making skills.

Socioscientific issues cover complex issues related to society, science, and technology such as food and energy scarcity, climate change, a decline in biological conservation, and sustainable development (Kinslow et al., 2019; Lee et al., 2019; Sutter et al., 2019; Zaikauskaite et al., 2020). The topic of climate change is one of the socioscientific issues that can be discussed in science education.

An important subject that is very important for students to master is climate change. One of the major issues facing the world in the twenty-first century is climate change, which will only get worse if nothing is done (Putri et al., 2022). Global challenges like climate change affect everyone, everywhere (United Nation, 2016). The learning carried out must be able to awaken students and train students to be able to make decisions on global issues related to climate change as a way to deal with the impacts of climate change.

Climate change is a socioscientific issue (Zaikauskaite et al., 2020) that can have an impact on health, livelihoods, food security, water availability, and economic growth (Hicks, 2019). Currently, climate change continues to occur, while human attitudes and behavior have not changed much to reduce the impact of this climate change (Hicks, 2019). Therefore, it is very important to teach students the topic of climate change so that students not only know the impacts but also realize that climate change has occurred, then they can form characters and attitudes that care more about the surrounding environment, and can make the right decisions to prevent impacts. worse than climate change, and provide the best decisions on controversial issues involving various sectors. Students are expected to be able to form awareness and sensitivity to environmental conditions which are the impact of climate change both now and in the future. As well as being able to contribute to the best decisions on issues related to socioscientific issues about climate change from various perspectives.

Students' decision-making skills are improved through learning using socioscientific issues. According to research (Dawson & Eilam, 2022), teachers who apply SSI lessons on climate change can greatly improve their students' decision-making abilities. Making better decisions is the benefit of implementing science education using socioscientific issues for environmental pollution materials (Rizal, 2016). Students' decision-making abilities can be enhanced by using modules with decision-making exercises in the context of SSI (Hsu & Lin, 2017). Based on previous studies it was found that the use of effective teaching materials to improve students' decision-making skills by using socioscientific issues as a source of dilemmas that must be decided.

Therefore, it is important to develop android-based socioscientific teaching materials for the topic of climate change so that teachers and students can have technology-based learning resources and can help practice decision-making skills which are very important to master in the 21st century.

Method

The method used in this research is a quantitative method. The research was conducted using a cross-sectional survey method, namely to collect data at a certain time. The purpose of this study was to find out the importance and need of teachers and students for the development of android-based socioscientific issues teaching materials to improve students' decision-making abilities. The subjects of this study were 30 seventh-grade students and 10 science teachers. The subject of this study was determined by purposive sampling, namely determining certain considerations that are believed to understand the required data (Sugiyono, 2016).

The data collection technique used in this study was a questionnaire containing questions in the form of open-ended questions and closed-ended questions filled in by students and teachers. The distributed questionnaire has been checked and validated by two experts in science education. Filling out a questionnaire by students was carried out to determine the level of students' ability to make decisions, information about the types of teaching materials students had used, students' interest in android-based teaching materials, and student's knowledge of the topic of climate change. Meanwhile, filling out the questionnaire by the teacher

was carried out to find out the steps the teacher had taken to improve students' decision-making abilities, the types of teaching materials that had been used or developed by the teacher, as well as the teacher's assessment of decision-making abilities.

The data analysis technique used in this study was started by grouping the focused questions on the questionnaire, making tables and filtering the questionnaire results, comparing the data obtained, and drawing conclusions.

Result and Discussion

The research outcomes will primarily center on three meticulously examined aspects: an assessment of teaching material needs, an evaluation of students' decision-making skills, and an analysis of both student and teacher feedback regarding android-based teaching materials. These findings, compiled by the researchers, will be presented in the following manner.

Analysis of Needs

Identify the level of need for android-based socioscientific issues teaching materials using the teacher's answers to related questions. Questionnaires containing open-ended questions were distributed to ten teachers. Table 1 below is a generalization of the answers given by ten science teachers.

Table 1. Results of Questionnaire Answers for Analysis of Needs for Android-Based Socioscientific Issues Teaching Materials

Indicators	Questionnaire Answer Results
Teaching materials used in schools	The types of teaching materials used are printed books, students' worksheets, materials from websites, and Android applications
Learning applications that have been used	E-module, Kahoot, Youtube, Google Classroom, dan Frequency
The importance of training students' decision-making skills	100% of teachers agree that this skill is important, but 70% of teachers think that this skill has not been trained
The way the teacher trains students' decision-making skills	Through activities such as choosing a class organizational structure, giving problems and choices to students to make decisions, conducting debates about certain materials, as well as discussing topical issues.
Teacher constraints in using SSI to improve students' decision-making skills	There are obstacles in integrating socioscientific issues in natural science materials because there are no reliable sources on socioscientific issues
Frequency of using socioscientific issues as a problem context in decision making	60% of teachers have never used SSI as a problem context for making decisions. 40% of teachers said they had used it on electricity, inheritance, ecology, the human digestive system, and global warming
The teacher's opinion if the development of android-based socioscientific issues teaching materials for climate change material is carried out	Agree, because the existence of these teaching materials will help to train students' decision-making skills

Based on the questionnaire answers obtained, it was found that the types of teaching materials commonly used in schools were printed teaching materials, modules, and students' worksheet in printed form. Meanwhile, 40% of teachers have also used Android applications but are limited to applications that can be used as a medium for online learning such as

Kahoot which is used for quizzes, Google Classroom as a forum for sharing material and questions, then Youtube which is used as a source of video information.

However, teachers have not used Android applications in the form of teaching materials, where students can access the material while at the same time working on practice and evaluation questions in the

application. Even though the role of teaching materials occupies a very strategic position and will determine the achievement of educational goals and can increase the effectiveness and efficiency of learning methods (Olawale, 2013). In addition, at this time technology is very vital in human life today and has a direct or indirect impact on the learning system (Yılmaz, 2021). One of the learnings related to technology is the use of learning applications (Brito et al., 2018).

Based on the results of the questionnaire, 100% of teachers agreed that decision-making skills are important 21st-century skills to be trained in students. As found in the 21st-century learning framework developed by (Partnership for 21st Century Learning, 2015) that students must be trained in order to have essential skills so they can be successful in facing the world today in the form of the ability to make judgments and decisions. Society in the future is expected to be able to make fair decisions about how to reach an agreement on various issues on a local and global scale (Fang et al., 2019). Meanwhile, 70% of teachers agree that currently these skills have not been trained optimally. The methods used by the teacher to train students' decision-making skills are through activities such as selecting class leaders, and representatives for competitions, conducting debates about certain materials, and group discussions on a problem. These activities can be said to be good to do as an effort to train students' decision-making skills.

Students' decision-making skills can be trained through science learning by integrating socioscientific issues as the context of problems that require a decision. Students experienced a significant increase in decision-making skills when teachers implemented SSI learning (Dawson & Eilam, 2022). Learning that uses SSI for environmental pollution material also gets positive results on students' decision-making skills (Rizal, 2016). In addition, it was found that the use of modules containing student decision-making activities in the SSI context could improve decision-making skills (Hsu & Lin, 2017).

However, based on the results of the answers from the questionnaire, teachers had difficulty integrating SSI into science learning materials, so the context of this problem was rarely used to train students' decision-making. The reason is due to the absence of relevant and reliable sources on the use of socioscientific issues to train students' decision-making skills. Teaching materials are needed to help teachers facilitate learning activities to achieve the expected learning objectives (Nwike & Catherine, 2013).

Teaching materials can also be a guide for students to direct all learning activities which are competency substances that must be learned and mastered (Prastowo, 2014). Thus, each respondent strongly agreed with the development of android-based socioscientific issues teaching materials because the existence of these teaching materials would help teachers and students practice decision-making skills in science learning.

Analysis of Students' Decision-Making Ability

Identify the level of students' ability to make decisions using students' answers to related questions. Questionnaires containing closed-ended questions were distributed to 30 students. Table 2 below is a generalization of the level of students' decision-making ability based on the steps taken by students in making decisions.

Table 2. Results of Questionnaire Answers for Analysis of Student's Decision-Making Ability

Indicators	Questionnaire Answer Results
Students make decisions based on personal feelings	83% of students make decisions based on their personal feelings
Students seek information before making decisions	70% of students seek information before making decisions
Students find out the essence of the problem before making a decision	87% of students find out the essence of the problem before making a decision
Students list possible solutions before making a decision	17% of students list possible solutions before making a decision
Students carry out an analysis of the advantages and disadvantages of a solution before deciding	43% of students analyze the advantages and disadvantages of a solution before deciding
Students evaluate after making a decision	27% of students evaluate the decision
Frequency of students making decisions about environmental issues	50% of students have made decisions about environmental issues

There are six stages that need to be carried out to produce the best decision, namely defining the problem, determining alternative solutions, seeking information, evaluating each alternative solution, analyzing the advantages and disadvantages of each alternative solution, making decisions, and evaluating decisions. (Ratcliffe, 1997).

These stages will be able to help to produce the best and most accountable decisions. Meanwhile, based on the data obtained, it was found that most students had not followed the decision-making stages properly so the

resulting decisions tended to be based solely on personal feelings without any analysis of the advantages and disadvantages of the resulting decisions. Individual personality can influence the tendency to make decisions, individuals tend to make decisions that can maximize and satisfy themselves (Miceli et al., 2018).

Characteristics of individuals are always diverse. Based on the findings, one aspect that affects the performance of decision-making is self-confidence (Dayeh & Morrison, 2020; Yoon et al., 2021). The findings by Dayeh & Morrison (2020), stated that decision-making will be more effective if members can reduce the error rate in decision-making by controlling the confidence level of members. These findings are also supported by Blanchard et al. (2020), which state that having an excessive sense of self-confidence will lead to a bias that can prevent from searching and processing information more deeply, this attitude will result in less information exchange between group members and the tendency of decision making is no longer following the desired goals.

Based on the data above, it can be seen that from the stage of making alternative solutions, analyzing weaknesses and strengths, and evaluating only a small number of students who did it. Students that apply decision-making strategies earlier will produce better group performance (Gresch et al., 2017; Zhu et al., 2021). Based on the findings by Gresch et al. (2017), the group of students that received training on strategy implementation in the decision-making process showed a planned and structured process compared to the group that did not receive strategy implementation training. This finding is supported by Zhu et al. (2021), who that early implementation of decision-making strategies will give better performance to the decision-making process.

Analysis of Student and Teacher Responses to Android-Based Socioscientific Issues Teaching Materials

The results of the questionnaire distributed to students and teachers found that the most frequently used learning resource was printed teaching materials. Android applications have been used during online learning during the pandemic, such as Kahoot for quizzes and Google Classroom for class management. However, there are no teaching materials that have been developed in the form of Android and can be accessed by students anywhere and anytime.

Basically, developing applications in the form of Android has a high opportunity because 100% of students have Android mobile phones and are used to accessing the internet using mobile phones. Learning in the era of globalization should follow the development of technology and communication because currently, technology has a vital role that has a direct or indirect impact on the education system (Yılmaz, 2021).

As many as 77% of students agree that the use of Android applications as learning resources is interesting. These findings are also supported by data from Statcounter (2022) that the percentage of Android users in Indonesia is 89%. However, it was recorded that only 33% of children used the internet for school work, and 63% used the internet for entertainment. Therefore, the development of Android-based teaching materials will be effectively carried out based on student interest and the percentage of use of these devices in society. And there is great potential for the world of education to be able to use smartphones to support learning.

Conclusion

From the needs analysis that has been carried out, the results show that it is necessary to develop android-based socioscientific issues teaching materials that can support the student learning process and are able to train students' decision-making skills. This android-based socioscientific issues teaching material is needed as a source of learning and training for students so they can apply the correct decision-making stages to produce an informed decision on the problem. Therefore, the development of SSI teaching materials needs to be carried out as a relevant resource and helps teachers and students to learn and practice decision-making skills.

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

References

Anagün, Ş. S., & Özden, M. (2010). Teacher candidate's perceptions regarding socio-scientific issues and their competencies in using socio-scientific issues in science and technology instruction. *Procedia - Social and Behavioral Sciences*, 9, 981–985. https://doi.org/10.1016/j.sbspro.2010.12.271

Bayram-Jacobs, D., Wieske, G., & Henze, I. (2019). A

chemistry lesson for citizenship: Students' use of different perspectives in decision-making about the use and sale of laughing gas. *Education Sciences*, *9*(2). https://doi.org/10.3390/educsci9020100

Blanchard, M. D., Jackson, S. A., & Kleitman, S. (2020). Collective decision making reduces metacognitive control and increases error rates, particularly for overconfident individuals. *Journal of Behavioral Decision Making*, *33*(3), 348–375. https://doi.org/10.1002/bdm.2156

BPS. (2020). Statistik Telekomunikasi Indonesia. *Katalog*, 1–14.

Brito, R., Dias, P., & Oliveira, G. (2018). Young children, digital media and smart toys: How perceptions shape adoption and domestication. *British Journal of Educational Technology*, *49*(5), 807–820. https://doi.org/10.1111/bjet.12655

Dawson & Eilam. (2022). Teachers' Strategies to Develop Students' Decision Making Skills Using the Socioscientific Issue of Climate Change. *Learning Science for Higher Education*. https://doi.org/https://doi.org/10.1007/978-981-19-1840-7_19

Dayeh, V., & Morrison, B. W. (2020). The Effect of Perceived Competence and Competitive Environment on Team Decision-Making in the Hidden-Profile Paradigm. *Group Decision and Negotiation*, *29*(6), 1181–1205. https://doi.org/10.1007/s10726-020-09701-2

Emery, K., Harlow, D., Whitmer, A., & Gaines, S. (2017). Compelling evidence: an influence on middle school students' accounts that may impact decision-making about socioscientific issues. *Environmental Education Research*, *23*(8), 1115–1129. https://doi.org/10.1080/13504622.2016.1225673

Fang, S. C., Hsu, Y. S., & Lin, S. S. (2019). Conceptualizing Socioscientific Decision Making from a Review of Research in Science Education. *International Journal of Science and Mathematics Education*, *17*(3), 427–448. https://doi.org/10.1007/s10763-018-9890-2

Garrecht, C., Eckhardt, M., Höffler, T. N., & Harms, U. (2020). Fostering students' socioscientific decision-making: exploring the effectiveness of an environmental science competition. *Disciplinary and Interdisciplinary Science Education Research*, *2*(1). https://doi.org/10.1186/s43031-020-00022-7

Gresch, H., Hasselhorn, M., & Bögeholz, S. (2017). Enhancing Decision-Making in STSE Education by Inducing Reflection and Self-Regulated Learning. *Research in Science Education*, *47*(1), 95–118. https://doi.org/10.1007/s11165-015-9491-9

Hicks, D. (2019). Education and climate change. In *A Student's Guide to Education Studies*.

https://doi.org/10.4324/9780429297212-14

Hsu, Y. S., & Lin, S. S. (2017). Prompting students to make socioscientific decisions: embedding metacognitive guidance in an e-learning environment. *International Journal of Science Education*, *39*(7), 964–979. https://doi.org/10.1080/09500693.2017.1312036

Kinslow, A. T., Sadler, T. D., & Nguyen, H. T. (2019). Socio-scientific reasoning and environmental literacy in a field-based ecology class. *Environmental Education Research*, *25*(3), 388–410. https://doi.org/10.1080/13504622.2018.1442418

Lee, Y. C., Grace, M., Rietdijk, W., & Lui, Y. C. (2019). A cross-cultural, cross-age, and cross-gender study of Hong Kong and UK secondary students' decision making about a biological conservation issue. *International Journal of Science Education*, *41*(18), 2696–2715.
https://doi.org/10.1080/09500693.2019.1693662

Luan, H., Li, T. L., & Lee, M. H. (2022). High School Students' Environmental Education in Taiwan: Scientific Epistemic Views, Decision-Making Style, and Recycling Intention. *International Journal of Science and Mathematics Education*, *20*(1), 25–44. https://doi.org/10.1007/s10763-020-10136-z

Miceli, S., de Palo, V., Monacis, L., Di Nuovo, S., & Sinatra, M. (2018). Do personality traits and self-regulatory processes affect decision-making tendencies? *Australian Journal of Psychology*, *70*(3), 284–293. https://doi.org/10.1111/ajpy.12196

Nwike, M. C., & Catherine, O. (2013). Effects of Use of Instructional Materials on Students Cognitive Achievement in Agricultural Science. *Journal of Educational and Social Research*, *3*(August), 103–108. https://doi.org/10.5901/jesr.2013.v3n5p103

Olawale, S. K. K. -d. (2013). the Use of Instructional Materials for Effective Learning of Islamic Studies. *Jihāt Al-Islām*, *6*(2), 29–40.

Papadakis, S., Kalogiannakis, M., & Zaranis, N. (2018). Educational apps from the Android Google Play for Greek preschoolers: A systematic review. *Computers and Education*, *116*, 139–160. https://doi.org/10.1016/j.compedu.2017.09.007

Partnership for 21st Century learning. (2015). *21st Century Student Outcomes*. 1–9. http://www.p21.org/our-work/p21-framework

Prastowo, A. (2014). *Pengembangan Bahan Ajar Tematik*. Kencana.

Putri, S. I., Huda, E. F., & Nikmah, N. (2022). Education and Climate Change: The Role of Universities - Fernando M. Reimers, Switzerland: Springer, 2021. *Australian Journal of Environmental Education*, 1–3. https://doi.org/10.1017/aee.2022.35

Ratcliffe, M. (1997). Pupil decision-making about socio-

scientific issues within the science curriculum. *International Journal of Science Education*, *19*(2), 167–182. https://doi.org/10.1080/0950069970190203

Rizal, H. P. (2016). *Penerapan Pembelajaran IPA Berbasis Socioscientific Issues Untuk Meningkatkan Kemampuan Pengambilan Keputusan Siswa SMP Berdasarkan Gender pada Materi Pencemaran Lingkungan*. Universitas Pendidikan Indonesia.

Safaat, N. (2011). *Pemprograman Aplikasi Mobile Smartphone dan Tablet PC Berbasis Android*. Informatika.

Statcounter. (2022). *Mobile Operating System Market Share Indonesia*. https://gs.statcounter.com/os-market-share/mobile/indonesia

Sugiyono. (2016). *Metode Penelitian dan Pengembangan (Research and Development)*. Alfabeta.

Sutter, A. M. K., Dauer, J. M., Kreuziger, T., Schubert, J., & Forbes, C. T. (2019). Sixth grade students' problematization of and decision-making about a wind energy socio-scientific issue. *International Research in Geographical and Environmental Education*, *28*(3), 242–256. https://doi.org/10.1080/10382046.2019.1613586

Tawil & LIliasari. (2013). *Berpikir Kompleks dan Implementasinya dalam Pembelajaran IPA*. Badan Penerbit UNM.

The Organization for Economic Cooperation and Development. (2022). *Trend Shaping Education 2022*. https://www.oecd.org/education/ceri/trends-shaping-education-22187049.htm

United Nation. (2016). *UN Report 2016-SDG Indicators*.

Yılmaz, A. (2021). The effect of technology integration in education on prospective teachers' critical and creative thinking, multidimensional 21st century skills and academic achievements. *Participatory Educational Research*, *8*(2), 163–199. https://doi.org/10.17275/per.21.35.8.2

Yoon, Y. J., Larson, J. R., & Huntsinger, J. R. (2021). The flexible impact of member affect in groups performing complex decision-making tasks. *Group Processes and Intergroup Relations*. https://doi.org/10.1177/1368430220985601

Zaikauskaite, L., Chen, X., & Tsivrikos, D. (2020). The effects of idealism and relativism on the moral judgement of social vs. environmental issues, and their relation to self-reported proenvironmental behaviours. *PLoS ONE*, *15*(10 October), 1–27. https://doi.org/10.1371/journal.pone.0239707

Zhu, X. S., Wolfson, M. A., Dalal, D. K., & Mathieu, J. E. (2021). Team Decision Making: The Dynamic Effects of Team Decision Style Composition and Performance via Decision Strategy. *Journal of Management*, *47*(5), 1281–1304. https://doi.org/10.1177/0149206320916232