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Hierarchy of End-of-use Options: Smartphones Reuse to Support Online Learning During COVID-19 Pandemic in Indonesia

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Abstract. This paper studied the hierarchy of end-of-use options for smartphones to support online learning during COVID-19 pandemic in Indonesia. The EOU options were first studied by reviewing relevant literature about e-waste in Indonesia and then a hierarchy of EOU options was drew up. Finally, integrating the result with the analysis from the literature review on the use of smartphones in online learning during the pandemic, we proposed a new hierarchy that could bridge the challenges in both aspects. As a result, it helps to reduce e-waste from used smartphones and at the same time helps underprivileged students to obtain smartphones for online learning.

INTRODUCTION

The COVID-19 pandemic has caused enormous changes in people's lives globally. Many physical activities have shifted to online ones, including the education sector, where almost all learning activities are carried out online. Therefore, the need for electronic devices that support online learning is inevitable. Students that come from high-income or economically capable families have the privilege to use either a desktop or laptop computer. However, for the ones with limited resources, their options might be limited to utilizing smartphones. Furthermore, marginalized or low-income communities might not own smartphones or mobile phones that can run video conferencing applications such as Google Meet, Zoom, and Microsoft Teams. A recent study confirmed that smartphones had enabled previously “disconnected” people to access the internet; 96% of internet users in Indonesia use smartphones to access the internet [1]. The Indonesian Ministry of Education and Culture has provided a data package subsidy to facilitate internet connections for educators and students, but not electronic devices.

On the other hand, the number of smartphone users in Indonesia is very large. By 2020, smartphone users in Indonesia are estimated to have reached 191.6 million [2]. Currently, Indonesia is the fourth-largest smartphone market after China, India and the United States. However, the usage phase of mobile phones in Indonesia is generally short, which is less than three years [3], and this leads to much electronic waste from discarded mobile phones. Therefore, the number of electronic wastes in Indonesia is dominated by mobile phones [4,5]. From the user's behavioral aspect, when the electronic products have reached their end-of-use, several studies have found that the old device will be sold, stored, or given to family or friends once the users have a newer replacement device. According to Andarani [4], Rimantho [6], and Safaat [7], selling electronic products to the secondhand market is the most common behavior. However, giving used smartphones or mobile phones to family or friends, or donating to other parties, is also a common practice.

This paper investigates the hierarchy of smartphones' end-of-use options from the literature that describe the condition before the COVID-19 pandemic and then propose an updated hierarchy based on the changes caused by the pandemic where smartphones are needed to support online learning.

METHODS

This work aims to present a hierarchy of end-of-use (EOU) options for smartphones under the COVID-19 pandemic disruption. We started with a literature review on e-waste and end-of-use options for smartphones focusing on the Indonesian context. Good practices from other countries are also considered to support the proposed theoretical framework of the hierarchy of EOU options. Furthermore, we conduct a content analysis of the relevant literature and draw up a hierarchy of EOU options before the pandemic.

There are many aspects of our life affected by the COVID-19 pandemic, specifically caused by the physical distancing policy to subdue the virus transmission rate. Therefore, the majority of activities are shifted from physical or onsite activities to remote or online activities. This requires information technology (IT) which needs to be supported by IT devices, such as smartphones. Therefore, we are focusing the review on major activities affected by the pandemic, which is learning activities. Based on a content analysis of these studies, we determine the importance of smartphones in this changed situation. We use the terms smartphone and mobile phone interchangeably because most work in literature does not differentiate them.

Integrated content analysis is then performed using two criteria, i.e., which EOU option is the most selected by Indonesian before the pandemic; and what can or need to be changed in responding to the COVID-19 pandemic. The results will be used to update the previous hierarchy of EOU options. Finally, a set of recommendations will be provided to support the realization of the proposed hierarchy.

RESULTS AND DISCUSSIONS

The results are presented in three sub-sections—first, the review of existing literature on e-waste and end-of-use options for smartphones in Indonesia. From the analysis, a hierarchy of EOU options is presented. Second, the review focuses on how the COVID-19 pandemic affects learning activities and recognizes the need for IT devices such as smartphones. Third, an updated Hierarchy of EOU Options for Smartphones is proposed, and several recommendations are provided to strengthen the proposed Hierarchy.

E-waste and End-of-use Options for Smartphones in Indonesia

Several studies focused on e-waste in Indonesia, especially from mobile phones. Andarani and Goto used a modified material flow analysis model to estimate the e-waste generated from households in Indonesia. They found that the highest quantity of e-waste was generated from mobile phones, which are 83%. However, only 6% of mobile phones went to the disposal or recycling process, and 64-77% were reused [4]. The term reuse represents a condition where the electronic equipment is donated or sold as secondhand. Maheswari et al. studied the stakeholder engagement for mobile phone reverse logistics in Indonesia. The survey found that the average length of mobile phone usage time is less than three years, and the three highest motives were damage, outdated features, and boredom [3]. Santoso et al. revealed that the average lifespan for a mobile phone as a non-saturated market product is 3.42 years in Indonesia. It has a shorter lifespan because, in a non-saturated market, sales are usually triggered by the introduction of new technology or new users rather than by the old product's end-of-life [5]. Despite the decrease of smartphone sales in the beginning of the COVID-19 pandemic, the smartphones market has shown an increase in the second Quarter in 2021 year-over-year, according to a study by Canalys.

Furthermore, consistent with previous results, they showed that the most discarded e-devices in Indonesia is mobile phones [4,5]. Mairizal et al. also showed that the lifespan of mobile phones in Indonesia is getting shorten over the years. The lifespan was 2.7 years in 2010 but reduced to 1.9 years in 2019. This trend was also found in China and even worldwide in general [8]. The short lifespan of mobile phones will affect the increased volume of resources used to produce new mobile phones, and even more alarming, it creates enormous e-waste that could exhaust the landfill.

There were several initiatives established to reduce the abovementioned impacts. Most developed countries have ratified environmental regulations such as WEEE handling and Extended Producer Responsibility (EPR). However, Junianto and Sugandha observed that Extended Producer Responsibility for mobile phones was not appropriately

implemented in Indonesia. The used products are collected or recovered by unauthorized or even illegal third parties without considering the appropriate safety measurements [9]. Yunita et al. studied e-waste management in Indonesia and observed that the formal sector handled only 10% of the e-waste. Most of the e-waste management activities were conducted by the informal sector, which might not have concerns for environmental sustainability. However, no specific regulations control the flow of used electronic goods at the end-of-life stage [10].

Another perspective of reducing e-waste is reusing or recycling the products, which extends the useful life of that product. Several studies focus on customer's behavior toward their mobile phone or smartphone at the end of the useful life or its end-of-use stage. Mobile phone is the most used mobile device for communication (96.9%) compared to computer and tablet. However, consumers' behavior in treating the used mobile phone varied. 38.6% kept it home, 27.7% gave it to others, 25.8% resell, and 9.7% thrown to bin. Many consumers did not know where to send the phone for recycling (40.9%), while others preferred to give the used phones to family or friends (32.1%) and kept them at home (28%) rather than recycling [3]. This result is somewhat similar to Hanafi et al., a study of managing WEEE (Waste Electrical and Electronic Equipment) in the sense that the recycling rate is meager. They observed that 42% of respondents chose to discard or donate the WEEE, 33% sell, 14% keep at home, 8% recycled, and 3% reuse them [11]. Pandebesie et al. observed from a survey in West Surabaya that 60% of respondents bought new electronic products because the old ones were damaged. Furthermore, 49% of respondents chose to sell their broken electronic equipment, 20% donated, 15% repaired, and 16% left it as is [12]. Rimantho conducted an e-waste survey in Surabaya, and the results show that the highest quantity of electronics equipment owned by respondents is mobile phones. At the end-of-use stage, most of the e-devices are sold to secondhand dealers (81%), given or sold for scrap dealers (14%), stored at home (2%), and donated (1%) [6]. Safaat et al. studied the e-waste disposal behavior in Java Island and found that the most influential storage behavior followed by donate, recycle, resale, and discard [7]. Siringo et al. observed communities in Jakarta and concluded that the most popular method of disposing of end-of-life ICT devices is keeping at home (39%), the next is selling (30%), donating (23%), disposing of (4%). Only 2% of respondents supported the idea of proper e-waste recycling [13].

The end-of-use options for a smartphone can be ranked according to customer's behavior, as shown in Fig. 1. The highest is reselling smartphones to the secondhand market [6,12]. The next highest option is giving to family/friends or donating to other parties [7,11], followed by keeping at home [3,13,14]. Only a tiny portion of used smartphones is sent to formal recycling facilities [4,6,9,11,13], and almost none was discarded [4,13,14].

The use of smartphones in online learning during the COVID-19 pandemic

Batubara [15] observed that many areas in Indonesia have not been equipped with the technology and infrastructure necessary to implement online learning. There are three indicators that affect the successful implementation of online learning, i.e., internet connection as the channel, information technology (IT) facilities as the infrastructure, suitable learning materials as the content.

The effectiveness of online learning is in question due to the sudden changes due to the pandemic situation. Gunawan et al. [16] studied the variations of models and learning platforms for lecturers during the COVID-19 pandemic time based on a survey. The results revealed that all lecturers implement online learning due to the physical distancing policy. The media used for learning, discussion, and sharing materials is primarily the social media applications such as WhatsApp. Zaini et al. explored the alternatives of learning media during the COVID-19 pandemic and found that most teachers (72%) used mobile phones in online learning, and the most used platform is WhatsApp (74.54%) [17]. Sole and Anggraeni found that smartphone is an effective instrument of learning in such conditions. They used four components to measure the effectiveness: program success, target success, program satisfaction, and achievement of overall goals [18]. Those studies showed that smartphone is sufficient to support the online learning during COVID-19 pandemic period.

Sa'diyah *et al.* [19] explored the use of smartphone-based learning to improve students' critical thinking skills during the Covid-19 Pandemic. There are four critical thinking skills indicators used in this study: understanding, application, analysis, evaluation, and generalizing. The results showed a positive result; the experimental class equipped with smartphones achieved significantly higher critical thinking skills compared to the control class.

Rulandari [20] investigated the impact of the COVID-19 pandemic on education in Indonesia. Since the learning activities must be carried out online, students should own adequate devices such as computers, laptops, or smartphones. However, for some students from economically struggling families, smartphone devices and internet connections are luxury items. Another problem is that the use of smartphones for learning is often misapplied by students, such as playing games instead of learning. However, Nashruddin and Tanasy studied the school policies on the use of Android devices in learning activities during the pandemic situation based on the analysis of the benefit

and weaknesses of using Android devices and parents' expectations. One of the proposed policies is providing opportunities for students to take advantage of Android devices as a learning instrument [21]. Hence, the use of smartphones is considered more beneficial rather than destructive despite the concerns raised in this study.

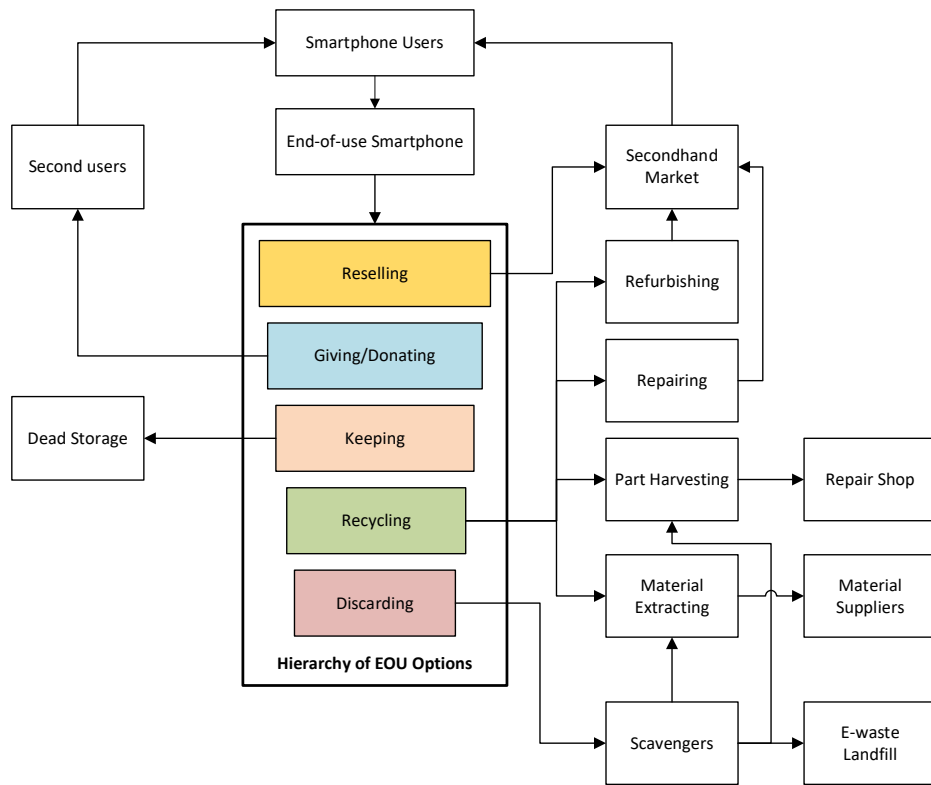


FIGURE 1. The hierarchy of EOU options for smartphones in Indonesia

Hermanto and Srimulyani surveyed the challenges of online learning during the COVID-19 pandemic. The survey results showed that the most tool used by students in online learning is the smartphone. Despite some challenges, they found that the success of online learning is significantly dependent on several integrated components, such as students, educators, learning resources, and technology used [22].

Laksana studied the college student's perception of the implementation of online learning in outer area of Indonesia. The survey indicated that 34% of students do not have adequate devices for online learning, and 55.5% considered the use of information technology ineffective [23]. Harefa and Sihombing conducted similar research for junior, senior high school and college students in remote area. The results showed that students in remote areas considered online learning is less effective because the internet connection and infrastructure do not adequately support their participation in online learning [24]. Not only the students, the teachers in remote areas also face challenges in learning activities during COVID-19 pandemic. Ujianti [25] revealed that the biggest challenges for them are having students with limited telecommunication equipment, a stable network, and limited budget for internet connection. Furthermore, Azhari and Fajri found similar obstacles faced by teachers in remote areas. They were concerned with the limitation of students' financial conditions to support online learning, like purchasing a smartphone or a computer and paying for internet data [25]. There is a disproportionate distribution of IT facilities throughout the regions in Indonesia, especially in rural areas with which hinder the effectiveness of online learning. These findings call for attention to the need for smartphones for online learning, especially in remote areas.

Proposed Hierarchy of EOU Options for Smartphones

Integrating the findings from smartphone end-of-use options with the use of smartphones in online learning during the COVID-19 pandemic, we identified several suitable provisions to bridge the challenges in both situations.

There are several suitable provisions identified to bridge the challenges in both situations, which serve as the basis for proposing the new hierarchy:

- A large number of not appropriately managed used smartphones that poses a threat to the environment now can be a blessing for students in the remote area who need smartphones to participate in online learning during the pandemic time.
- Previous options i.e., keeping-at-home and recycle (in good or moderate condition), are directed to donation scheme for reuse
- Used smartphones in non-working condition are directed to low level recycle process such as part harvesting and material extracting

Therefore, the hierarchy of EOU options for smartphones was modified as presented in Fig. 2. The proposed hierarchy of EOU options needs to be supported by several initiatives that strengthen the realization of the new hierarchy, which are;

- (1) Campaigning for smartphone donation: the focus of the campaign is helping underprivileged students to have smartphones for online learning
- (2) Using digital platforms to collect the used smartphones: the focus is collecting the ones that previously went to dead storage or were kept at home and the ones that were given to friends or family who might not need them
- (3) Implementing the product-service system: the focus involves relevant companies to support better options for end-of-use smartphones rather than leaving them as e-waste
- (4) Preparing a good business model: the focus is to manage the collection, inspection, repairing, and distribution of the donated phones
- (5) Collaboration with smartphone's big brands: the focus is to obtain the old phones from the trade-in offers.

CONCLUSION

This paper studied the hierarchy of end-of-use options for smartphones to support online learning during Indonesia's COVID-19 pandemic. By performing a literature review and content analysis on two aspects, i.e., e-waste and EOU options for smartphones in Indonesia and the use of smartphones in online learning during the pandemic situation; we integrated both results and proposed a new hierarchy of EOU options that could bridge the challenges in both aspects. It helps to reduce e-waste from used smartphones and at the same time helps underprivileged students to obtain smartphones for online learning. Several recommendations to strengthen the realization of the proposed hierarchy were presented: campaigning, using digital platforms and implementing the product-service system, business model, and collaboration with big brands.

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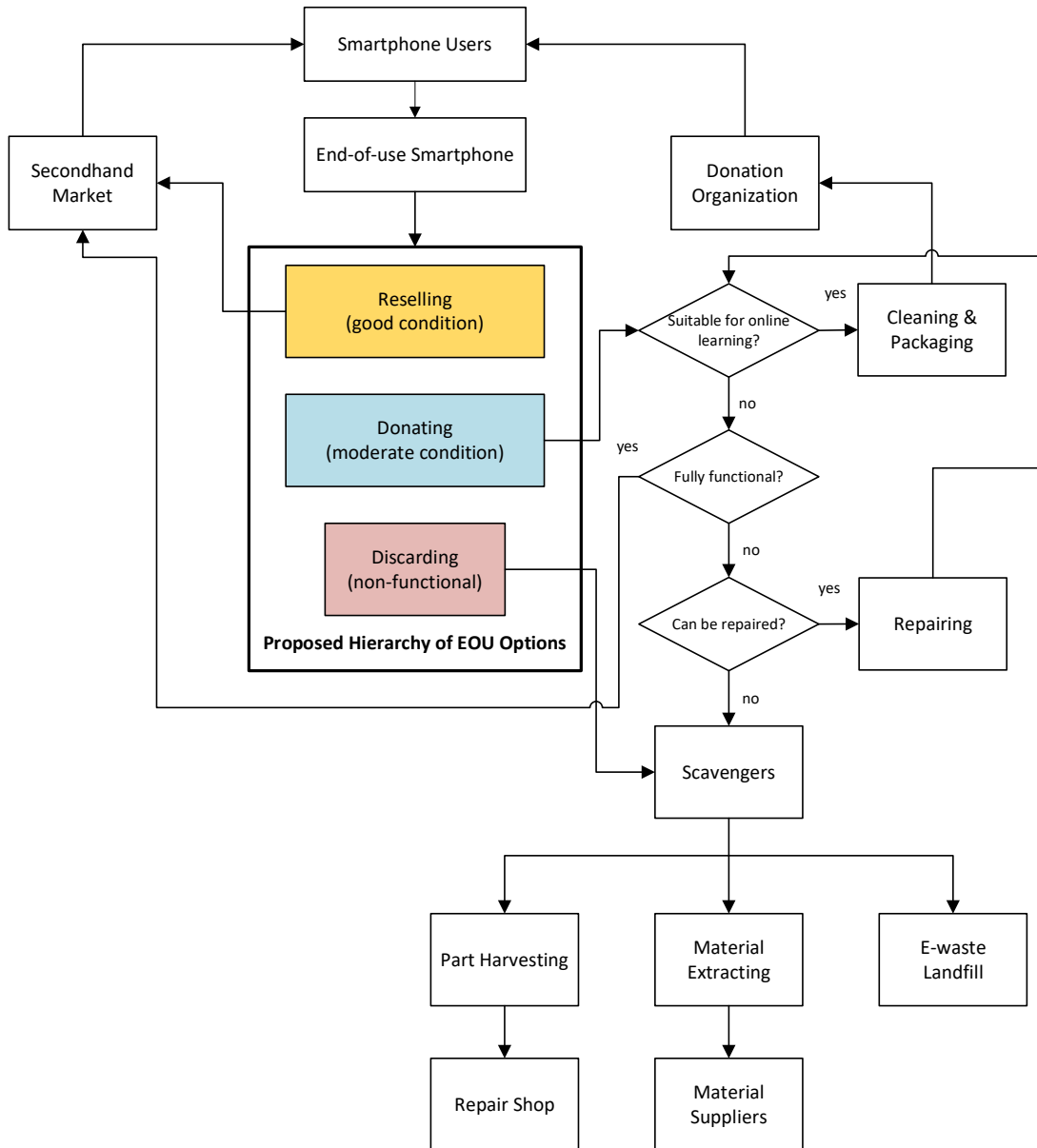


FIGURE 2. The proposed hierarchy of EOU options for smartphones in Indonesia to support online learning

REFERENCES

1. Statista Research Department, [Share of internet users who access via mobile phones in the Asia-Pacific region in 2020, by country and device](#) (Statista, 2021).
2. H. Nurhayati-Wolff, [Number of smartphone users in Indonesia from 2017 to 2020 with forecasts until 2026](#) (Statista, 2021).
3. H. Maheswari, G. Yudoko, and A. Adhiutama, "Stakeholder Engagement in Quattro Helix Model for Mobile Phone Reverse Logistics in Indonesia: A Conceptual Framework," in *IOP Conference Series: Materials Science and Engineering* **277** (IOP Publishing, 2017), 012062.
4. P. Andarani and N. Goto, [Journal of Material Cycles and Waste Management](#) **16**(2), 306-320 (2014).

5. S. Santoso, T. Y. M. Zagloel, R. Ardi, and A. Suzianti, "Estimating the Amount of Electronic Waste Generated in Indonesia: Population Balance Model," in [IOP Conference Series: Earth and Environmental Science](#) **219** (IOP Publishing, 2019), 012006.
6. D. Rimantho, [Journal of Engineering and Science Research](#) **1**(2), 234-244 (2017).
7. M. Safa'at, T. Y. M. Zagloel, R. Ardi, and A. Suzianti, "Consumer Behavior and Awareness Analysis of Electronic Waste in Indonesia: A Case Study in Java Island" in [IOP Conference Series: Earth and Environmental Science](#) **219** (IOP Publishing, 2019), 012007.
8. A. Q. Mairizal, A. Y. Sembada, K. M. Tse, and M. A. Rhamdhani, [Journal of Cleaner Production](#) **293**, 126096 (2021).
9. A. B. Junianto and D. C. Sugandha, "EPR Approach for Better Waste Management System for Mobile Phone Design in Indonesia," in [IOP Conference Series: Materials Science and Engineering](#) **847** (IOP Publishing, 2020), 012065.
10. M. T. Yunita, T.Y.M. Zagloel, and R. Ardi, "Development of Funding Model in E-waste Management Systems for Households Products in Indonesia," in [IOP Conference Series: Earth and Environmental Science](#) **219** (IOP Publishing, 2019), 012005.
11. J. Hanafi, H. J. Kristina, E. Jobiliong, A. Christiani, A. V. Halim, D. Santoso, and E. Melini, "The Prospects of Managing WEEE in Indonesia" in [Glocalized Solutions for Sustainability in Manufacturing](#) (Springer, Berlin, Heidelberg, 2011), pp. 492-496.
12. E. S. Pandebesie, I. Indrihastuti, S. A. Wilujeng, and I. D. A. A. Warmadewanthi, [Environmental Science and Pollution Research](#) **26**(27), 27930-27939 (2019).
13. R. Siringo, H. Herdiansyah, and R. D. Kusumastuti, [Global Journal of Environmental Science and Management](#) **6**(2), 203-214 (2020).
14. E. Damanhuri, "[Post-Consumer Waste Recycling and Optimal Production](#)" (BoD–Books on Demand, 2012).
15. B. M. Batubara, [Budapest International Research and Critics Institute-Journal \(BIRCI-Journal\)](#) **4**(1), 450-457 (2021).
16. G. Gunawan, N. M. Y. Suranti, and F. Fathoroni, [Indonesian Journal of Teacher Education](#) **1**(2), 61-70 (2020).
17. H. Zaini, A. Hadi, F. A. Sofyan, and A. Hamzah, [Webology](#) **18**(1), 154-165 (2021).
18. F. B. Sole and D. M. Anggraeni, "Effectiveness of Use of Smartphone Communication Technology as Mobile Based Learning Media for STKIP Weetebula Students in the Covid-19 Pandemic Period" in [Proceedings of International Joint Conference on Arts and Humanities](#) (Atlantis Press, 2020), pp. 338-343.
19. A. Sa'diyah, I. Wilujeng, and N. Nadhiroh, "The Effect of Using Smartphone-Based Learning Media to Improve Students' Critical Thinking Skills During Covid-19 Pandemic" in [Proceedings of the 6th International Seminar on Science Education](#) (Atlantis Press, 2021), pp. 374-379.
20. N. Rulandari, [Ijomata International Journal of Social Science](#) **1**(4), 242-250 (2020).
21. N. Nashruddin and N. Tanasy, [Lembaran Ilmu Kependidikan](#) **50**(1), 66-73 (2021).
22. Y. B. Hermanto and V. A. Srimulyani, [Jurnal Pendidikan dan Pengajaran](#) **54**(1), 46-57 (2021).
23. D. N. L. Laksana, [Journal of Education Technology \(JET\)](#) **4**(4), 502-509 (2020).
24. S. Harefa and G. L. A. Sihombing, [F1000Research](#) **10**, 867 (2021).
25. P. R. Ujianti, [Proceedings of 5th International Conference on Early Childhood Education \(ICECE 2020\)](#), (Atlantis Press, 2021), pp. 343-346.
26. B. Azhari and I. Fajri, [International Journal of Mathematical Education in Science and Technology](#) **53**(7) 1875072, 1934-1954 (2022).