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Manuscript submitted to Education Research International

1 message

Education Research International <aravindsidharth.somasekharan@hindawi.com> Thu, Oct 21, 2021 at 3:57 PM
To: sulisworo@gmail.com

Hindawi

Dear Dr. Sulisworo,

Congratulations, the manuscript titled "The Science Teachers' Optimism Response to the Use of Marker-Based Augmented Reality in the Global Warming Issue" has been successfully submitted to Education Research International.

We will confirm this submission with all authors of the manuscript, but you will be the primary recipient of communications from the journal. As submitting author, you will be responsible for responding to editorial queries and making updates to the manuscript.

In order to view the status of the manuscript, please visit the manuscript details page.

Thank you for submitting your work to Education Research International.

MANUSCRIPT DETAILS

Kind regards,
Aravind Sidharth Somasekharan
Education Research International

Gmail sulisworo dwi <sulisworo@gmail.com>

The Science Teachers' Optimism Response to the Use of Marker-Based Augmented Reality in the Global Warming Issue: Manuscript returned to draft

2 messages

Ronezen Igamin <ronezen.igamin@hindawi.com> Fri, Oct 22, 2021 at 5:16 PM
To: sulisworo@gmail.com
Cc: aravindsidharth.somasekharan@hindawi.com

Hindawi

Dear Dr. Dwi Sulisworo,

We have reviewed your manuscript "The Science Teachers' Optimism Response to the Use of Marker-Based Augmented Reality in the Global Warming Issue" with ID No. 7264230 and found the following issues which need to be solved before moving on:

- **Authors & Affiliations**
  - The author lists on the system and in the PDF file are different. Please confirm the correct author list and ensure that all authors have an affiliation and an email address listed. System:"Dwi Sulisworo" "Ratnawati Ratnawati" "Dian Artha Kusumaningtyas" "Trikinasih Handayani" "Wahyuningsih Wahyuningsih" "Adi Jufriansah" "Azmi Khusnani" "Erwin Prasetyo" PDF: "Dwi Sulisworo" "Ratnawati" "Dian A. Kusumaningtyas" "Trikinasih Handayani" "Wahyuningsih" "Adi Jufriansah" "Azmi Khusnani" "Erwin Prasetyo"

Additional Comments:

This paper has been returned to the draft for the reasons listed above. Please could you log into your account and address these points as soon as possible? The changes should be made on this submission 7264230, please do not submit a new manuscript.

Please log into your account to make the required updates. Follow the steps outlined below, and we kindly ask that you do not submit a brand new manuscript.

1. Click on the manuscript tile for The Science Teachers' Optimism Response to the Use of Marker-Based Augmented Reality in the Global Warming Issue, which will show the status "Complete submission".
2. You will see all 4 submission steps. All the information will be pre-filled as you submitted the manuscript, so you will not need to complete the entire submission again. Click through the steps until you reach the area that needs updating.
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4. When all necessary changes have been made, click the green "Submit manuscript" button at the bottom of step 4, and this will return the manuscript to the Hindawi team.

Kind regards,
Ronezen Igamin

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sulisworo dwi <sulisworo@gmail.com> Fri, Oct 22, 2021 at 7:43 PM
To: Ronezen Igamin <ronezen.igamin@hindawi.com>

Dear Editor,
Thank you for your review. Unfortunately, I have difficulty finding the Login button.
Please inform me of that button.
Thank you very much for your assistance.
Regards,
Dwi Sulisworo
[Quoted text hidden]

Gmail sulisworo dwi <sulisworo@gmail.com>

7264230: Revision requested

1 message

Namaziandost Ehsan <support@hindawi.com> Tue, Nov 2, 2021 at 1:19 AM
Reply-To: Aravind Sidharth Aravind Sidharth <aravindsidharth.somasekharan@hindawi.com>
To: Sulisworo Dwi <sulisworo@gmail.com>

Hindawi

Dear Sulisworo Dwi,

In order for your submission "The Science Teachers' Optimism Response to the Use of Marker-Based Augmented Reality in the Global Warming Issue" to Education Research International to proceed to the review process, there needs to be a revision.

Reason & Details:

"

Dear author/s, Based on the reviewers' comments and my own assessment, your paper needs "major revision". Please revise the paper based on the reviewers' comments (highlight all changes in a different color for each reviewer's comments) and provide a separate file, namely "responses to reviewers' comments". Looking forward to receiving your revision. Good luck.
Ehsan Namaziandost

For more information about what is required, please click the link below.

MANUSCRIPT DETAILS

Kind regards,
Namaziandost Ehsan

Education Research International

9075840: Decision Finalized

2 messages

Gladys Joy Joy Donino <gladysjoy.donino@hindawi.com> Mon, Oct 25, 2021 at 8:09 PM
Reply-To: Gladys Joy Joy Donino <gladysjoy.donino@hindawi.com>
To: sulisworo@gmail.com
Cc: ratnawati51@gmail.com, dian.artha@pfis.uad.ac.id, trikinasihhandayani@gmail.com, wahyuningsih.ikipmu@gmail.com, saompu@gmail.com, husnaniazmi@gmail.com, wintyo212@gmail.com

Dear Dr. Sulisworo,

We have noticed that the manuscript titled “The Science Teachers’ Optimism Response to the Use of Marker-Based Augmented Reality in the Global Warming Issue" submitted to the Education Research International has been submitted twice with IDs 7264230 and 9075840

According to our policy, manuscripts must be submitted with the understanding that they have not been published elsewhere and are not under consideration by Hindawi, or any other publisher.

Therefore, we will not consider manuscript 9075840 and will proceed with the review process of manuscript 7264230.

If you have further inquiries regarding your manuscript, please do not hesitate to get in touch.

Best regards,

Gladys

Gladys Joy Donino
Editorial Screener

---

sulisworo dwi <sulisworo@gmail.com> Mon, Oct 25, 2021 at 8:52 PM
To: Gladys Joy Joy Donino <gladysjoy.donino@hindawi.com>

Thank you for your email. I understood the reason.
Best regards.
Dwi
[Quoted text hidden]

The Science Teachers' Optimism Response to the Use of Marker-Based Augmented Reality in the Global Warming Issue

Dwi Sulisworo[1], Ratnawati Drusmin[1], Dian Artha Kusumaningtyas[1], Trikinasih Handayani[2], Wahyuningsih Wahyuningsih[3], Adi Jufriansah[4], Azmi Khusnani[4], Erwin Prasetyo[4]

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Correspondence should be addressed to Dwi Sulisworo; sulisworo@gmail.com

Abstract

During the Covid-19 pandemic, almost all regions of Indonesia, including Sikka, East Nusa Tenggara, Indonesia, have implemented e-learning. However, this method has not been conducted in all schools due to the problem of uneven internet access. Disconnection from the internet makes it difficult to conduct this process effectively even though students have smartphones. Furthermore, the expectation of education quality improvement in sciences also gets higher with the development of today's world technology, and this cannot be avoided. Augmented Reality (AR) gives a variety of opportunities to be utilized as science learning media embedded on smartphones even without an internet connection. Therefore, this study aims to conduct an intervention towards the teachers through the training and workshops on the use of Augmented Reality for science learning on the topic of Global Warming. This research was action research approach. In considering this problem, the intervention of teachers' behavior and perception was conducted through training and workshops on the use of augmented reality for science learning using one-shot case study research design. This program had four stage: need identification, strenthening the understanding of using AR, training and worskhop implementation, and evaluation. The participants of this program were 24 science teachers from 10 schools at junior high schools in Sikka Regency, where 17 were females, 7 were males. The marker-based AR was developed based on learning media need assessment provided by teachers. Teacher optimism was measured using a questionnaire with a Likert scale. The program's implementation led teachers to understand the use of AR in learning, significantly to develop HOTs (higher-order thinking skills) in science learning. The results of this study implies for the development of school policies to establish digital learning media used without the internet on various learning issues in rural areas.

Introduction

The Covid-19 pandemic is having a different impact on learning practices in Indonesia. Besides the need to improve their reaction in the teaching and learning process-related factors are also essential. In rural areas with little internet access, a conducive situation for online learning is relatively limited [1]. Furthermore, the demands for competence development that meet the needs of living in the era of Industrial Revolution 4.0 cannot be simply ignored in learning.

Industrial revolution 4.0 may help to overcome the obstacles related to online learning in pandemic to limit the direct interaction. The themes of artificial intelligence, robotics, cloud computing, big data, internet of things (IoT), augmented reality (AR), and virtual reality (VR) give a lot of opportunities for learning following the goals of new skills in this era. The use of a variety of learning media based on competence requirements will support innovative and creative learning as a part of HOTs (higher-order thinking skills) [2,3]. This expectation corresponds to the educational objectives set in the 2013 curriculum.

AR is one of the newest technologies in the era of Industrial Revolution 4.0 and has offered various possibilities to bridge the gap in the quality of education [4-6]. It is used as a science learning media to support a variety of performances in the sciences [7,8]. Furthermore, it can also be embedded on smartphones without an internet connection, therefore, the utilization can be a solution in learning including in Sikka, particularly when there is no internet access.

Global learning development has also been anticipated by the government through the Curriculum of 2013. The provision mentions a variety of learning models and strategies used to achieve learning goals. Meanwhile, the three models used are project-based, problem-solving, and discovery learning, and they can also be used by utilizing AR in science learning. These can be supporting factors in the implementation of AR to improve the quality of education in rural areas. However, in particular rural areas including Sikka, many teachers experience obstacles in the teaching and learning process. Developing the skills of the teacher in the era of the industrial revolution is an essential element for successful learning [9]. The characteristics of learners related to the ability to learn independently should also be considered to optimize the use of the media [10].

During the initial discussion with the chief of the Science Teacher Association and two junior high school science teachers in Sikka, several obstacles in science learning for adaptation in the pandemic era were discussed. Generally, learners have gadgets that enable the use of digital materials, and this is related to students' perception in electronic-based learning [11,12], including students in Sikka, Indonesia [13]. However, in online learning, there are several obstacles in terms of internet network availability. One of the alternative solutions is providing digital learning sources accessed without the internet (embedded on the gadget). The partner problem in this situation is that junior high school science teachers have no adequate skills in using digital learning media with particular strategies. This problem encouraged the implementation of a behavior and perception intervention focusing on science learning at junior high schools in Sikka, East Nusa Tenggara. This is conducted as a solution in partnership between the Department of Education, Culture and Sports, Science Teacher Association, Institute of Teacher Training and Education, Muhammadiyah Maumere, and Ahmad Dahlan University to improve the quality of science learning at junior high schools. The program implementation resulted in the teachers with AR understanding, developing HOTs in science learning as the output as well as several copyrights in the form of videos and the AR-based application.

Literatur Review

Online Learning Obstacles and Opportunies during Pandemic Tambahi referensi

During the pandemic, almost all schools have implemented online learning either on their consciousness or because of government policies. However, not all schools can implement this policy well due to various obstacles. The results of the Ref study [14] stated three

obstacles to online learning during the pandemic. The lack of capabilities to communicate remotely, weak internet speed, and the difficulty of students' understanding of some subjects in the absence of classroom interaction. In comparison, the study conducted by Ref. [15] stated that limited quotas and internet networks caused inefficiencies during online learning. It can be understood that it becomes an obstacle in mitigating learning during a pandemic in areas where internet networks are limited. Likewise, quotas are relatively expensive for people with limited economic levels. In Indonesia, there is a tendency for teachers not to implement learning strategies following the concept of good online learning. The platform and the learning activities mainly use WhatsApp [15]; it indicates a lack of teacher skill to arrange online learning. Research Ref [16] adds that a critical constraint in online learning in Indonesia is teachers' skill in implementing appropriate strategies and low learning motivation. Other studies corroborate the findings regarding the obstacles to online learning during the pandemic. It is both in terms of technical aspects and the skills of teachers and students. There are at least three main obstacles to good online learning: limited internet access, not all students having gadgets, and teaching skills in managing online learning. The aspect of teacher limitations in managing learning includes skills in using online learning platforms, developing learning media, and managing online interactions.

14. Lassoued, Z., Alhendawi, M., & Bashitialshaaer, R. (2020). An exploratory study of the obstacles for achieving quality in distance learning during the COVID-19 pandemic. *Education Sciences*, *10*(9), 232.

15 Bahasoan, A. N., Ayuandiani, W., Mukhram, M., & Rahmat, A. (2020). Effectiveness of online learning in pandemic COVID-19. *International journal of science, technology & management*, *1*(2), 100-106.

16. Rahayu, R. P., & Wirza, Y. (2020). Teachers' perception of online learning during pandemic Covid-19. *Jurnal Penelitian Pendidikan*, *20*(3), 392-406.

Educational policymakers and school administrators have been trying to find various solutions so that online learning can run smoothly. This effort cannot immediately solve problems, especially those related to sudden changes and cannot be resolved quickly. Some of the efforts made are providing learning platforms, training and workshops for teachers, providing digital learning content, and increasing internet access. The Indonesian government also applies these policies to schools. The participation of higher education in supporting government policies is significant for teachers, especially for rural areas and islands which are relatively limited in resources.

This pandemic situation has provided vast opportunities for the penetration of information and communication technology in rural schools. The awareness of education managers so that learning continues to run well has become a driving force for teachers to increase competence in managing digital-based learning both online and offline. Internet access constraints need to be anticipated and resolved by providing various digital learning content accessed through gadgets owned by students. This effort was to continue implementing social distancing and because of the reduction in direct interaction at schools. In line with the issue of Industrial Revolution 4.0, Augmented Reality is one alternative to digital-based learning. It does not have to use the internet. Adjusting this technology in education can also be related to various global issues that are important to students.

The used AR for Learning Tambahi referensi

As mentioned before, in the environment of students who cannot get internet access, providing learning resources that can improve learning performance with independent and group learning becomes very important [7-9]. However, the media in science learning, especially about global warming, has limitations in explaining a phenomenon [10-12]. Augmented reality can enrich existing media by adding various deeper and more complete activities available on smartphones [13]. This feature will be activated when obtaining a trigger from the material contained in the AR marker [14]. With these advantages, these learning media are more practical and effective for developing new competencies in this era [15-17]. The learning material embedded, e.g. module by augmented reality can be designed to improve students' competencies. However, research developing this module is still relatively little developed as an alternative learning media during the pandemic, especially in areas where internet access is not covered.

The research results [18][19] show that Indonesian people are among those with a high level of mobile technology-based social media use. With the Covid-19 pandemic that demands the strengthening of online learning, not all students can take advantage of the potential of this technology in education. This benefit is especially true in areas that do not have good internet access. One technology that can bridge this is the use of AR.

Recent studies on Technology Enhanced Learning have placed AR as necessary in increasing learning effectiveness. AR is a technique in informatics that combines two-dimensional or three-dimensional virtual objects into three-dimensional real space and projects these virtual objects in real-time [20-22]. AR can stimulate the user's perception and senses. This technique combines modules (two-dimensional) with additional three-dimensional virtual information in learning. This combined information can be displayed with the help of mobile devices such as webcams, computers, smartphones, or google [21]. With this technique, the user can see virtual objects with the intermediary of mobile technology. These advantages are used in science learning to explain various phenomena more fully. It is impossible to write in a book to increase the immersion when understanding phenomena [23][24]. Studies on AR in science learning show promising results for improving competence in critical thinking and collaboration skills.

Materials and Methods

Context of Program

The participants of this program were 24 science teachers at junior high schools in Sikka Regency, where 17 were females, 7 were males; 16 teachers were 20-35 years old. Meanwhile, 7 teachers were 35-50 years old, 1 teacher was older than 50; they were all from 10 schools). The method used was a training and workshops on the use of AR for science learning, and the topic used as Global Warming. The program was conducted from 10 April to 20 September 2021. Furthermore, the implementation of activities was blended and some activities were conducted offline at the Institute of Teacher Training and Education, Muhammadiyah Maumere (participants attended the event with the health protocols following the provision of the Covid-19 Task Force) and online by using the Zoom meeting application. Questionnaires were distributed through Google Form to collect data on the participants' responses.

Instrumentation and Analysis Techniques

There are two kinds of research instruments: a needs analysis instrument and an application optimism instrument. The needs analysis instrument was a questionnaire with open-ended questions covering the obstacles encountered, the alternative solutions implementation, and the implementation results' effectiveness. Questionnaires were shared using Google Forms distributed before participants took part in the training and workshops. The results were analyzed using Affinity Diagram and Pareto techniques. The optimism level questionnaire adapted from Lund (2001) included five statements: the usefulness of AR media that can be accessed by the internet, experience using AR media, belief that AR media is practical for learning, confidence in learning media with manuals, belief in increasing independent skills. This questionnaire was shared using Google Forms too. The results were processed qualitatively based on the proportions.

1. Lund, A. M. (2001). Measuring usability with the use questionnaire12. *Usability interface*, *8*(2), 3-6.

Stages of Program

The stages to achieve the goals of the teacher's behavior and perception intervention program related to AR-assisted learning are shown in Figure 1.

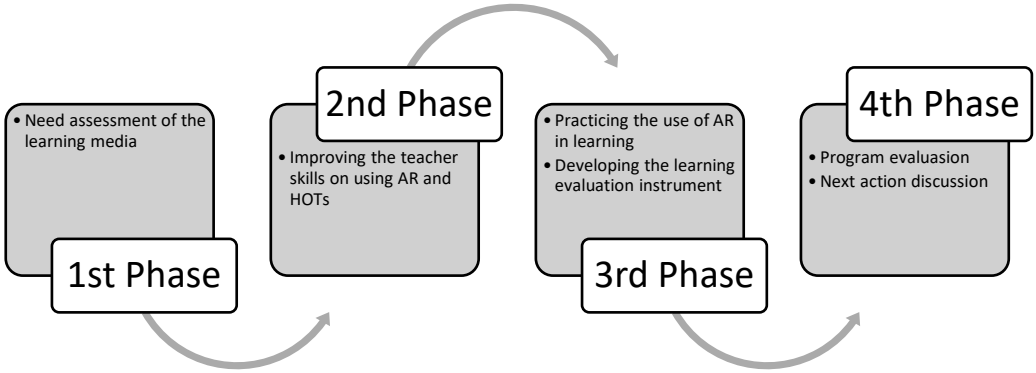


Figure 1: Stages of Program Implementation

1st Phase: Need Identification of Learning Media. This stage was conducted by delivering questionnaires through Google Form to determine a variety of obstacles in science learning amidst the pandemic era. The questionnaires were in the form of open questions and the results were analyzed by using the techniques of Affinity Diagram and Pareto to determine the aspects of the learning obstacles. The results were also supported with statements from two resources (the chief of Science Teacher Association and the principal of the junior high school) and became fundamental for the next stage in determining the training materials.

2nd Phase: Strengthening the Understanding of Using AR for Developing HOTs. Following the learning obstacles identified in stage I, participants attended an online training with three speakers in this stage. The first speaker delivered materials about AR-based media to develop HOTS in science learning at junior high schools. The second

speaker explained the government's policy of school quality improvement in the era of Industrial Revolution 4.0. Meanwhile, the third speaker delivered the role of higher education institutions in the partnership of the online learning implementation in Sikka. After this training, the participants were given questionnaires to measure the rate of teachers' beliefs in the use of AR for learning.

3rd Phase: Training on Using AR in learning. Based on the data analysis on stage II, AR-based learning media was developed to be embedded into gadgets on the topic of Global Warming. Therefore, teachers and students do not need to have internet access when using this application. In this stage, teachers were given training and workshops to use an AR-based application in science learning, and the implementation was blended. The participants attended the event in the Institute of Teacher Training and Education, Muhammadiyah Maumere, while the trainers interacted through online platforms. The first trainer explained a variety of instruments to measure the success of science learning assisted with AR. The second trainer, as an expert in AR development, gave training on how to use KOFIN, an AR-based application, related to the topic of Global Warming. In addition, the third trainer explained how to arrange questions for science learning evaluation on the topic of Global Warming. The participants collectedquestionnaires related to the follow-up plans and the success rate of the program through Google Form.

4th Phase: Program Evaluation. This stage was conducted to obtain the success rate of the teacher's behavior and perception intervention program in using AR for learning and follow-up plans after training in the form of classroom action. The results of this stage will be a recommendation for the next teachers' competence development program.

Results

Science Learning Obstacles

The required identification of learning media collected through Google Form disclosed a variety of science learning obstacles amidst the pandemic era in Sikka. The questionnaires were in the form of three open questions. The results analyzed by using the techniques of Affinity Diagram and Pareto. Figures 2 to 4 show the results.

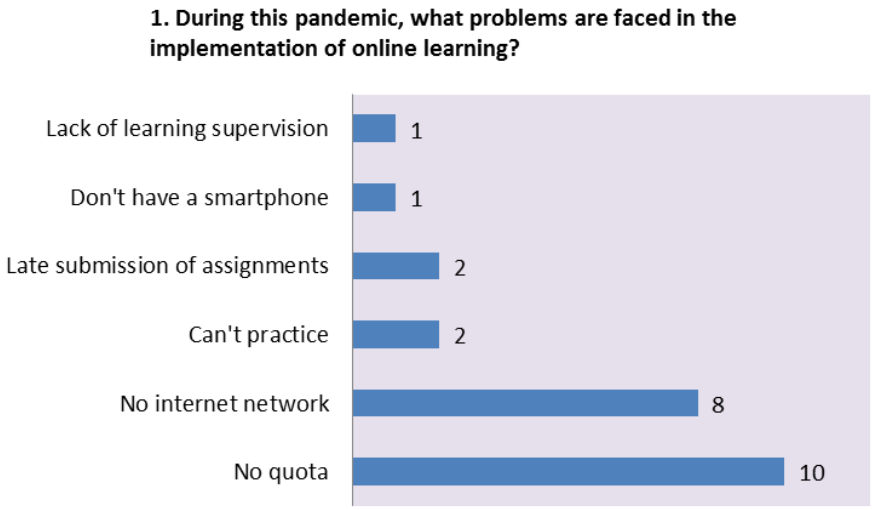
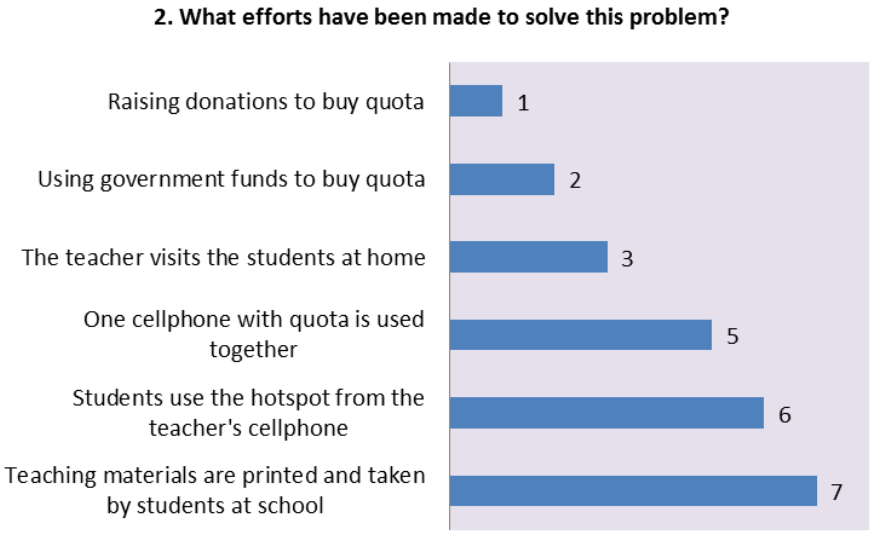
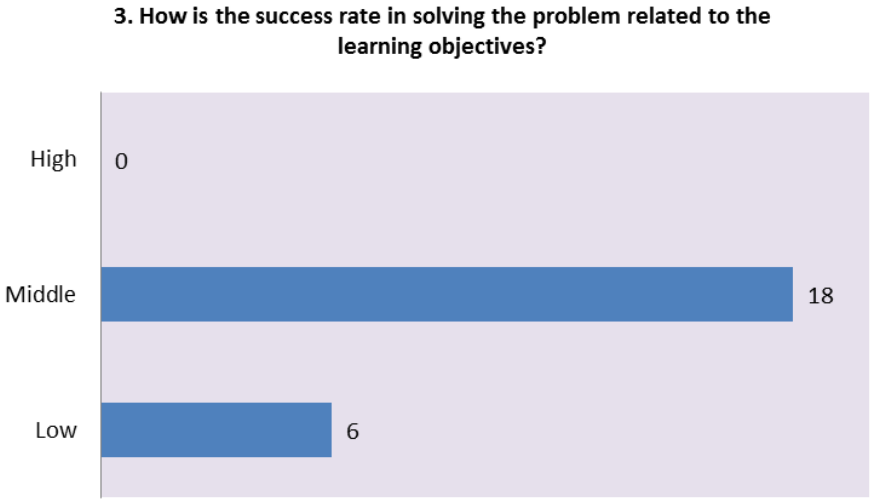


Figure 2: The online learning problem



231
232 Figure 3: Teachers initiative to solve the learning problem



233
234 Figure 4: The effectiveness of the initiative implementation

235 **Optimism Level of Using AR**

236 With the training, the teachers gave responses in terms of their optimism for implementation
237 at their schools. The results of questionnaires collected using Google Form are seen in
238 Figures 5 to 8.

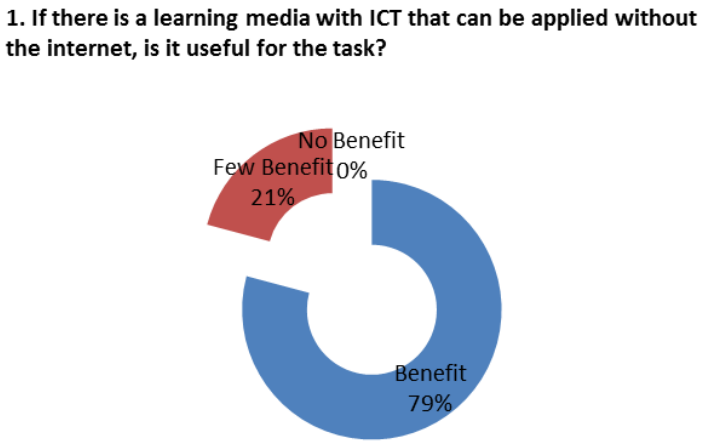


Figure 5: The intention of ICT based media without internet

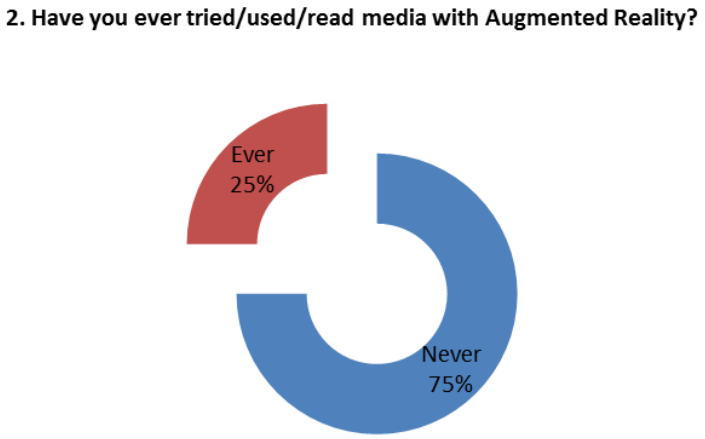


Figure 6: Teacher experiences with using AR

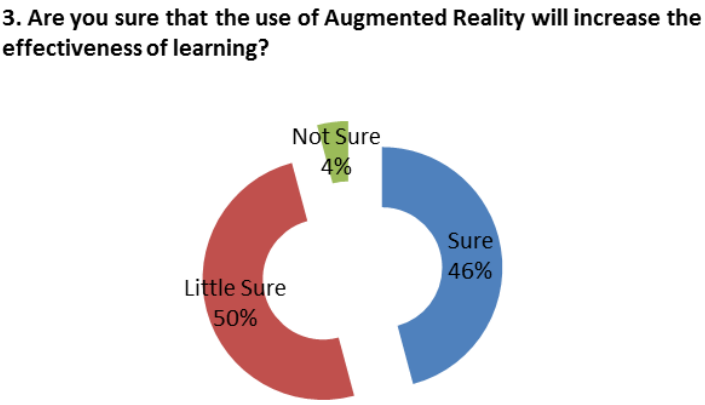


Figure 7: Teachers' optimism on using AR

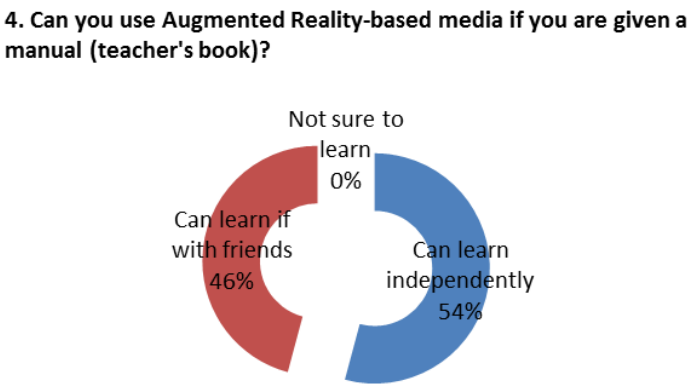


Figure 8: Teachers' responses to their skills to use AR

AR on the Topic of Global Warming

Considering the teachers' responses, AR-based learning media was then developed to be embedded on the gadgets for the topic of Global Warming. It uses markers to bring out the Global Warming phenomena. The results of the media development were three marker-based ARs. In the activities of the teachers during the workshop, they creatively provided several alternatives to the use of marker-based AR. Teachers can use this media either as part of a worksheet or comic or stand alone as a direct media. Figure 9 shows AR markers that have been printed and used for learning.

Figure 10 is the AR marker pinned in the tree as an alternative learning media.

Figure 9: Products of AR cards Markers

Figure 10: AR Pinned on the Tree

Discussion

Affinity Diagram and Pareto showed that the significant obstacles are low internet access, teachers' skills in implementing online learning strategies, and variation of learning media. During the pandemic, teachers tried to run science learning online following the policies of the local education office. The two main challenges are not having a quota for internet access and no internet network. These two things are essential requirements to conduct online learning. Many other studies related to online education in various countries also show that these two issues are obstacles that need attention [check references]. Teachers try to apply digital-based learning online, but internet access is limited. Increasing access is undoubtedly an ideal solution, but this solution requires a relatively long time because it is related to various policies at a higher level from several ministries. The fastest solution while still paying attention to the learning objectives is to develop digital learning media used without the internet. Many studies have shown the effectiveness of this kind of media.

Furthermore, they should be alternative learning that does not require internet access but still uses technology. Digital media installed on gadgets also provides opportunities to encourage various learning skills and student competencies. The use of technology in the current era is critical to master science materials at this secondary school level [14-16]. Teachers can improve various competencies relevant to the 21st century by utilizing technologies such as critical thinking skills [17-19], creativity [20,21], and collaboration [22,23].

The data obtained shows that almost all efforts are activities to provide an internet quota. Seven respondents changed online learning by providing printed materials. This result is undoubtedly beyond expectations for the development of various alternative digital learning solutions. There are relatively no teachers who have tried to develop or use digital learning media installed on gadgets. Applications that can be accessed offline and embedded in devices have not been set. This situation will undoubtedly affect the level of efficiency and effectiveness of learning. Several possibilities need to be revealed further why teachers have not tried this alternative. Several opportunities are due to the skills of teachers in rural areas in developing digital learning media. Several other researchers have studied this indication. This situation leads to the need to improve the skills of teachers to use digital media installed on gadgets and develop relevant learning stages using these media.

Meanwhile, the development of applications directly on the device becomes a new opportunity to provide learning resources [24,25]. Several teacher responses in dealing with obstacles showed negative results for the alternatives. This finding is an opportunity for the application of AR embedded in gadgets as a learning alternative. The observation reported by the chief of the Science Teacher Association also showed similar findings of science learning obstacles. It is also supported by the principal of junior high school SMP Negeri I, who mentioned how science learning and the barriers of online learning implementation. The obstacles in terms of supporting facilities for online learning influence the learning performance [10, 11]. The follow-up to this result is to provide learning media installed on the gadget and provide training and workshops on its use in learning.

In the needs analysis, the teacher explains that the provision of digital learning media installed on gadgets can encourage better learning during this pandemic. AR was also responded positively as an alternative in teaching science following current technological developments. The teachers were given training on using AR to develop HOTs to transform

the good perceptions of technology-based science learning (AR). This understanding also refers to educational policies from the government and the partnership with other stakeholders. With the training, the teachers gave responses in terms of their optimism for implementation at their schools. The actual findings showed a high opportunity in the use of AR in science learning. After training on AR, teachers (79%) stated that ICT-based applications running without internet access could complete understanding during this pandemic. The teacher uses an AR-based application embedded in smartphones during the training.

Furthermore, this experience is their reason for opening up opportunities for AR in science learning. The expected result of this utilization is an increase in students' competence following the needs as in other studies [25,26]. Teachers' optimism to apply AR in learning certainly needs to be supported by good skills. Other studies related to education in Indonesia, especially in rural areas, indicate the teachers feeling. Many teachers do not have the opportunity to improve their skills in using digital technology. These results are the same as the results in this research, which shows that teachers need training and workshops on using this technology. These results form the basis for the development of AR and provide related training to teachers.

The development of AR and interventions for teachers in the form of training and workshops responded to the condition of teacher skills. The majority of teachers (75%) have never used AR, and their experience using and integrating with learning strategies is valuable. This media is engaging for teachers to organize more varied learning. Training is given to teachers to master three critical competencies: the operation of AR-based learning media, development of learning strategies, and measurement of HOTs-oriented learning outcomes. While at the workshop, the teacher experienced project-based group learning with the output of learning strategies for the issue of Global warming using AR media and HOTs-based learning outcomes measurement instruments.

Furthermore, AR media that provides a high level of immersion with suitable learning strategies can increase students' competence. This result can be explained by motivation theory, and a good learning environment (media, methods, materials) will encourage better learning motivation. The impact of good motivation is to ask for high learning and boost good performance [26,27].Teachers practice using marker-based AR as an appropriate learning strategy. In terms of optimism, some feel unsure about applying it in their learning (4%), and this optimism is essential to ensure the success of its implementation. Several other studies support this finding that teacher optimism will increase the chances of success in applying both technology strategies and learning media [28-30]. Therefore, it is necessary to examine the factors that make teachers feel optimistic about their application. AR-assisted learning media have several formats that can be used flexibly, such as cards, worksheets, and comics. The creativity in using these various forms is an indication of their optimism.

Part of this teachers’ optimism is shown in the level of independence to learn AR-assisted media. All teachers stated that they can learn to use AR and apply it either manually (54%) or studying with friends (46%). These results showed high opportunities to apply an AR-based application to support science learning due to several benefits and do not need internet access to use. The immersion aspect of AR also becomes the excellence of this technology [26,31]. Besides, teachers also tend to have a strong belief in its utilization, even though some do not believe in the media effectiveness. The results of the analysis recommend the use of AR for science learning. Following the analysis on the characteristics of science learning and the broader interest, an AR-based application on the topic of Global Warming was agreed to be

developed. This application is directly embedded in the gadget and does not need internet access.

Considering the teachers' responses, AR-based learning media was then developed to be embedded on the gadgets for the topic of Global Warming. It uses markers to bring out the global warming phenomena. To make sure teachers' ability to use AR is developed, the teachers, as a group or individual task, have created learning strategies assisted with AR test items to find out the learning effectiveness, and questionnaires to measure the students' responses. Furthermore, it was disclosed that AR products can be used in a variety of learning strategies and developing HOTs following the results of a study by [32,33]. The combination of virtual and real objects is the benefit of this digital media to increase motivation and learning outcomes [26,27]. There are several techniques of using AR for learning developed by the teachers in this training and workshop. The teachers' ideas of using AR in various strategies are believed to increase some students' skills, such as the results of other studies. This belief is also in line with similar research related to the use of AR in various forms [19,34].

This study implies that there is a need for policies from schools to facilitate teachers in their implementation. This policy is mainly because not all teachers have sufficient skills in the use of this media. The continuous training reaching all teachers using AR that integrates various learning strategies enables more engaging and effective learning. In addition, AR media with the theme of Global Warming can be used in science learning and other knowledge. The global warming phenomenon impacts various sectors of life, so studies from multiple scientific perspectives will provide good insights for students. Success in this broader study requires support from school administrators and the ministry of education.

Conclusion

The training conducted with participants of science teachers at junior high schools in Sikka gives positive impact on the implementation of digital technology-based learning. Meanwhile, the AR-based application on the topic of Global Warming can be used with a variety of strategies. The instruments to measure the learning outcomes that meet the expected competencies in the era of Industrial Revolution 4.0 can also be developed. Furthermore, the AR applications should be implemented in a variety of formats to support more meaningful learning. This will broaden the benefits and strengthen the partnership that has been built during the training. The partnership is particularly for the implementation of the classroom action study as the follow-up of the program. Mentoring from higher education institutions in the implementation of classroom action is also required to improve the quality of the output.

Data Availability

The participants' response data used to support the findings of this study are available from the corresponding author upon request.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgments

The authors are grateful to the Research and Community Service Institute of Ahmad Dahlan University, Teacher Science Association of Sikka.

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Author Contributions

Conceptualization, Dwi Sulisworo; Data curation, Adi Jufriansah, Azmi Khusnani, and Erwin Prasetyo; Formal analysis, Dwi Sulisworo; Funding acquisition, Dwi Sulisworo; Investigation, Erwin Prasetyo; Methodology, Dwi Sulisworo, and Dian Artha Kusumaningtyas; Resources, Dwi Sulisworo; Supervision, Dwi Sulisworo; Validation, Dwi Sulisworo, Dian Artha Kusumaningtyas, and Trikinasih Handayani; Visualization, Azmi Khusnani; Writing – original draft, Dwi Sulisworo; Writing – review & editing, Dwi Sulisworo.

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Gmail sulisworo dwi <sulisworo@gmail.com>

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1 message

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