Development of augmented physics animation (APA) with the integration of crosscutting concepts about the COVID-19 as a supplement to the introductory physics course

Cite as: AIP Conference Proceedings **2320**, 020025 (2021); https://doi.org/10.1063/5.0037459
Published Online: 02 March 2021

Yudi Guntara, Asep Saefullah, Firmanul Catur Wibowo, Lukman Nulhakim, Dina Rahmi Darman, Ilham Akbar Darmawan, Irwanto, Sigit Setiawan, and Tubagus Umar Syarif Hadi Wibowo

Development of Augmented Physics Animation (APA) with the Integration of Crosscutting Concepts About the COVID-19 as a Supplement to the Introductory Physics Course

Yudi Guntara[1,a)], Asep Saefullah[1], Firmanul Catur Wibowo[2], Lukman Nulhakim[3], Dina Rahmi Darman[1], Ilham Akbar Darmawan[4], Irwanto[4], Sigit Setiawan[5], and Tubagus Umar Syarif Hadi Wibowo[6]

[1]*Department of Physics Education, Universitas Sultan Ageng Tirtayasa, Serang, Banten 42124, Indonesia*
[2]*Department of Physics Education, Universitas Negeri Jakarta, Jakarta 13220, Indonesia*
[3]*Department of Science Education, Universitas Sultan Ageng Tirtayasa, Serang, Banten 42124, Indonesia*
[4]*Department of Electrical Engineering Vocational Education, Universitas Sultan Ageng Tirtayasa, Serang, Banten 42124, Indonesia*
[5]*Department of Primary School Teacher Education, Universitas Sultan Ageng Tirtayasa, Serang, Banten 42124, Indonesia*
[6]*Department of History Education, Universitas Sultan Ageng Tirtayasa, Serang, Banten 42124, Indonesia*

[a)]Corresponding author: guntaray@untirta.ac.id

Abstract. The purpose of this study was to produce augmented physics animation (APA) with the crosscutting concept of the COVID 19 pandemic. APA was used as a supplement to introductory physics courses. The research method used Research and Development (R&D) with the 4D development model, which consists of (1) define, (2) design, (3) develop, and (4) disseminate. Assessment of the product involved three material experts from the fields of physics, chemistry, and biology. In addition, an education expert was also involved, especially regarding teaching materials. The user's motivation level involved thirty students (N = 30) from the Department of Physics Education, UNTIRTA, in the second semester. The products produced were interactive teaching materials used augmented reality technology, integrated with crosscutting concepts of the COVID 19 pandemic. The results showed that the APA developed was "feasible" in terms of material and educational aspects. Also, this augmented physics animation can increase student motivation levels in deepening fundamental physics. APA makes it easier to understand the concepts of physics associated with real life, especially concerning the COVID 19 pandemic.

INTRODUCTION

The work challenges that will be faced by scholars in the 21st century are more complex. This is indicated by the fact that there is no match between the system and the device that facilitates the link between the accumulation of experience and knowledge on campus and the expertise used at work [1]. One of the factors causing this problem is limited scientific mobility. Reasoning capacity does not develop due to a lack of insight into other knowledge outside the field of study. The fact is in the department of physics education. Students who are less exposed to other areas of science tend to see problems with "kacamata kuda," leading to the belief that some fields of science do not seem to contribute significantly to life. Therefore, the ideal is for graduates to have the capacity to be acrobatically capable and independent in utilizing existing theoretical knowledge to solve real problems in the field [2]. Such ability is only possible to develop if students are allowed to learn through various activities such as inquiry that supports experiential learning [3]. This activity is carried out so that students have strategic problem-solving abilities by linking theory and real problems.

The 9th National Physics Seminar 2020
AIP Conf. Proc. 2320, 020025-1–020025-8; https://doi.org/10.1063/5.0037459
Published by AIP Publishing. 978-0-7354-4064-7/$30.00

Students majoring in physics education is educated to become reliable candidates for physics teachers. A reputable teacher indicates that it can produce competent students too. However, a problem often faced by students in schools is the lack of motivation in learning physics. Physics is considered difficult to understand and has nothing to do in everyday life. This is a challenge for prospective teachers to be ready to enter the world of work. Several solutions have been offered in finding alternative problems that have been mentioned, including using the STEM approach [4], SETS [5], STS [6], and others. However, the integration that is carried out is still lacking limited to the incorporation of technological, mathematical, and social dimensions that are not yet too flexible. Therefore, to cover up these shortcomings, a crosscutting concept is introduced in lectures [7]. The material was packaged by linking it with several disciplines to discuss a focus of problems comprehensively. That way, prospective teachers would be stimulated to be more developed, especially in terms of pedagogy. Also, prospective teacher students have the provision to motivate their students to study physics.

The outbreak of the COVID 19 pandemic in Indonesia needs to be studied by physics education students to contribute to themselves and social life. Also, the crosscutting concept provides the experience for prospective teachers to get used to preparing meaningful learning. Although this review of COVID 19 is more inclined to the disciplines of biology and chemistry, it does not rule out being examined using physics. Therefore, to support government policy regarding an independent campus and participate in dealing with COVID 19, a lecture supplement is needed that addresses the real problems and integrates the crosscutting concept of the COVID 19 pandemic between the disciplines of physics, biology, and chemistry. But there are weaknesses in learning the concept of COVID 19 because of its microscopic nature [8]. The solution for this limitation, computer technology is needed to visualize microscopic matters [9]. One technology that can be used is augmented reality so that microscopic material is modeled so that students know the concepts learned [10,11]. AR supports learning with a crosscutting concept [12] and can enhance learning activities [13]. Besides, the use of AR is by industry challenges 4.0, which places more emphasis on developing 21st-century skills [14]. AR is suitable for learning based on interactive learning, game-based learning, collaborative learning, and experiential learning [15]. Whereas, based on research by Pedaste [16], AR combined with inquiry-based learning successfully achieves cognitive, motivational, and affective abilities. Therefore, it is necessary to develop a supplement of lectures, especially in basic physics courses that can integrate material on the COVID 19 pandemic deepened with crosscutting concepts between physics, chemistry, and biology. The developed application is named Augmented Physics Animation (APA) and is used to increase student motivation in learning physics.

METHOD

The method used in this research was Research and Development (R&D) by adapting the 4D development model [17]. The 4D development model consists of 4 main stages: define, design, develop, and disseminate. The stages of development in detail refer to the article by Marwanti [18], but it briefly displays in FIGURE 1.

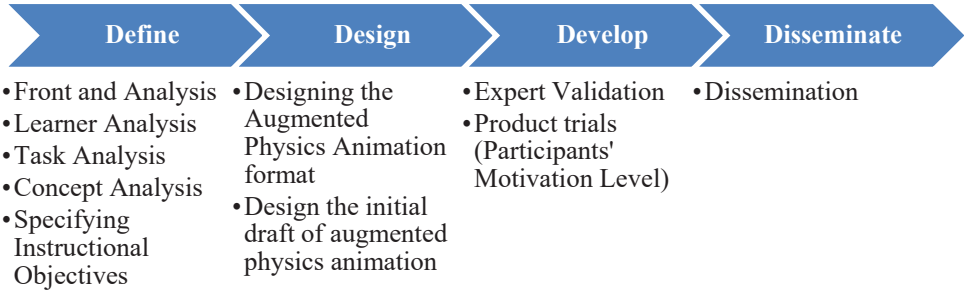


FIGURE 1. 4D development stage

The subjects of the trial research were students of the second semester (N = 30), majoring in physics education, Sultan Ageng Tirtayasa University. There were several instruments used in this study, including a) Augmented Physics Animation Assessment Instrument. It was used to obtain data on the expert judgment of the developed augmented physics animation. The results of this assessment serve as the basis for product improvement before being trialled. This sheet uses a scale of polytomous from 1 to 4 and was filled in by four experts. Data analysis techniques for product feasibility questionnaire used a modified Likert scale using scale 4. Reference to scale four is seen in the article Guntara [19]. The IMMS (Instructional Materials Motivation Survey) Instrument was an integral part of the

ARCS model designed by Keller [20,21]. The IMMS instrument was used to measure students' motivation levels. This sheet used a scale of polytomous from 1 to 7. According to Keller, four components affect motivation in the learning process: attention, relevance, confidence, and satisfaction (ARCS). All the components contributed to sustaining motivation throughout the learning process; four instructional design principles should be met. The IMMS instrument had been applied and proved to have good internal consistency and validity in measuring learners' motivational features in the e-learning setting [22].

RESULTS AND DISCUSSION

Define

Front and Analysis

A preliminary study was conducted to identify the main problems underlying the development of Augmented Physics Animation (APA). This stage is carried out by interviewing and seeing the results of evaluations from the Basic Physics I course to students majoring in physics education (N=61) at Sultan Ageng Tirtayasa University. The interview results show that students have difficulty understanding abstract physics material. Also, students do not have motivation in lectures because the content presented is not directly related to daily life. Learning is monotonous, only using the lecture method. In line with the acquisition of the Basic Physics I exam, students who get an A (satisfactory) score, there are five students or only 8%. The literature study results found an alternative solution to integrate crosscutting concepts in lectures and be supported by augmented reality technology. The integration of crosscutting concept is very suitable for students in the early semester because they also study general chemistry and biology.

Learner Analysis

According to Piaget's theory of cognitive development, second-semester students have an average age of 19-20 years and can be categorized in the formal operational stage. This stage has characteristics, including students being able to think conceptually, thinking hypothetically, and reasoning abstractly so that students can reason without having to deal with objects or events directly. This is suitable for the use of augmented reality technology in lectures.

Concept Analysis

Concept analysis uses to design any physics concepts that will integrate into augmented physics animation. In addition, cross concepts to support crosscutting concepts have also been developed, namely by taking the theme of Pandemic COVID 19. These concepts are then summarized and presented in FIGURE 2.

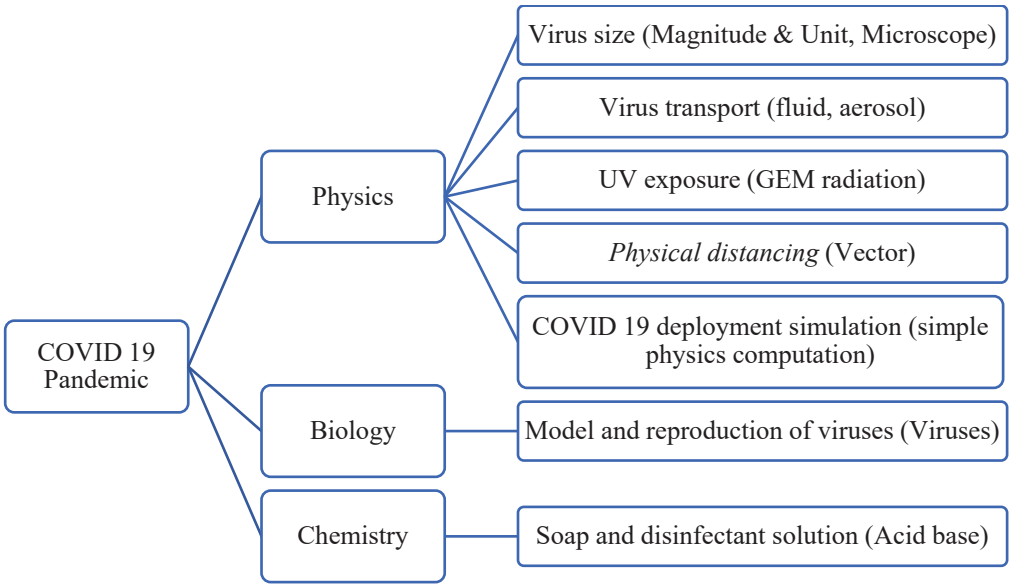


FIGURE 2. Mapping concept of integration of crosscutting concept COVID 19

Task Analysis and Specifying Instructional Objectives

The purpose of lectures is derived from indicators (the results of task analysis) and arranged based on the material to be delivered. The objectives set out in lectures are shown in TABLE 1.

TABLE 1. APA Lecture Objectives

No	Topics	Objectives
1	Virus size	1. Using scientific notation in determining the size of the coronavirus and its parts 2. Explain the types of electron microscopes and their uses (TEM, STEM, SEM, ESEM, and REM) in investigating coronaviruses
2	Virus transport	3. Analyzing the process of coronavirus transfer through the air (fluid) 4. Explain the characteristics of the fluid 5. Analyzing environmental conditions (aerosols) that allow the coronavirus to move
3	UV exposure	6. Explain the spectrum of electromagnetic waves that are useful for killing coronaviruses 7. Calculate the frequency, wavelength of electromagnetic waves
4	Physical distancing	8. Analyzing the direction of movement of the coronavirus transmitted by sneezing from affected patients
5	COVID 19 deployment simulation	9. Explain how to transmit the coronavirus
6	Model and reproduction of viruses	10. Explain the parts of the coronavirus 11. Explain how to breed the coronavirus in the body
7	Soap and disinfectant solution	12. Explain the components of soap and disinfectants (acid-base) that cause the coronavirus to die.

Design

The results of this stage are the Augmented Physics Animation design with the integration of the COVID 19. pandemic crosscutting concept. In general, the design phase consists of two steps: the APA format and data collection instruments. APA presented in two media, namely in print and 3D. In printed form, a module is created to show

scanned markers. Then,the animation is formed in a 3D model to make it easier for students to understand the concepts, especially concerning the coronavirus. TABLE 2 presents the components in preparing the APA module.

TABLE 2. Format of the Augmented Physics Animation Module integrated Crosscutting concept COVID 19

No	Aspect	Information
1	Modul component	Cover, preface, table of contents, usage instructions, concept map, achievement indicators, material summary accompanied by markers, sample questions, practice questions and answer keys.
2	Content	The material in this module is compiled with the theme COVID 19, so that there are links between several concepts from across disciplines.
3	Problems	The questions are arranged to practice the students' problem solving skills

The 3D APA model is designed using such software, including Blender, Vuforia, Unity, and Android Studio. Blender software is used to create 3D objects. Vuforia is used to upload markers that have been designed and then integrated into unity. Unity software used to combine (package) the results of 3D objects (blenders) and markers (Vuforia), then compile them into .apk files with the help of Android Studio. The AR object design scheme can see in FIGURE 3.

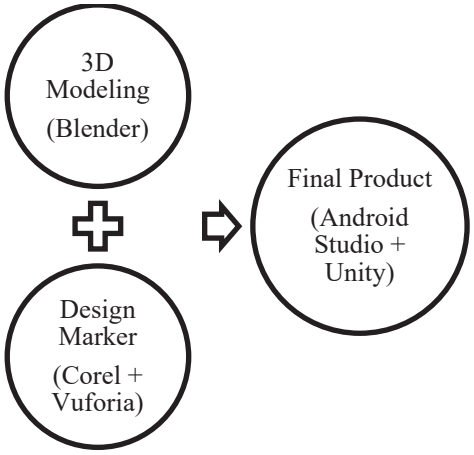
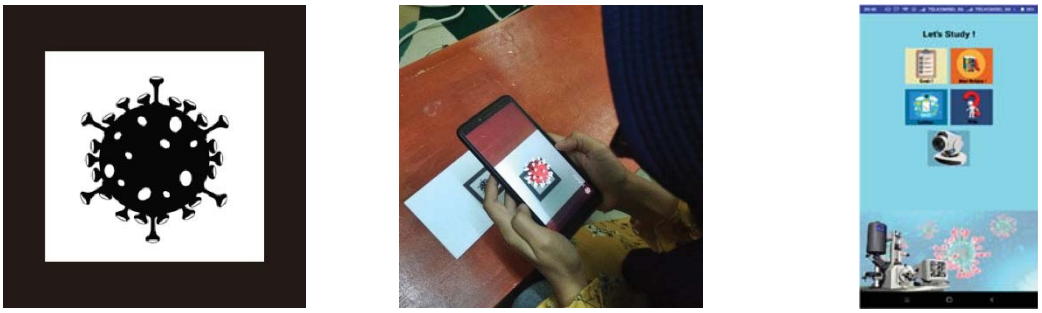


FIGURE 3. The Design Process of Augmented Physics Animation

Figure 4 shows one of the results of the design of markers and 3D objects from APA.



(a) (b) (c)

FIGURE 4. (a) marker; (b) 3D objects that appear after scanning the marker; (c) initial display of APA

Develop

Product Assessment Results

Experts then assess products that are designed. This assessment uses product assessment instruments. Product assessment (N = 4) was carried out by media and material experts, namely physics, chemistry, and biology. TABLE 3 shows the results of the expert assessments.

TABLE 3. Results of the Augmented Physics Animation Assessment (N = 4)

No	Aspect	Minimum	Maximum	Mean
1	Content (5 items)	2,75	3,50	3,15
2	Construct (5 items)	3,00	3,75	3,25
3	Display (5 items)	3,50	3,50	3,50
4	Linguistic (5 items)	3,00	3,75	3,25
Overall (20 items)		3,06	3,63	3,29

Overall, the interpretation of the average APA assessment gets "very satisfying" results. However, some comments need to be corrected; among others, the material needs to be completed, especially regarding content related to COVID 19, and the basic physics material on the theme of COVID 19 needs to profound (material aspects). Instructions for use in the module need to be explained in detail because some students are not yet familiar with augmented reality technology (construction aspects).

Product Trial Results (Participants' Motivation Level)

Augmented Physics Animation, which has been assessed and revised, is then tested on a limited basis in the classroom. The trial was conducted on students majoring in physics education in the second semester at UNTIRTA (N = 30), using IMMS from Keller to see the level of student motivation after using APA. The trial results are presented in TABLES 4 and 5.

TABLE 4. Scores of motivation level (N=30)

Item	Minimum	Maximum	Mean
Attention (12 items)	3.83	6.10	4.61
Relevance (9 items)	4.13	4.90	4.54
Confidence (9 items)	4.20	5.00	4.49
Satisfaction (6 items)	4.03	4.77	4.43
Overall (36 items)	4.05	5.19	4.52

TABLE 5. Range of Motivation Level

Motivation level	Scores	Total N=30	Percentage
High level	5.51 – 7.00	1	3.00%
Upper medium level	4.01 – 5.50	24	80.00%
Medium level	2.51 – 4.00	5	17.00%
Low level	<2.50	0	0.00%

Of the 30 students, overall , the minimum motivation level was 4.05, while the maximum motivation was 5.19. It noted that the mean overall motivation level was 4.52, which was quite positive. One student (3.00%) has a high motivation level, 24 (80.00%) has a medium motivation level, 5 (17.00%) has a moderate motivation. From the attention aspect, the lowest item about "The way the information arranged on the page helped keep my attention." It means that some information presentations are still not well understood by students. Then it should be in the module; the display of information or instructions must arrange adequately and clearly. While the highest item about "Something was interesting at the beginning of this course that got my attention." It means that in the preliminary presentation, such as the use of images and information relating to everyday life, especially COVID 19, it is an exciting student motivation to learn. So the earliest part is essential to attract the attention of students in line with research by Bunce [23]. At the beginning of each chapter, the APA module begins with illustrations or examples of physics materials, especially in handling COVID 19.

In the aspect of relevance, the lowest item about "There were stories, pictures, or examples that showed me how this material could be important to some people." (COVID 19) tends to be somewhat forced. Increasing motivation, all material should contextually package so that the content discussed is directly related to daily life [24]. While the highest items regarding "Completing this course were important to me" and "The content of this course will be useful to me." Students consider that the material presented is essential and useful to learn regardless of the information that is less relevant beforehand. The content is essential because, at this time, in the middle of the COVID 19 Pandemic, students need additional information to learn and determine attitudes. Students have been able to capture the subject matter that was delivered, because before when they were in middle school, the material had been studied. Besides, the integration of 3D objects can increase students' understanding and motivation in line with research by Dünser [25].

In the aspect of confidence, the lowest item about "When I first looked at this course, I had the impression that it would be easy for me." It means that students assume that the "first glance" determines student motivation in lectures. As explained earlier, the introductory presentation needs to think out carefully. The material presented in the introduction should be material that is easy but very directly related to daily life, especially COVID 19. So, don't directly discuss high-level content. Even though students can already think abstractly in the early student phase, his thoughts are still in the development stage. So, do not immediately be given a heavy burden at the beginning of the delivery of material. Submission of content should be preceded by a qualitative approach, namely, honing the ability of representation [19]. An essential point in learning basic physics is students can understand the concepts of physics in depth. Students are required not only to be able to solve the problems alone but also to solve problems comprehensively or not just be great in calculations. While the highest item (on the contrary, negative statements) regarding "The exercises in this course were too difficult." It means that the practice questions presented are too challenging to understand. It can cause student motivation to learn will decrease because it will create a "bad mood" for learning. The presentation of questions should be arranged based on cognitive processes, from the easiest to the most difficult [26]. So, don't submit all high-level questions.

In the aspect of satisfaction, the lowest item about "feedback showed that students were not satisfied with the feedback they could receive." They expected there to be more interaction and feedback from the course team. high about "The wording of feedback after the exercises, or of other comments in this course, helped me feel rewarded for my effort." It indicated that learners were overall satisfied with the courses, and their sense of satisfaction would be very high if they could complete the whole course. But in broad outline, based on the results of IMMS, it shows that the level of students' motivation in undergoing lectures with the help of integrated Augmented Physics Animation COVID 19 is satisfactory. Students consider that the integration of various concepts integrated into one theme, COVID 19, makes learning physics more meaningful.

Disseminate

This stage has not been carried out in research considering there are some 4D steps that have not been implemented. The effectiveness test stage has not yet carried out because there is a government policy for schools from home. In the next research, and effectiveness test will be conducted to see the effectiveness of APA in improving students' problem-solving abilities.

CONCLUSIONS

Based on the results of the discussion of the formulation of the problem, two conclusions can draw. First, this research produced a product in the form of Augmented Physics Animation (APA). APA results of the development in the way of modules equipped with markers to bring up 3D objects. Besides that, physics material is packaged in the theme of COVID 19 Pandemic to integrate crosscutting concepts so that basic physics lectures are more meaningful. What is developed has met the eligibility criteria. Based on the results of an assessment conducted by media and material experts, it is stated that APA is suitable for lectures. Also, based on IMMS results, it shows that the level of motivation of students in undergoing lectures with the help of integrated Augmented Physics Animation COVID 19 is at a satisfactory level. 3D objects attract students and add curiosity to learn more. Likewise, students assume that the integration of various concepts integrated into one theme, namely COVID 19, makes learning physics more meaningful.

REFERENCES

1. I. A. Darmawan, N. E. Budiyanta, D. Aribowo, M. Fatkhurokhman, M. A. Hamid, Y. Guntara, and S. Nurhaji, *J. Phys. Conf. Ser.* (2020), p. 12048.
2. T. Raya, *Konsesp-Konsep Kegur. Dalam Pendidik Islam* **51** (2019).
3. Y. Guntara and M. M. Nona, *Gravity Sci. J. Res. Learn. Phys*. **5**, (2019).
4. L. Artiani, "Pengembangan Lembar Kerja Peserta Didik (LKPD) dengan Pendekatan Science, Technology, Engineering and Mathematics (STEM) Berbasis Picture," Thesis, UIN Raden Intan Lampung, 2020.
5. O. R. Hasanah, "Keefektifan Media Pankat (Paket Anion Kation) Berbantuan Worksheet Package Bervisi Sets Sebagai Media Pembelajaran Penamaan Senyawa Anorganik," Thesis, Universitas Negeri Semarang, 2016.
6. E. Rustiani*, J. Elem. Educ*. **3**, 20 (2014).
7. C. J. Harris, J. S. Krajcik, J. W. Pellegrino, and K. W. McElhaney, *Menlo Park. CA SRI Int.* (2016).
8. Z. Zazhi, xing bing xue Liu, Z. Zh, and L. Zhonghua, *Ncbi.Nlm. Nih. Gov* **41**, 145 (2020).
9. F. C. Wibowo, *et al.*, *AIP Conf. Proc.* (2019), p. 20015.
10. I. Aripin and Y. Suryaningsih, *J. Sainsmat* **8**, (2019).
11. I. Wulandari, F. S. Irwansyah, and I. Farida, *Journal of Physics: Conference Series* **1280** (3), p. 032016 (2019).
12. J. Kerr and G. Lawson, *Int. J. Art Des. Educ*. **39**, 6 (2020).
13. M. Flores-Bascuñana, P. D. Diago, R. Villena-Taranilla, and D. F. Yáñez, *Educ. Sci*. **10**, (2020).
14. K. Ottogalli, D. Rosquete, A. Amundarain, I. Aguinaga, and D. Borro, *Appl. Sci*. **9**, (2019).
15. M. F. A. Hanid, M. N. H. Mohamad Said, and N. Yahaya, *Univers. J. Educ. Res*. **8**, 51 (2020).
16. M. Pedaste, G. Mitt, and T. Jürivete, *Educ. Sci*. **10**, (2020).
17. Thiagarajan, S. Semmel, and M. Semmel, *Instructional Development for Training Teachers of Exceptional Children* (Indiana University Bloomington, India, 1974).
18. K. Marwanti, S. Suherman, F.C. Wibowo, D.R. Darman, and Y. Guntara*, J. Penelit. Pengemb. Pendidik. Fis*. **6**, 1 (2020).
19. Y. Guntara and I. Wilujeng, *J. Kependidikan Penelit. Inov. Pembelajaran* **2**, 302 (2018).
20. J. Keller, *J. Instr. Dev.* **10**, 2 (1987).
21. O. Keller, S. Schmeling, A. Müller, and M. Benoit, *J. Instrum*. **11**, (2016).
22. D.A. Cook, T.J. Beckman, K.G. Thomas, and W.G. Thompson, *Acad. Med*. **84**, 1505 (2009).
23. D.M. Bunce, E.A. Flens, and K.Y. Neiles, *J. Chem. Educ*. **87**, 1438 (2010).
24. M. Murtiani, A. Fauzan, and R. Ratnawulan, *J. Penelit. Pembelajaran Fis*. **1**, (2012).
25. A. Dünser, L. Walker, H. Horner, and D. Bentall, in *Proc. 24th Aust. Comput. Interact. Conf.* (2012), pp. 107–114.
26. M. Ibnu, B. Indriyani, H. Inayatullah, and Y. Guntara, in *Pros. Semin. Nas. Pendidik. FKIP* (2019), pp. 205–210