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Light Wave Digital Learning Material with Augmented Reality and CTL Model to Improve Students' 4C Skill

Insyirah Erlenida Novit[1], Febrian Virijai[2], Asrizal[3]*

[1] Study Program of Physics Education, FMIPA, Universitas Negeri Padang, Padang, Indonesia
[2] Study Program Master of Physics Education, FMIPA, Universitas Negeri Padang, Padang, Indonesia
[3] Physics Department, FMIPA, Universitas Negeri Padang, Padang, Indonesia

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ABSTRAK

Pembelajaran abad 21 seharusnya menerapkan keterampilan abad 21 siswa yakni keterampilan 4C. Keterampilan ini diperlukan siswa untuk berhadapanakan persaingan global dimasa depan. Hasil studi pendahuluan memperlihatkanketerampilan 4C siswa masih rendah. Solusi dari permasalahan adalah siswamembutuhkan media ajar yang lebih interaktif dan memiliki daya tarik akanminat belajar, bahan ajar digital dengan Augmented Reality terintegrasi model CTL menjadi solusi permasalahan tersebut. Tujuan penelitian ini untukmenentukan analisis kebutuhan, validitas dan praktikalitas penggunaan bahan ajar digital dengan AR terintegrasi model CTL. Metode penelitian ini memakaipenelitian research and development melalu penggunaan model pengembanganHannafin & Peck. Instrumen penelitian meliputi instrumen analisis kebutuhan, lembar angket validasi dan lembar angket praktikalitas.Teknik dalam menganalisis data dipakai yakni statistik deskriptif, kualitatif, dan kuantitatif. Berdasarkan data yang telah dianalisis terdapat tiga hasil penelitian. Pertama, hasil penelitian analisis kebutuhan yang menyatakan masih rendahnya keterampilan 4C siswa. Kedua, hasil validasi produk didapatkan nilai rata-rata sebesar 0,8 berada pada kategori valid. Ketiga, hasil praktikalitas produk didapatkan nilai rata-rata sebesar 86 berada dalam kategori sangat praktis. Implikasi dari hasil penelitian yaitu bahan ajar digital berbantuan AR terintegrasi model CTL dapat dijadikan sumber belajar alternatif untuk mencapai tujuan pembelajaran, kemudian guru dapat mengkontruksi keterampilan 4C siswa melalui bahan ajar digital Fisika AR-CTL.

ABSTRACT

The learning in 21st century should implement students' 21st century skills, known as 4C skills. These skills are needed by students to face global competition in the future. The preliminary research results show that skills of 4C by students are still lack. The way for fix the problem is that students need learning media that is more interactive and attracts interest in learning. Digital learning materials with Augmented Reality integrated with CTL models are a solution to the problem. The research purpose was to analyze the needs analysis, validity, and practicality of using digital learning materials with an AR integrated CTL model. This research method uses research and development using the Hannafin & Peck development model. The research instruments include a needs analysis instrument, a validation questionnaire sheet, and a practicality questionnaire sheet. The techniques for data analysis used are descriptive, qualitative, and quantitative statistics. Based on the data that has been analysed, there are three research results. First, the needs analysis research results stated that the low 4C skills of students. Second, the product validation results obtained an average value of 0.8 in the category was valid. Third, the product practicality results obtained an average value of 86 in the very practical category. The research results implication are that digital teaching materials with AR and CTL can be used as alternative learning resources to achieve learning goals, then teachers can construct students' 4C skills by using AR-CTL Physics digital teaching material.

1. INTRODUCTION

The education in 21st century should motivate students' various abilities to compete healthily. The learning in 21st century can be said to be learning that prepares the 21st century generation (Mu'minah & Suryaningsih, 2020; Urip Umayah & Riwanto, 2020). There are four competencies that students can train to face global competition: skills of critical thinking, creativity, communication, and collaboration. These global challenges have be taught to students in relevant with teaching and education so that they have skills for 21st-century learning. 21st century education demands a balance of technology and learning that is innovative, creative, collaborative, learner-centered, and prioritizes the skills of students (Sulistyaningrum et al., 2019; Yusliani, E., Burhan, H. L., & Nafsih, 2019).

*Corresponding author.
E-mail addresses: asrizal@fmipa.unp.ac.id (Asrizal)

The practice of learning in 21st century must ensure student-centered learning based on the real world. The principle applied of learning in 21stcentury is student-centered learning, or collaborative learning that asks students to be active participants and connected to real-world contexts integrated with community life (Asrizal et al., 2018; Yudiana, 2020). To develop learning in 21st century, teachers must begin with a single step, shifting from the traditional learning focus to teacher pattern to a learning focus to student pattern (Kodri & Anisah, 2020; Purwani et al., 2021). The government also seeks to equip Indonesia's youthful generation to be faithful, productive, creative, innovative, and successful citizens capable of contributing to the lives of society, the state, and global civilization. The government's efforts can be accomplished if education adjusts the mastery of technology by following the development of ICT.

Mastery of technology in learning should be able to create more active and creative students. Education that used to be completely manual has now been transferred to a digital form that is more effective and efficient. ICT materials for teaching need to be utilized in physics learning to create active, interactive, and meaningful learning. Therefore, the use of ICT in learning can change it more easy for students to develop their thinking skills. Examples of ICT utilization in assisting the process of learning are presentation media, media of learning such as e-learning, electronic materials for teaching, and ICT-based materials for teaching (Asrizal et al., 2022; Asrizal & Utami, 2021). ICT materials for teaching that are integrated with the learning model will be more effective in improving students' 4C skills.

However, the reality on the ground is not in similar with the expected conditions. The main problem relates to students' 4C skills, as evidenced from a series of critical thinking, creative, collaboration, and communication tests: 51, 53, 51, and 50, which indicate that 21st century skills are in the category in low. This is in line with several studies that show students' 4C skills are still lack. The first research explains that in the process of learning, the materials for teaching used have not been able to improve students' 4C skills (Rusdin, 2018). The second research explains that skills of 4C by students are still low; active students tend to only have critical and skills of creative thinking, while others do not (Anggreni & Yohandri, 2022). The observation results at SMAN 8 Padang show that activities of learning have not yet reached the guidance of the 2013 curriculum and 21st century learning.

The observations made in the initial research are the analysis of learning problems, analysis of students' 4C skills, analysis of student characteristics, and analysis of learning settings. The initial research used a questionnaire distributed to students of class XI MIPA and two physics teachers through observation activities made by the researcher at SMAN 8 Padang. The initial research results obtained showed a difference between the actual and ideal conditions. There are four researchers who have offered solutions for developing electronic or digital materials for teaching. First, a research entitled flip book-based electronic materials development for teaching to increase student outcomes in learning (Yulaika et al., 2020). Second, a research entitled the development of contextual-based high school physics materials for teaching on temperature and heat material (Astiti, 2019). Third, a research entitled CTL-based physics E-Modules using the Kvisoft Flipbook Maker application to improve the science literacy of SMA/MA students (Nurhasnah & Sari, 2020). Fourth, a research entitled the audio-visual mediadevelopment of learning with a approach of Contextual Teaching Learning (CTL) to increase learning motivation of student (Avania & Sholikhah, 2021). The four studies developed teaching material products and E-Modules for learning, applied them to SMA/MA students, measured students' 4C skills level, learning motivation, science literacy level, and students' concept mastery. This previous research is a fundamental source for conducting this research, because these four studies discuss about digital teaching materials, students' 4c skills, and the ctl model. Researchers will develop digital teaching materials AR-CTL with updates that are not yet in previous researchers.

The development of materials for teaching by several previous researchers has several limitations. The use of digital materials for teaching by adding Augmented Reality (AR) technology equipped with the model of Contextual Teaching and Learning (CTL) is a solution to these problems. AR technology will make physics lessons more real and the CTL model will link physics lessons with students' daily lives. This research differs from prior studies in three ways. The first difference is that the materials for teaching used are ICT-based. The second difference is that the materials for teaching integrate the CTL model with AR technology based on real-world problems. The third difference is that the research place is aimed at grade XI students at SMAN 8 Padang. This research is different from previous research. The first novelty lies in the materials for teaching developed in the shape of digital materials for teaching packaged in the shape of applications, which can be used on smartphones by adding augmented reality technology. The second novelty of digital materials for teaching is made interactive with the addition of videos, images, and animations, that can generate student interest in learning.

There are three theories related to the development of this digital teaching material. The first theoretical review of the solution relates to digital materials for teaching. Digital materials for teaching are a collection of resources that have been arranged in a specific order and can be mastered by students which

are encapsulated in digital or electronic form and can be accessed through technological devices such as computers, tablets, or smartphones (Sriwahyuni et al., 2019; Winatha et al., 2018). Digital materials for teaching consist of learning materials that are systematically arranged to achieve objectives of learning that are presented or published in electronic format. The composition of electronic materials for teaching in general must contain a cover (containing the title, class, semester, and identity of the compiler), KI and KD, achievement indicators, teaching material, practice questions, competency tests, and references. Digital materials for teaching have several advantages over ordinary printed materials for teaching. This electronic teaching material is more durable, practical and easy to use anywhere and anytime (Ridho et al., 2020; Rindaryati, 2021).

The second theoretical review of the solution deals with Augmented Reality. The utilisation of technology in the educationfield, one of which is the application of Augmented Reality technology in education. Augmented Reality is a technology that mixes the virtual and real worlds and is displayed through technological devices (Lutfi Novitasari, 2019; Sanjaya, 2013). The use of AR technology through mobile technology is able to provide various information regarding the visualization of objects in the shape of reality (Pradana, 2020; Ropawandi et al., 2022). AR also has advantages in terms of interaction because it employs markers to display specific three-dimensional objects that are directed at the camera. Furthermore, the application of the concepts presented might improve pupils' reasoning and imagination (Majid & Salam, 2021; Pradana, 2020).

The third theoretical research of the solution is related to the CTL model. The CTL model is a teaching method in which professors offer real-world scenarios in the classroom and urge students to create connections between their knowledge and its application in daily life. Its implementation, the CTL learning model requires lesson planning that reflects the concepts and principles of contextual teaching and learning (Hanik et al., 2018; Sanjaya, 2013). CTL model also has characteristics that distinguish it from other learning models, namely cooperation, mutual support, fun, excitement, not boredom, learning with passion, integrated learning, and using various active student sources (Rahman, 2020; Rusman, 2019). Learning in contextual has seven indicators that must be reflected or appear in the process of learning. The seven indicators are as follows: constructivism, inquiry, questioning, learning community, modelling, reflection, and authentic assessment.

Based on the above statement, the development of digital materials for teaching with AR integrated with the CTL model to improve students' 4C skills needs to be done. Digital materials for teaching with AR and CTL will improve students' knowledge, attitudes, and skills because the technology in AR and the syntax of the CTL model can make the learning process student-centered. 21st Century learning is learning that avoids teacher-centered learning activities. This research is required for growth materials for teaching that are interesting and interactive in the process of learning. The interactive process is needed because it can clarify the material taught through an attractive video display. The research purpose is to analyze the needs analysis, reveal the test of validityresults, and reveal the testof practicalityresults of using materials for teaching with AR integrated with the CTL model to increase students' 4C skills.

2. METHODS

This research used research and development(R&D)methods. R&D methods is a research used to make a particular product and then test the validity and practicality of the product (Sugiyono, 2012). The product produced in this research is a digital teaching material of light waves with Augmented Reality integrated CTL model. This research uses the Hannafin & Pack design model to make a product. The development of Hannafin & Pack has a goal with a product-oriented learning design model that will produce a product that is indispensable and needs to be produced. The Hannafin & Pack design model has three main phases, starting with needs analysis, design, and development and implementation (Hershey, 2019).

This research used several instruments to collect data. First, a questionnaire on teachers' difficulty on the utilization of ICT in materials for teaching. Second, performance assessment questions such as problem solving for critical thinking skills, story problems for creative thinking skills, and teamwork during group practicum for communication and collaboration skills were given to students to measure their 4C skills. Third, document analysis in the form of physics lesson plans of teachers to analyze objectives of learning and settings; fourth, student characteristics analysis to see the background, learning motivation, learning interest, and learning style of students. Fifth, the validation sheet for digital materials for teaching. The validity instrument contains components in five assessments, namely substance of material, display of visual communication, design of learning, software utilization, and assessment of CTL. Sixth, the practicality sheet of digital materials for teaching according to students. The practicality instrument consists of an assessment of the components of benefit, ease of use, attractiveness of presentation, clarity, CTL integration, and software use.

The technique for data analysis used in the research is descriptive statistical analysis technique, namely by describing the needs analysis results, validity test analysis, and practicality test analysis in the shape of tables or graphs. The teacher constraints analysis on the use of ICT in teaching material is presented in tabular form. The student 4C skills analysis, student characteristics, objectives of learning, learning settings, validity tests and practicality tests are presented in the shape of graphs. The assessment for this research uses a scale of Likert with a score of 1-5 with the following conditions: 5 means Strongly Agree (SA), 4 means Agree (A), 3 means Enough Agree (EA),2 means Disagree (DA), and 1 means Strongly Disagree (SDA). The test of validity results were then analyzed using the Aiken's V formula with expert validation categories ≥0.6 categorized as valid and <0.6 categorized as invalid (Azwar, 2015). The practicality test results were analyzed descriptively quantitatively with the categories 80 to 100 are excellent, 66 to 79 are good, 56 to 65 are sufficient, 40 to 55 are less, and 30 to 39 are failures (Arikunto, 1998).

3. RESULT AND DISCUSSION

Results

Needs Analysis Results

Based on the Hannafin & Pack development model, the first stage conducted in this research is a needs analysis. The first need for analysis is the learning problems analysis at SMAN 8 Padang related to the utilization of ICT in materials for teaching. The instrument used is a questionnaire of learning problems given to two physics teachers at SMAN 8 Padang. The teacher difficulty analysis on the use of ICT in teaching material is shown in Table 1.

Table1. The Teacher Difficulty Analysis on the Use of ICT in Teaching Material Result

Teacher Difficulty on the Utilization of ICT in Teaching Material	Score
Difficulty in creating digital materials for teaching	82
Difficulty in mastering digital materials for teaching	72
Difficulty in using software	80
Difficulty in creating digital materials for teaching using software	80
Difficulty in using digital materials for teaching for learning	80

Table 1 shows that the data by the teacher difficulty Analysis on the use of ICT in teaching material in the value range 72-82. First, the analysis results show that teachers are difficult in making digital materials for teaching, such as making learning tutorials in the shape of digital content, linking material to real-world contexts, and presenting material in digital form. Second, teachers are difficult in mastering digital materials for teaching, such as difficulties in implementing material simulations, difficulties in implementing discussion forums, difficulties in implementing modules, and other materials in digital form. Third, teachers are difficult in using software, such as constrained in operating the latest software and constrained in learning how to utilize the software. Fourth, teachers are difficulty in making digital materials for teaching using software, never using software in making materials for teaching, having difficulty utilizing the latest features in the software, and having difficulty determining software that is suitable for making digital materials for teaching. Fifth, because of difficulties in teaching, managing students, and displaying digital materials for teaching, teachers are limited in their use of digital materials for teaching for learning. From the data obtained, it can be concluded that teachers feel constrained and have difficulties utilizing ICT in materials for teaching.

The second needs analysis is related to the students' 4C skills analysis, which include skills of critical thinking (C_1T), skills of creative thinking (C_2T), communication skills (CM), and student collaboration (CL). The instrument used to measure students' 4C skills is a series of questions and performance tests given to 35 students in class XI SMAN 8 Padang. The students' 4C skills analysis is shown in Figure 1.

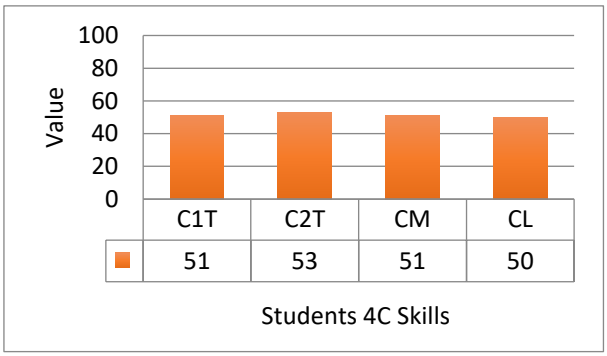

Figure 1. Students' 4C Skills

Based on Figure 1, it can be explained that students' 4C skills are still very low. The scores obtained from a series of critical thinking, creative, collaboration, and communication tests are in the range of 50 to 53, which indicates that 21st century skills, especially students' 4C skills, are still in the category in low. First, students' skills of critical thinking worth 51 are in the category in low; the low skills of critical thinking of students are seen from their answers in problem solving. Second, skills of creative thinking by students worth 53 are in the category in low; the low skills of creative thinking of students are seen from the answers of students who have not been able to develop unique and varied opinions. Third, students' communication skills worth 51 are in the category in low. The low communication skills of students are seen in their performance when they make presentations after experiment. Fourth, collaboration skills worth 50 are in the very category in low. The low level of collaboration skills shown in the performance of students solving problems in groups. Based on these four assessments, it shown that students' 4C skills have not achieved the expected results, so this requires an update in learning so as to get more optimal results and in similar with the learning in 21st century objectives.

The third need for analysis is the student characteristics analysis at SMAN 8 Padang. The instrument used was a characteristic questionnaire distributed to 35 students in class XI. The student characteristics analysis has four indicators that are measured: background (BG), learning interest (IL), learning motivation (LM), and student learning style (LS). The student characteristics analysis shown in Figure 2.

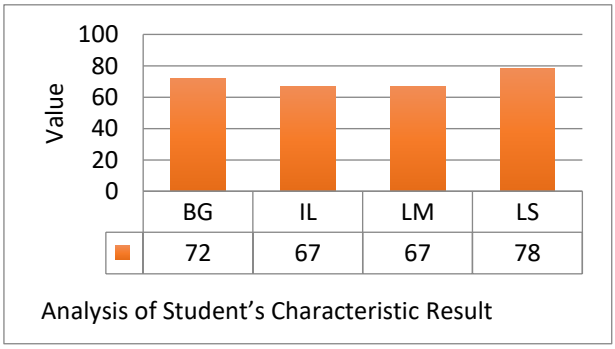

Figure 2. Student's Characteristic Analysis Result

Based on Figure 2, it shown how the characteristics of 35 students in physics learning The analysis results show that the value of student characteristics is in the range of 67 to 78. Indicators of the background and learning style of students are in the category was good, with values in the order of 72 and 78. While indicators of student interest in learning and student learning motivation are in the sufficient category with a value of 67, This can be interpreted as indicating that the internal factors of students have not fully supported the physics process of learning. Student learning motivation greatly affects student interest in learning; the higher the learning motivation, the higher the student interest in learning. Student background affects student learning styles, and student learning styles are related to how students understand learning. Overall, student characteristics can affect students' 4C skills.

The fourth need analysis is the learning settings analysis conducted by physics teachers. The observation instrument used is guided by Ministerial Regulation Number 22 in 2016 regarding the process of activities of learning that take place in the classroom. The learning activity process is conducted by implementing the lesson plan that has been made by the teacher. Activities of learning conducted include

preliminary activities (PRA), core activities (COA), and activities for closing (CLA). A learning problems analysis is shown in Figure 3.

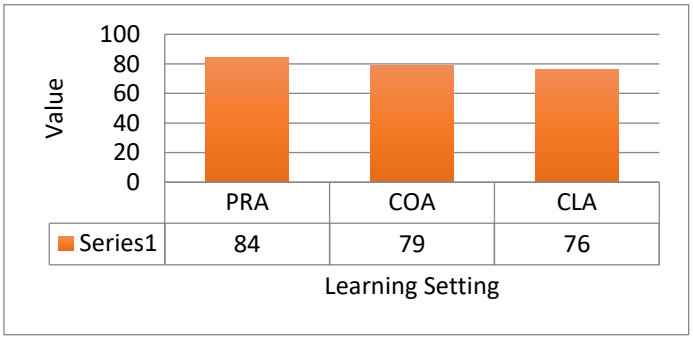

Figure 3. Learning Setting

Based on Figure 3, the physics teacher learning settings analysis results, which include introductory activities, core activities, and activities for closing, shown. Preliminary activities are in the category was good with a score of 84, but in the preliminary activities, the teacher has not provided learning motivation to students. Core activities are in the category was good with a score of 79. In the core activities, the teacher has not used the learning model properly, such that the steps in the model have not been seen and 21st century skills in the process of learning have not been seen. The closing activity is in the good enough category with a score of 76. In the closing activity, the teacher is not seen informing the learning activity plan for the next meeting. Overall, the average value obtained is 79.6, meaning that activities of learning at SMAN 8 Padang are in similar with the implementation of ideal learning. However, it is necessary to improve and increase the core activities and activities for closing so that the implementation of learning is more optimal.

Validity Test Results

The next research results are the product validation results. Digital materials for teaching that have been developed are then validated by experts to reveal their validity. The validation instrument used has assessment components that include material substance (MS), learning design (LD), visual communication display (VC), software utilization (SU), and CTL integration assessment (CA). The product validation results is shown in Figure 4.

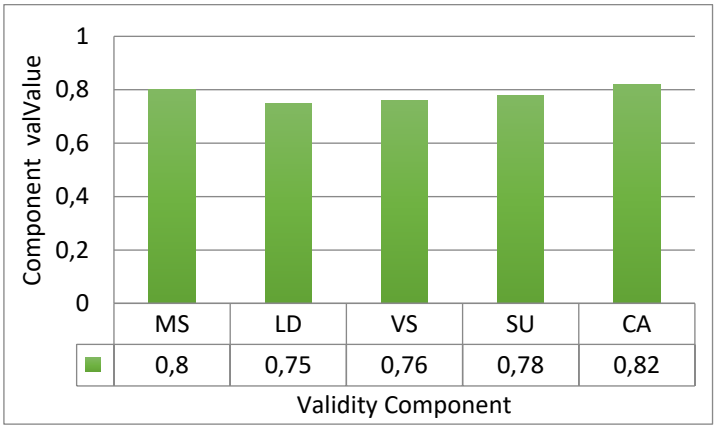

Figure4. Validity Test Results

Based on the data analysis in Figure 4, the validation of digital materials results for teaching based on five validity components can be explained. The five components, namely material substance, visual communication display, learning design, software utilization, and CTL assessment, are in the valid category with the Aiken's V value range of 0.75 to 0.82. The material substance component indicators consist of 1) truth, 2) material coverage, 3) correctness, and 4) readability. Indicators of the visual communication component consist of 1) navigation, 2) font, 3) media, 4) color, 5) animation, and 6) layout. Indicators on the learning design component consist of 1) title, 2) KI and KD, 3) objectives of learning, 4) material, 5) sample questions, 6) exercises, 7) worksheets, 8) compilers, and 9) references. Indicators on the software

utilization component consist of 1) interactivity, 2) supporting software, and 3) originality. Indicators on the CTL assessment component consist of 1) contextual nature and 2) contextual components. The average result of Aiken's V analysis based on five components is 0.8 with a valid category. This shows that the validity of digital materials for teaching for light waves with AR integrated with the CTL model is in the valid category and is suitable for use in learning.

The next research result is design. The product developed is a digital teaching material for light waves with AR integrated with the CTL model to improve students' 4C skills. Digital materials for teaching are designed using Unity and Blender software. Digital materials for teaching are designed based on the structure of written materials for teaching. The following are the design of digital materials for teaching results, which shown in Figure 5.

(a) (b)

Figure 5. (a) Cover design, (b) Main Menu Design

Based on Figure 5, the design of this digital teaching material consists of a cover and main menu. The cover of the digital teaching material contains the title of the digital teaching material, the compiler of the digital teaching material, and the class to be studied, namely, grade 11 high school. On the cover, there is also a play button to start selecting material to be studied and a red menu exit button in the right corner of the cover. The main menu contains a menu to display materials, videos, worksheets, exercises, and animations in the shape of an AR camera. The material section contains the identity of materials for teaching, basic competencies, objectives of learning, material descriptions in similar with the CTL model, sample questions, summaries, and reference sources. In the worksheet section, there are student worksheets and student experiment links that use Phet simulation software. The video and AR camera section is an interactive section because students can interact directly by watching learning videos or seeing 3D animations generated from AR technology by scanning the AR camera section.

To produce quality digital materials for teaching, the validator provides some suggestions and input for improving digital materials for teaching. There are several suggestions from validators that are used as an initial step in improving digital materials for teaching. First, the writing on digital materials for teaching is still small, and the screen cannot be enlarged. The suggestion is to enlarge the content display screen and adjust the background balance. Second, the exercise questions have no discussion. The suggestion is to add a discussion to each exercise questions. Third, the picture has no description or source. The suggestion is to add a description and source of each image. Fourth, the evaluation questions are not yet in similar with the indicators and objectives of learning. The suggestion is to modify the evaluation questions in similar to the indicators and learning objectives. Fifth, the buttons on digital materials for teaching are not varied. The suggestion is to add navigation buttons such as menu, back, next and exit.

Improvements to digital materials for teaching are made according to validator suggestions and input. The first improvement made was to enlarge the font of the writing and minimize the background image. Second, adding discussion to the exercise. Third, adding captions and sources to the images. Fourth, adjusting evaluation questions with indicators and objectives of learning. Fifth, adding buttons to exit, enter, and return to the previous page on digital materials for teaching. The improvements that have been made aim to produce valid digital materials for teaching.

Practicality Test Results

After the research results have been validated, the student practicality test is conducted to reveal the practicality of the product that has been developed. The practicality instrument used has assessment components that include benefits (BF), ease of use (EU), attractiveness of presentation (AP), clarity (CL), CTL integration (CI), and software use (SU). The each component practicality analysis is show in Figure 6.

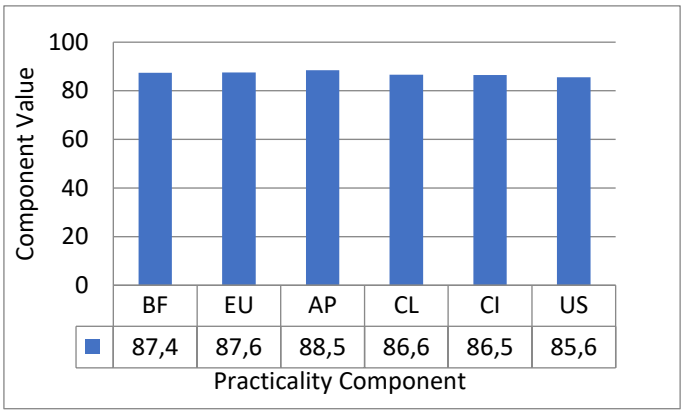

Figure 6. Practicality Test Results

Figure 6 shown that the value of each component of practicality distributed by 32 students of class XI SMAN 8 Padang is in the category was very good in the range of values 85.6 to 87.6. The useful component indicator is worth 87.4 in the category was very good. The easy-to-use component indicator is worth 87.6 in the category was very good. The indicator of the attractiveness component is worth 88.5 in the category was very good. The clarity component indicator is worth 86.6 in the category was very good. The CTL integration component indicator is worth 86.5 in the category was very good. The indicator of the software use component is worth 85.6 in the category was very good. Thus, the digital materials for teaching developed can be useful, easy to use by users, interesting, clear, and digital materials for teaching integrated with the AR and CTL models.

Discussion

The first needs analysis results show that there are problems with learning. These problems include Physics materials for teachings at school have not utilized technology, and materials for teaching have not been integrated with the model. This results in the objectives of learning of 21st-century education not being achieved properly. Some problems indicate that there is a need for new solutions and innovations to support learning. In similar with the research result that proves that we are entering a new era, the process of learning in schools requires new innovations to support the process of learning. One of them is developing electronic or digital materials (Putri & Asrizal*, 2023; Woessner et al., 2021). By using digital materials for teaching, students and teachers can save time in implementing learning, save costs, reduce the use of paper, and master technology according to the demands of 21st century education (Laili et al., 2019; Rindaryati, 2021).

The second needs analysis results showed that students' 4C skills were still low, as seen from a series of tests and work performances. This is due to teachers who still dominate the learning process so that students lack thinking activities and interaction between fellow students (Mahdalena & Daulay, 2020; Williams et al., 2009). The third needs analysis results are related to student characteristics. Student characteristics can affect student learning outcomes later. By knowing student characteristics, teachers can choose the right learning resources, the right learning mode, and organize the class to make learning more (Deslauriers, L., Schelew, E., & Wieman, 2019; Sumarsono & Firanti, 2021). The analysis results are one of the reasons for the importance of developing digital materials for teaching with Augmented Reality integrated with the CTL model.

The fourth analysis results show that the activities of learning designed by teachers are not in similar with the guidance of the 2013 curriculum. The activities of learning analyzed consisted of three categories: opening activities, core activities, and activities for closing. In the core activities, it has not been possible to have the right model that can involve students' activities in learning. This can result in more monotonous and boring learning. In the closing activity, it has not described the activity of taking advantage of the material that has been learned. Activities of learning need to be well designed so that educational goals can be achieved. Involving student activities directly can provide learning experiences for students (Darmaji et al., 2022; Heirdsfield et al., 2007). One solution that can provide student learning experiences is the existence of learning resources such as this research, which is to develop products in the shape of digital materials for teaching for light waves with AR integrated with the CTL model in the shape of applications that can be accessed via smartphones.

The results further show that digital materials for teaching with AR integrated with CTL models are declared valid and practical for improving students' 4C skills. These results are in similar with research

conducted by previous researcher stated that digital materials for teaching can improve students' 4C skills (Agusti, 2022; Marsa & Desnita, 2020; Virijai et al., 2022). Digital materials for teaching are designed to be more interesting and interactive by adding videos, animations, AR camera technology, experiment using phEt simulation, and integrating CTL models that can help the process of learning achieve objectives of learning according to 21st century guidance. The materials of teaching developed have advantages, namely: they can visualize learning material through videos, realize the abstraction of physics concepts in the shape of images, and can be used for self-research (Khunaeni, L. N., Yuniarti, W. D., & Khalif, 2020; Sinaga, 2020).

This research is focused on developing a product, namely light wave digital materials for physics teaching. Digital materials for teaching made using Augmented Reality technology and integrating CTL learning models to improve students' 4C skills are the findings of this research. Light wave material is very suitable if studied with AR because it can display material in 3D so that it looks more real. Materials for teaching in digital form provide encouragement to students to explore, expand, and explain learning materials to develop their critical thinking, creative, communication, and collaborative skills. The research implication results is that teachers must provide learning motivation, guide, and direct students in constructing or building student skills through digital materials for teaching with AR and integrating CTL learning models. The development of digital materials for teaching is limited by materials for teaching developed using ICT in learning, limited to class XI light wave material, and this research is limited by using Unity and Blender software in designing digital materials for teaching. The solution to this limitation is that future researchers are expected to create digital teaching materials for all materials in class XI SMA and using more software to design teaching materials.

4. CONCLUSION

Based on the research and discussion results, three conclusions were drawn. First, the needs analysis results obtained as a guideline for developing digital materials for teaching show that there are problems in learning related to the use of technology, students' 4C skills are still low, and existing materials for teaching at school have not been integrated with the model. Second, the validity of digital materials for teaching for light waves with AR integrated with the CTL model is in the valid category. Valid digital materials for teaching mean that the digital materials for teaching have been tested by experts and can continue to the practicality test stage for students. Third, the practicality value of using digital materials for teaching for light waves with AR integrated with the CTL model is in the very practical category. Practical digital materials for teaching are materials for teaching that have benefits and provide convenience to students in their use. The research implication results is that through digital materials for teaching with AR integrated with the CTL model, teachers are expected to motivate, guide, and direct students in building their 4C skills. Further researchers hope to develop digital teaching materials with AR and CTL based on all physics learning materials so as to produce complete digital teaching materials and in the future digital teaching materials with AR and CTL can be widely tested and reach the use trial stage so that the coverage and quality of digital teaching materials are better.

5. REFERENCES

Agusti. (2022). Analisis Kebutuhan Modul fisika berbasis Contextual Taching and Learning (CTL) untuk Meningkatkan Kemampuan Berpikir Kritis Siswa. *In Prosiding Seminar Pendidikan Fisika FITK UNSIQ*, *3*(1), 54–61. https://ojs.unsiq.ac.id/index.php/semnaspf/article/view/4460.

Anggreni, Y. D., & Yohandri, Y. (2022). Pengembangan E-book Berbasis Discovery Learning Terintegrasi Keterampilan 4C Untuk Pembelajaran Fisika SMA. *Jurnal Eksakta Pendidikan (Jep)*, *6*(2), 117–127. https://doi.org/10.24036/jep/vol6-iss2/695.

Arikunto. (1998). *Prosedur Penelitian*. Rinneka Cipta.

Asrizal, A., & Utami, A. W. (2021). Effectiveness of Mechanical Wave Learning Material Based on ICT Integrated CTL to Improve Students Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *7*(4), 632–641. https://doi.org/10.29303/jppipa.v7i4.837.

Asrizal, A., Zan, A. M., Mardian, V., & Festiyed, F. (2022). The Impact of Static Fluid E-Module by Integrating STEM on Learning Outcomes of Students. *Journal of Education Technology*, *6*(1), 110–118. https://doi.org/10.23887/jet.v6i1.42458.

Asrizal, Amran, A., Ananda, A., Festiyed, F., & Sumarmin, R. (2018). The development of integrated science instructional materials to improve students' digital literacy in scientific approach. *Jurnal Pendidikan IPA Indonesia*, *7*(4), 442–450. https://doi.org/10.15294/jpii.v7i4.13613.

Astiti. (2019). Pengembangan Bahan Ajar Fisika SMA Berbasis Kontekstual Pada Materi Suhu dan Kalor. *Jurnal Pembelajaran Sains*, *3*(1), 29–34. https://doi.org/10.17977/um033v3i1p29-%2034.

Avania, W. F., & Sholikhah, N. (2021). Pengembangan Media Pembelajaran Audio Visual Dengan Pendekatan Contextual Teaching Learning (CTL) untuk Meningkatkan Motivasi Belajar Siswa. *Edukatif : Jurnal Ilmu Pendidikan*, *3*(5), 2531–2538. https://doi.org/10.31004/edukatif.v3i5.885.

Azwar. (2015). *Penyusunan Skala Psikologi*. Pustaka Belajar.

Darmaji, D., Kurniawan, D. A., Astalini, A., & Sukarni, W. (2022). Description of Student Responses Toward Implementation of Discovery Learning Model in Physics Learning. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *12*(1), 1–10. https://doi.org/10.30998/formatif.v12i1.8168.

Deslauriers, L., Schelew, E., & Wieman, C. (2019). Improved Learning in a Large-Enrollment Physics Class. *Science*, *332*(6031), 862–864. https://doi.org/10.1126/science.1201783.

Hanik, N. R., Harsono, S., & Nugroho, A. A. (2018). Penerapan Pendekatan Contextual Teaching and Learning dengan Metode Observasi untuk Meningkatkan Hasil Belajar pada Matakuliah Ekologi Dasar. *Jurnal Pendidikan Matematika Dan IPA*, *9*(2), 127–138. https://doi.org/10.26418/jpmipa.v9i2.26772.

Heirdsfield, A., Davis, J., Lennox, S., Walker, S., & Zhang, W. (2007). Online learning environments: What early childhood teacher education students say. *Journal of Early Childhood Teacher Education*, *28*(2), 115–126. https://doi.org/10.1080/10901020701366699.

Hershey. (2019). Multicultural Instructional Design: Concepts, Metodologies, Tools, and Aplications. United State of America. *IGI Global*.

Khunaeni, L. N., Yuniarti, W. D., & Khalif, M. A. (2020). Pengembangan modul fisika berbantuan teknologi augmented reality pada materi gelombang bunyi untuk SMA/MA kelas XI. *Physics Education Research Journal*, *2*(2), 83–94. https://doi.org/10.21580/perj.2020.2.2.6144.

Kodri, K., & Anisah, A. (2020). Analisis Keterampilan Metakognitif Siswa Sekolah Menengah Atas dalam Pembelajaran Ekonomi Abad 21 di Indonesia. *Edunomic Jurnal Pendidikan Ekonomi*, *8*(1), 9. https://doi.org/10.33603/ejpe.v8i1.2815.

Laili, I., Ganefri, & Usmeldi. (2019). Efektivitas Pengembangan E-Modul Project Based Learning Pada Mata Pelajaran Instalasi. *Jurnal Imiah Pendidikan Dan Pembelajaran*, *3*(3), 306–315. https://doi.org/10.23887/jipp.v3i3.21840.

Lutfi Novitasari, A. (2019). Aplikasi Pengenalan Senjata Tradisional Indonesia Menggunakan Augmented Reality Berbasis Android. *JATI (Jurnal Mahasiswa Teknik Informatika)*, *3*(2), 23–29. https://doi.org/10.36040/jati.v3i2.850.

Mahdalena, M., & Daulay, M. I. (2020). Pengembangan Pembelajaran Fisika Berbasis Saintifik Untuk Meningkatkan Kemampuan Berpikir Kritis Dan Komunikasi Verbal Siswa Sma. *Journal on Teacher Education*, *2*(1), 39–48. https://doi.org/10.31004/jote.v2i1.903.

Majid, S. N. A., & Salam, A. R. (2021). A Systematic Review of Augmented Reality Applications in Language Learning. *International Journal of Emerging Technologies in Learning*, *16*(10). https://doi.org/10.3991/ijet.v16i10.17273.

Marsa, P. B., & Desnita, D. (2020). Analisis Media, Sumber Belajar, dan Bahan Ajar Yang Digunakan Guru Fisika SMA Materi Gelombang Di Sumatera Barat Ditinjau Dari Kebutuhan Belajar Abad 21. *Jurnal Eksakta Pendidikan (Jep)*, *4*(1), 81. https://doi.org/10.24036/jep/vol4-iss1/422.

Mu'minah, I. H., & Suryaningsih, Y.-. (2020). Implementasi Steam (Science, Technology, Engineering, Art and Mathematics) Dalam Pembelajaran Abad 21. *BIO EDUCATIO : (The Journal of Science and Biology Education)*, *5*(1), 65–73. https://doi.org/10.31949/be.v5i1.2105.

Nurhasnah, & Sari, L. A. (2020). E-Modul Fisika Berbasis Contextual Teaching And Learning Menggunakan Aplikasi Kvisoft Flipbook Maker Untuk Meningkatkan Literasi Sains Peserta Didik SMA/MA Kelas XI. *NATURAL SCIENCE: Jurnal Penelitian Bidang IPA Dan Pendidikan IPA*, *6*(1), 29–40. https://ejournal.uinib.ac.id/jurnal/index.php/naturalscience/article/view/1554.

Pradana, R. W. (2020). Penggunaan Augmented Reality Pada Sekolah Menengah Atas Di Indonesia. *Jurnal Teknologi Pendidikan : Jurnal Penelitian Dan Pengembangan Pembelajaran*, *5*(1), 97. https://doi.org/10.33394/jtp.v5i1.2857.

Purwani, E., Hasan, K., & Alamsyah, H. (2021). *Peningkatan Hasil Belajar dengan Menggunakan Model Problem Based Learning Pendekatan SSTEAM Pada Siswa*. *3*(3), 296–302. https://doi.org/10.26858/tpj.v2i3.26764.

Putri, R. M., & Asrizal*, A. (2023). Need Analysis of Developing Digital Teaching Materials to Improve 21st Century Skills. *Jurnal IPA & Pembelajaran IPA*, *7*(2), 108–117. https://doi.org/10.24815/jipi.v7i2.29797.

Rahman. (2020). Penerapan Model Pembelajaran Contextual Teaching And Learning (CTL) Dan Media Video Dalam Meningkatkan Hasil Belajar IPA Pada Siswa Sekolah Dasar (SD). *Jurnal Mitra Swara Ganesha*, *7*(2), 21–36. http://www.ejournal.utp.ac.id/index.php/JMSG/article/view/1014.

Ridho, M. H., Wati, M., Misbah, M., & Mahtari, S. (2020). Validitas Bahan Ajar Gerak Melingkar Berbasis Authentic Learning Di Lingkungan Lahan Basah Untuk Melatih Keterampilan Pemecahan Masalah.

Journal of Teaching and Learning Physics, *5*(2), 87–98. https://doi.org/10.15575/jotalp.v5i2.8453.

Rindaryati, N. (2021). E-Modul Counter Berbasis Flip Pdf pada Mata Pelajaran Penerapan Rangkaian Elektronika. *Jurnal Imiah Pendidikan Dan Pembelajaran*, *5*(2), 192. https://doi.org/10.23887/jipp.v5i2.31240.

Ropawandi, D., Halim, L., & Husnin, H. (2022). Augmented Reality (AR) Technology-Based Learning: The Effect on Physics Learning during the COVID-19 Pandemic. *International Journal of Information and Education Technology*, *12*(2). https://doi.org/10.18178/ijiet.2022.12.2.1596.

Rusdin, N. M. (2018). Teachers' Readiness in Implementing 21st Century Learning. *International Journal of Academic Research in Business and Social Sciences*, *8*(4). https://doi.org/10.6007/ijarbss/v8-i4/4270.

Rusman. (2019). *Model-model Pembelajaran (Mengembangkan Profesionalisme Guru Edisi Kedua)*. Raja Grafindo Persada.

Sanjaya, W. (2013). *Penelitian Pendidikan, Jenis, Metode dan Prosedur*. Kencana Prenada Media Group.

Sinaga, P. (2020). Bahan Ajar Fisika untuk Pembelajaran Daring di Masa Pandemi. *Prosiding Nasional Seminar Fisika 6.0*, *3*, 3. http://proceedings2.upi.edu/index.php/sinafi/article/view/1235.

Sriwahyuni, I., Risdianto, E., & Johan, H. (2019). Pengembangan Bahan Ajar Elektronik Menggunakan Flip Pdf Professional Pada Materi Alat-Alat Optik Di SMA. *Jurnal Kumparan Fisika*, *2*(3), 145–152. https://doi.org/10.33369/jkf.2.3.145-152v.

Sugiyono. (2012). *Metode Penelitian Kuantitatif dan Kualitatif dan R&D*. Alfabeta.

Sulistyaningrum, H., Winata, A., & Cacik, S. (2019). Analisis Kemampuan Awal 21st Century Skills Mahasiswa Calon Guru SD. *Jurnal Pendidikan Dasar Nusantara*, *5*(1), 142. https://doi.org/10.29407/jpdn.v5i1.13068.

Sumarsono, S., & Firanti, A. (2021). Identification of Informatics Engineering Student Learning Styles in the Independent Learning Era. *Jurnal Pendidikan Dan Pengajaran*, *54*(2), 306. https://doi.org/10.23887/jpp.v54i2.28672.

Urip Umayah, & Riwanto, M. A. (2020). Transformasi Sekolah Dasar Abad 21 New Digital Literacy untuk Membangun Karakter Siswa Di Era Global. *JURNAL PANCAR (Pendidik Anak Cerdas Dan Pintar)*, *4*(1), 1--10. https://www.ejournal.unugha.ac.id/index.php/pancar/article/view/308.

Virijai, F., Asrizal, A., & Festiyed, F. (2022). Meta Analisis Pengaruh Bahan Ajar Terhadap Kemampuan Berpikir Kritis Siswa Dalam Menghadapi Era Revolusi 4.0. *Jurnal Penelitian Pembelajaran Fisika*, *8*(1), 54. https://doi.org/10.24036/jppf.v8i1.115806.

Williams, M. K., Foulger, T. S., & Wetzel, K. (2009). Preparing Preservice Teachers for 21st Century Classrooms: Transforming Attitudes and Behaviors About Innovative Technology. *Journal of Technology and Teacher Education*, *17*(3), 393–418. https://www.learntechlib.org/primary/p/28216.

Winatha, K. R., Naswan, S., & Ketut, A. (2018). Pengembangan E-modul Interaktif Berbasis Proyek Pada Mata Pelajaran Simulasi Digital Kelas X di SMK TI Bali Global Singaraja. *Jurnal Teknologi Pembelajaran Indonesia*, *8*(1). https://doi.org/10.23887/jtpi.v8i1.2238.

Woessner, M. N., Tacey, A., Levinger-Limor, A., Parker, A. G., Levinger, P., & Levinger, I. (2021). The Evolution of Technology and Physical Inactivity: The Good, the Bad, and the Way Forward. *Frontiers in Public Health*, *9*, 655491. https://doi.org/10.3389/fpubh.2021.655491.

Yudiana, I. K. (2020). Effectiveness of Value Clarification Technique (VCT) in Learning History to Increase the Value Nationalism, Democracy, and Multiculturalism. *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal*, *3*(1), 552–563. https://doi.org/10.33258/birle.v3i1.851.

Yulaika, N. F., Harti, H., & Sakti, N. C. (2020). Pengembangan Bahan Ajar Elektronik Berbasis Flip Book Untuk Meningkatkan Hasil Belajar Peserta Didik. *JPEKA: Jurnal Pendidikan Ekonomi, Manajemen Dan Keuangan*, *4*(1), 67–76. https://doi.org/10.26740/jpeka.v4n1.p67-76.

Yusliani, E., Burhan, H. L., & Nafsih, N. Z. (2019). Analisis integrasi keterampilan abad Ke-21 dalam sajian buku teks fisika SMA Kelas XII Semester 1. *Jurnal Eksakta Pendidikan (JEP)*, *3*(2), 184–191. https://doi.org/10.24036/jep/vol3-iss2/392.