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Evaluating ICT literacy: Physics ICT test based on Scratch Programming for high school students

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ABSTRACT

The integration of various learning content is important in the education process to develop the multi-competences of graduates. This is a response to the Industrial Revolution 4.0. ICT helps graduates compete and master the competencies needed in various scientific fields, especially physics. Efforts to build ICT literacy in learning Physics must complete an evaluation tool containing comprehensive Physics content. The ICT literacy test instrument as an evaluation tool can be packaged with scratch programming activities to help uncover ICT literacy based on computational physics concepts. This study aims to develop an ICT literacy test instrument with physics content based on Scratch programming for middle-level students. This research is development research with a research stage adapted from the development stage by Borg and Gall, including (1) Potential and problem analysis; (2) Data collection; (3) Product design; (4) Design validation and design revision; (5) Product trial; (6) Analysis and reporting. The test subjects were 106 students. The Physics ICT questions were developed to consist of 20 questions. Based on the validity test, a total percentage of 85.33% is obtained with proper criteria. The reliability of the test is shown by the results of calculations with Alpha Cron of 0.716 high categories. Overall, the PICT test is feasible to be used as an ICT literacy test for Physics content.

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INTRODUCTION

The current rapid development of technology has an impact on the demands of change in various countries, including Indonesia (Hidayatno et al., 2019; Li et al., 2019). This change affects the education paradigm significantly (Martinez, 2018; Raja & Nagasubramani, 2018). The production of various technology-based equipment, especially digital technology, as an impact of the industrial revolution 4.0 is one of the factors that directly change the technical orientation of education process (Bonfield et al., 2020; Muktiarni et al., 2019). Some educational activities, especially in the learning process that previously required complex instruments and materials, can now be reduced to a virtual activity packaged in state-of-the-art technology (Rusilowati et al., 2020).

Science learning in general and physics learning, in particular, is one of the fields that gets the impact of technological developments (Gero et al., 2019; Sari & Wilujeng, 2020). The rapidity of information from various sources that can be accessed easily and quickly provides easy access to learning materials by students (Costa et al., 2021). For example, students no longer need to search for physics content from the basic theory level to formulas through printed books which usually take longer (Baron, 2017; Hilton, 2020). In line with this, the importance of awareness and strategies for using technology is needed by students so that the use of technology is effective in helping learning Physics (Hendawi & Nosair, 2020).

Currently, the concept of ICT (Information and Communication Technologies) literacy is a benchmark for the extent to which students use and master technology. ICT literacy is the basic skill needed to manage digital information and communication skills based on technology to be able to solve problems effectively (Ciptaningrum et al., 2021; Kim et al., 2019). Based on this definition, ICT literacy is currently an important core skill, such as in the United States, Great Britain, and Japan, which have implemented curricula for computing, computer science, and informatics. In addition, these countries carry out various studies on the types of content to be studied, teaching methods, and assessments to support the curriculum in general and the physics curriculum in particular (Computer Science Teachers Association, 2017).

The integration between mastery of physics content and ICT literacy is also one of the special features of the new paradigm of physics learning (Lestari & Prasetyo, 2019; Sulisworo et al., 2017). Assignment of material to solving problems related to physics can be done using a computational approach which is part of ICT-based learning (Rusilowati et al., 2020; Sunarti & Rusilowati, 2020). This integration occurs to the level of the way of thinking, namely the computational and scientific way of thinking which is the procedure for uncovering physical phenomena as a whole and comprehensively (Akmam & Anshari, 2018; Gero et al., 2019; Lopez & Hernandez, 2015).

The close relationship between ICT literacy and mastery of physics content is a breakthrough in physics learning. Alternative skills needed to master physics content such as critical and creative thinking skills today are ICT literacy. These skills have a cross-section of aspects, although they are not fully representative, ICT literacy can be a sufficient alternative orientation. The Evaluate and Create aspects are part of ICT literacy based on the Educational Testing Service (ETS) and are aspects that can represent the needs of critical and creative thinking skills (Ross et al., 2019; Senkbeil, 2022).

The interaction between ICT literacy and mastery of physics concepts then directs researchers to the issue of how to measure ICT literacy which at the same time measures mastery of physics concepts. This integration is not in the context of reducing evaluation details but as an effort to present the relevance of physics learning to the current needs of ICT acceleration (Dewi & Rusilowati, 2019; Mwambela et al., 2019; Owate & Williams, 2014). Today, computer programming is an important part of ICT literacy. Computer programming is one part of ICT currently widely used in learning that is closely related to Mathematics and Science (Lopez & Hernandez, 2015; Rusilowati et al., 2020). Furthermore, physics learning can be packaged with ICT content, namely programming so that an ICT-based evaluation tool approach allows it to be used.

In line with the relevance of ICT to physics learning, the physics learning evaluation instrument may be packaged together with physics content-based ICT problems and activities. This is to integrate ICT into physics learning without separating the two into unrelated segments. This integration is on the one hand a debate, where there is an assumption that there is a bias in the conception of physics or ICT skills measured through evaluation tools. One item of evaluation tool is influenced by two things that are considered independent, namely ICT skills and mastery of physics concepts (Ellermeijer & Tran, 2019; Yehya et al., 2018). The other side shows things that are far different from the previous view. In the process, ICT-based physics learning will produce good outputs because the two have a close relationship and in its application will have a tendency to increase the efficiency of multiple learning outcomes. Good ICT literacy will provide more potential for students to master physics concepts and vice versa, so that the assumption of independence of these two things can be reduced or even eliminated along with the dependence of today's learning on the concept of ICT (Ellermeijer & Tran, 2019; Yehya et al., 2018).

Physics reveals natural phenomena with a mathematical approach. The mathematical approach can technically be packaged in computing-based ICT. Computing, which is part of ICT, has a relationship with mathematics and science in terms of the flow of problem-solving, namely in the form of algorithmic activities (Gretter & Yadav, 2016; Negoro et al., 2020). Scratch as a programming platform shows this relationship, one of which is in making motion simulations, mathematical and physical relationships in the concept of motion are realized in programming algorithms (Computer Science Teachers Association, 2017; Gretter & Yadav, 2016; Lopez & Hernandez, 2015; Rusilowati et al., 2020). Scratch offers a wide variety of creations (animation and narration, presentations, interactive images, simulations, games, etc.) and has generated a large community of users around it, from children to adults all over the world (Lopez & Hernandez, 2015). Unlike advanced programming languages, Scratch is based on building block-based programming puzzles, more like a simple jigsaw puzzle. Thus, even though the learning process is through computational programming, Mathematics and Physics content is not ruled out (Rusilowati et al., 2020). Based on this, ICT literacy can be revealed from references to computer programming activities, one of which is the Scratch platform.

Many pieces of research on the development of ICT literacy evaluation instruments have been carried out. Most ICT instruments are compiled in the form of questionnaires, such as the SABER-ICT questionnaire that is compiled by Taquez et al. (2017) and UICT-TER developed by Guillén-Gámez and Mayorga-Fernández (2021). The other side shows that the instrument test in the form of a questionnaire tends to have a low cognitive level. Efforts to uncover ICT literacy at a high cognitive level need to involve the domains of literacy, numeracy, and ICT which are integrated in such a way (Falck et al., 2021). This domain is covered by the analysis of physical phenomena through programming that involves scientific literacy, numerical activities based on mathematical models, and the use of ICT.

Opportunities to uncover aspects of ICT literacy with physics content through programming activities are tried to be utilized by researchers. The test instrument allows it to be arranged by looking at how students overcome physics problems through computer programming. Currently, many studies have begun to reveal ICT literacy in physics learning as has been done (Temaugee et al., 2021; Sunday et al., 2019) by developing instruments to measure ICT with physics learning orientation. Unfortunately, most of the instruments that are made do not fully package physics content at the cognitive level, but only in the form of a questionnaire or questionnaire that reveals whether or not learning activities using ICT has been implemented. In addition, computer programming that allows packasging of cognitive activities referred to above is still rarely found as a basis for developing ICT instruments.

Based on the issues that arise as mentioned above, through this research, the researchers developed an ICT literacy instrument for students with Physics content based on computer programming, namely Scratch. Computer programming with Scratch can be structured in such a way without the need for mastery of programming languages because the preparation of the algorithm uses command blocks so that it can reduce cognitive measurement bias, namely mastery of physics content due to low skills in compiling programming language instructions textually.

METHOD

This research is categorized as educational development research or commonly abbreviated as R&D (Educational Research and Development). This type of research (R&D) is a process for developing and validating a product (Sugiyono, 2010). The product developed is the Physics Information and Communication Technologies (PICT) test for middle-level students. The development of the PICT test consists of six stages adapted from 10 stages from the Borg and Gall R&D stages as shown in Figure 1 (Negoro et al., 2020).

At the beginning of the activity, an analysis of the potential problems related to the need for an ICT-based physics learning evaluation tool was carried out. The data obtained were analyzed and used as a reference for designing the PICT test as a research product. The PICT test is used to analyze and evaluate the mastery of the physics concept of wave matter. The PICT test is a multiple-choice test containing wave content with three segmentations, namely simple harmonic motion segments, traveling waves, and stationary waves. The items developed in the PICT test are 21 items with five multiple choices as options that have a distractor as an effort to reduce the consistency of the truth of how to answer randomly (without analysis).

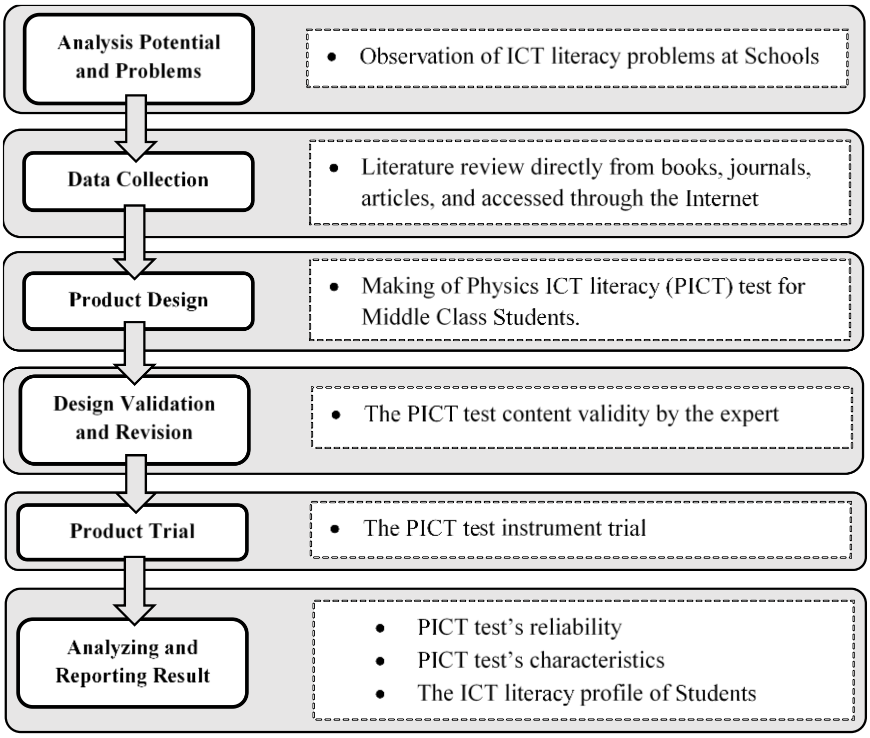

Figure 1. Step of Physics ICT test Production

Before being tested, the feasibility of the test instrument is tested by conducting a feasibility assessment through expert judgment. Feasibility test by expert judgment through filling out a questionnaire. This feasibility assessment is to determine the validity of the content in terms of the material aspect, the completeness of the content, the suitability of the test items to aspects, the strength of the instrument to reveal the mastery of the wave concept. The results of the feasibility test through expert judgment were analyzed using Formula (1) (Negoro et al., 2020), where P = rating percentage, f = score earned, and N = overall score. The explanation of the criteria is presented in Table 1.

$$P = \frac{f}{N} x\ 100\% , \qquad \text{.............................} \ (1)$$

Table 1. Eligibility Criteria

Percentage	Interpretation
85% < value ≤ 100%	Very Feasible
70% < value ≤ 85 %	Feasible
50% < value ≤ 70 %	Feasible Enough
1 % < value ≤ 50 %	Not Feasible

In this study, field trials were conducted at SMA Kesatrian 2 Semarang and SMA Teuku Umar Semarang to 106 students. The trial was carried out to obtain test results as instrument analysis material in the form of characteristics, namely the level of difficulty, discriminating power of questions for each PICT test item, and profile of students' wave concept mastery.

The analysis of the research results was carried out by using the reliability test which was carried out by using the Cronbach Alpha formula. Then the concept mastery profile is described descriptively so that the field description is more explained in addition to the degree of concept mastery.

FINDINGS AND DISCUSSION

PICT Test is a product resulting from this research. This test instrument is useful as a tool to measure ICT skills as well as to measure the mastery of the concept of middle level students through scratch programming. An overview of the achievements of these two aspects will be presented in the profile. Currently, there are still many problems regarding the acceleration of mastery of physics concepts through the use of technology in which students have not been able to effectively utilize the existence of technology to understand physical phenomena. One thing that is a problem is ICT skills that students do not have. The need for ICT skills test instruments to be a reference for improving education, especially physics learning is increasing. PICT test with the function of revealing ICT skills as well as revealing a mastery of physics concepts can be a choice for teachers to be used as a reference for strategic improvement of teaching quality.

Analysis Potentials and Problems

Potentials and problems based on needs analysis, that is, it is still rare for test instruments to reveal ICT skills based on physics content. In addition, the improvisation of physics learning which is currently needed due to the Industrial revolution 4.0 requires ICT skills to be possessed by every human being from various fields even though at different levels. Furthermore, the concept of multi-competence becomes a reference for current education, which when students graduate, they will be faced with a competitive world of work that demands a variety of skills.

Data Collection

Information obtained from literature is read directly from books, journals, articles, and accessed via the Internet. Information was extracted through discussions with expert practitioners. Based on the results of information gathering, the components that need to be developed in the PICT test instrument include aspects of the test relevant, rational, and consistent in revealing ICT skills. Relevant tests, namely the physics content raised have a relationship with real-life so students' analysis is relevant to their lives. The rational test means that the test has the power to reveal each component of ICT skills with a good logical comparison to translate. Meanwhile, a consistent test reveals every aspect of thinking skills in a focused manner to minimize bias.

Product Design

Based on the analysis of potentials, problems, and sources of informants, a PICT test instrument was developed which is used to analyze and evaluate ICT skills and get an overview of the profile of students' mastery of physics concepts. The PICT test is in the form of a multiple-choice test consisting of 21 items. Each question includes several objective items. The PICT test is specifically used for wave learning with Scratch programming. The use of the scratch program to reveal the components of ICT skills based on mastery of computational physics concepts.

The PICT test is prepared by adapting the components described by the Educational Testing Service (ETS), namely Define, Access, Manage, Integrate, Evaluate, and Create. ETS formulates the main components of ICT literacy which can be seen in Table 2.

Table 2. Aspects of Information and Communication Technology (ICT) Literacy

Aspect	Definition
Define	Use digital tools to identify and represent information needs
Access	Collecting and/or retrieving information in a digital environment
Manage	Using digital tools to apply existing organizational or classification schemes to information
Integrate	Interpret and represent information, such as by using digital tools to synthesize, summarize, compare, and compare information from various sources
Evaluate	Assess the extent to which digital information meets information needs, including determining the authority, bias, and timeliness of materials
Create	Adapting, implementing, designing, or building information in a digital environment

This component of ICT skills is relevant to ICT skills based on physics content. Physics learning activities are in the form of analyzing physical phenomena which are then written down mathematically to cover the five components of ICT literacy. Scratch programming, which is closely related to mathematical content, becomes a tool in the activity of building students' ICT skills based on physics content.

The PICT test cannot be separated from physics learning activities using Scratch programming because the main elements and content of the ICT literacy items raised in the PICT are computational physics analysis using Scratch. Besides, the wave material was raised because it refers to information that there are still many difficulties experienced by students in mastering the concept of waves. Several studies have shown misconceptions that occur in the conception of physics, especially the wave material, as evidenced by the concept mastery test. Based on the research, there are still many misconceptions about the interpretation of concepts, including misconceptions about the speed of wave propagation, frequency, phase difference, and so on (Kogetsu & Taniguchi, 2014; Barniol & Zavala, 2016; Reyes & Rakkapao, 2018). In addition, the mathematical equations that explain the relationship between concepts are still difficult for middle-level students (Kennedy & de Bruyn, 2011; Somroob & Wattanakasiwich, 2017; Zaleha, 2017; Auli et al., 2018).

The PICT test tries to reveal ICT literacy through physics content which includes mathematical equations even though it is packaged in a computer programming algorithm. This is another approach so that students' comprehensive understanding of a phenomenon can have physical and mathematical details as well. This description is revealed through items in the form of questions on how mathematical equations can form a wave simulation.

Design Validation and Revision

After the initial product is completed, the next step is to test the content validity by a validator who is an expert. The validator checked the criteria for the test instrument including (a) material aspects, namely the suitability of items with the test objectives and the population of the test-takers, (b) construct aspects, namely the accuracy of the information that is presented in the items, and (c) language aspects, namely the clarity of words/phrases/diagrams respectively. Based on the material feasibility test questionnaire, a total percentage of 85.33% was obtained with appropriate criteria. The results of the feasibility test conducted by three validators are presented in Table 3.

Table 3. Expert Validation Results

Validator	Content (%)	Constructs (%)	Language (%)	Mean (%)
Validator 1	86	85	87	86
Validator 2	84	87	90	87
Validator 3	83	84	82	83
Mean (%)	84.33	85.33	86.33	85.33
Criteria	Very Feasible	Feasible	Very Feasible	Very Feasible

Test Results

The PICT test instrument was tested on 106 middle-level students from SMA Kesatrian 2 Semarang and SMA Teuku Umar Semarang. The activity before the PICT trial was carried out was reviewing the wave material with assistance using scratch programming by researchers and school facilitators. Based on the test results, the results can be described in the form of the characteristics of the test instrument, and the ICT literacy profile of the students.

Characteristics of PICT Test

The aspects of Information and Communication Technologies (ICT) literacy that are targeted to be measured are define, access, manage, integrate, evaluate, and create. This aspect has been clearly described by the Educational Testing Service (ETS). The characteristics of the PICT test are described by means of the average value, standard deviation, discrepancy, and also the level of difficulty of the questions. The reliability of the test is shown by the results of the 106 students' PICT test. The PICT instrument that was tested consisted of 20 item questions. The reliability results show Cronbach's alpha value of 0.571, that is in the high category. The average value, standard deviation, discrepancy, and level of difficulty of the test results are presented in Table 4.

Table 4. Characteristics of PICT test from Trial Results

Item	Mean	Std. Deviation	Discrepancy	Level of Difficulty
1	0.74	0.444	0.56	0.71 a)
2	0.62	0.490	0.43	0.65 b)
3	0.63	0.486	0.44	0.65 b)
4	0.68	0.471	0.53	0.65 b)
5	0.62	0.490	0.52	0.42 b)
6	0.53	0.503	0.55	0.51 b)
7	0.66	0.477	0.56	0.61 b)
8	0.68	0.471	0.66	0.61 b)
9	0.65	0.481	0.63	0.44 b)
10	0.62	0.490	0.52	0.54 b)
11	0.69	0.465	0.55	0.52 b)
12	0.74	0.444	0.66	0.53 b)
13	0.71	0.459	0.65	0.58 b)
14	0.72	0.452	0.64	0.42 b)
15	0.66	0.477	0.67	0.53 b)
16	0.65	0.481	0.61	0.66 b)
17	0.65	0.481	0.68	0.34 b)
18	0.65	0.481	0.67	0.41 b)
19	0.72	0.452	0.75	0.28 c)
20	0.51	0.503	0.76	0.26 c)

a) Easy b) Medium c) Difficult

Based on the test results presented in Table 4, it can be seen that the overall test items have a good tendency based on the average value of discriminating power which is quite good and the level of difficulty is quite good. The power of difference can be said to be good because the range of differentiating power possessed by the PICT test ranges from 0.40 to 0.70, although there are items that exceed this range, namely items 19 and 20, which are worth 0.75 and 0.6 and are classified as very good. As for the level of difficulty, almost all of them are in the range of questions with a moderate level of difficulty except for items 19 and 20 which are classified as items with a high level of difficulty.

Every aspect of ICT literacy can be identified through each PICT test item which is based on computer programming activities with the main content of the wave. One aspect, namely evaluate, for example, has indicators identified by items which contain analysis, namely comparing the simulation design of the scratch programming results with the applicable theory or physical law.

In general, the aspects of accessing, managing, and integrating are described by students' skills in identifying and managing programming needs in the form of computing tools, both software, and hardware, while the evaluate and create aspects are described by students' skills in analyzing physics concepts to be applied in programming. The evaluate and create aspects are indicators of students' mastery of physics concepts.

The components of each aspect are described in the form of activities which are then used as indicators in measuring aspects of ICT literacy. The PICT test segmented the components of each aspect as in Figure 2.

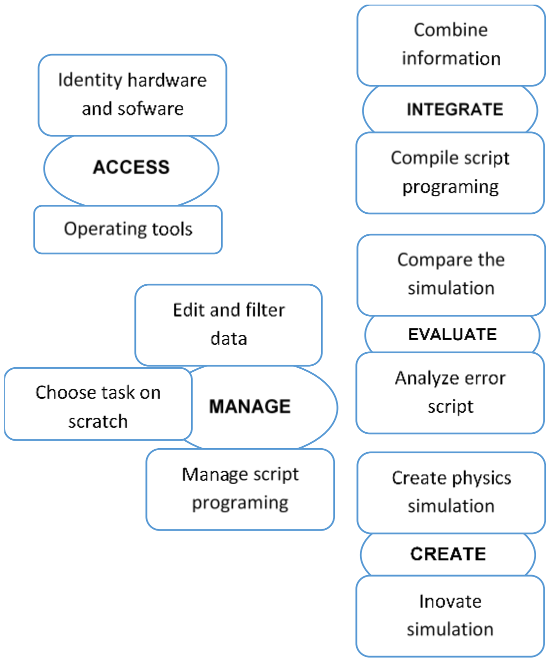

Figure 2. Aspects and Components of ICT Literacy

ICT Literacy Pre-Service Teachers

Programming activities are the focus of analyzing students' ICT literacy. Programming activities have a flow that can accommodate all aspects of ICT literacy, namely access, manage, integrate, evaluate, and create. The dominance of physics content in each activity aims to identify aspects of ICT literacy, students' mastery of physics concepts can also be revealed.

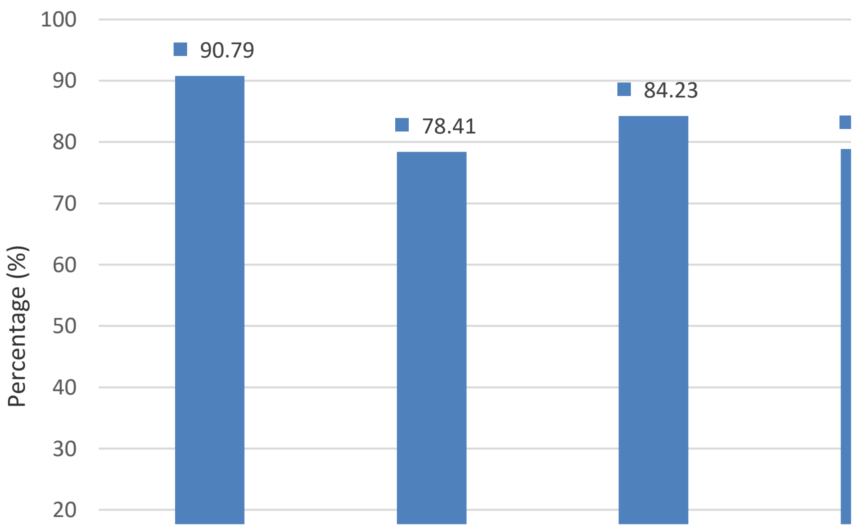

Figure 3. Achievement of Student ICT Literacy

Based on Figure 3, it can be seen that the highest percentage of achievement of ICT literacy skills is in the Access aspect and the lowest percentage of achievement is in the Create aspect. The access aspect is of high value because the use of program access is relatively the same as the use of applications in general so that students can adapt quickly, while the create aspect requires a deepening of mastery of scratch programming in the script processing process. The realization of students' ideas so that they can be used as a complete simulation is constrained by the preparation of a script that is relatively new for students.

Descriptively, it can be explained how mastery of physics concepts can also be revealed in addition to ICT literacy. For example, the PICT test item which reveals the creative aspect with questions and answer choices as shown in Figure 2, reveals the create aspect with indicators of how students build physics simulations from scripts that are in accordance with the formulations, theories, and laws of physics. The physical theory in question is the theory of vibrations and waves related to simple harmonic oscillations.

Today's ICT literacy is very important for learning physics because this skill is relevant to today's developments. The next important thing to note is how to measure students' ICT literacy. A valid test instrument is a must to support the identification of students' ICT literacy needs. Thus, researchers and practitioners need to test the validity and relevance of judgments. Overall data analysis shows that the PICT test is sufficient to test and a good basis for measuring students' ICT literacy with wave material physics content.

The PICT test construction is in the form of computational physics content where physics concepts are tested through a computational approach in the form of programming activities. This is strongly supported by many studies that reveal the close relationship between physics and programming (Ciprian, 2019; Ferrarelli & Iocchi, 2021; Kiv et al., 2019). The PICT test is structured in such a way according to this close relationship to reveal students' ICT literacy based on wave physics content.

Materials experts are engaged during the item development stage to review the depth of each item. Interviews were also conducted. Although this test is relatively easy to administer and allows for random answers by guessing, it still has enough distinguishing power for each item. This is indicated by the difference power index and the level of difficulty of the questions.

Our next hope is that the PICT test can be used as a measuring tool in research related to ICT literacy. The PICT test is also expected to reveal mastery of physics concepts through ICT-based learning. Although it can be acknowledged that the validation procedure described in this study is still in its early stages, we hope that this effort has an approach that can be used as a reference for developing and validating tests of ICT literacy in other science content.

CONCLUSION

Based on the results of research and discussion, it can be concluded that the product developed, namely the Physics ICT Literacy (PICT) test is valid as an ICT literacy instrument. This is shown from the results of the content validity test obtained a total percentage of 85.33% with appropriate criteria. The reliability of the test is shown by the test results of 106 students. The MCT instrument tested for its reliability level consists of 20 objective items. The level of instrument reliability is indicated by the value of Cronbach's alpha which is 0.716 with a high category.

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