

Create multiple-choice tests based on experimental activities to assess students' 21st century skills in heat and heat transfer topic

Sherlin Illene, Selly Feranie, Parsaoran Siahaan

Department of Physics Education, Faculty of Mathematics and Science Education, Indonesia University of Education, Bandung, Indonesia

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ABSTRACT

Currently, we are facing the rapid development of information and communication technology (ICT) that characterizes the 21st century. Challenges, problems, life, and careers in the 21st century can be successfully faced if we master the 21st century skills. However, nowadays it is still very rare to develop a 21st century skill measurement model, so it is necessary to develop test instruments to measure 21st century skills. The development of test instruments to measure 21st century skills in Indonesia is still very open by paying attention to the clarity of the instrument in describing real phenomena and complete data as material for problem solving. Based on the description above, the researchers developed a multiple-choice test based on experimental activities to measure students' 21st century skills which are creativity, critical thinking, collaboration, communication (4Cs) in heat and heat transfer using research and development (R&D) methods with the analyze, design, develop, implement, and evaluate (ADDIE) stage. Development begins with conducting literature and field studies, designing and making videos of experiment activities, compiling open-ended questions, distributing them to 12th graders of science, analyzing answers based on references, developing answer options, developing multiple choice tests, conducting validation by experts, and testing limited to students. The product of this research is expected to be used by educators and students for independent learning activities or as an example to develop multiple choice tests based on experimental activities to measure 21st century skills in other physics materials and other subjects.

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Corresponding Author:

Sherlin Illene

Department of Physics Education, Faculty of Mathematics and Science Education

Indonesia University of Education

Dr. Setiabudhi Road No. 229, Bandung, West Java, Indonesia

Email: sherlin.yasa00@upi.edu

1. INTRODUCTION

Today, we are facing the rapid development of information and communication technology that characterizes the 21st century. Information can be accessed anywhere and anytime by using technology or machines designed to meet all human needs [1]. This condition affects several fields, one of which is the field of education which has the main role to equip students to be able to face challenges in the future, including 21st century learning with skills that are often called 21st century skills [2], [3]. According to Taber [4], 21st century skills include collaborative problem-solving skills, complex problem-solving skills, creativity, and digital information literacy. Challenges, problems, life, and careers in the 21st century can be successfully

faced if we master 21st century skills [5], [6]. Therefore, students need to master learning and innovation skills, information, media, and technology skills, as well as life and career skills to be able to become productive citizens who contribute to solving problems in the 21st century [7]. This research is focused about learning and innovation skills, namely critical thinking and problem-solving skills, creativity and innovation, communication skill, and collaboration skill, which are known as the creativity, critical thinking, collaboration, communication (4Cs) [8], [9].

This is in accordance with the 2013 curriculum which is applied in Indonesia in developing the lives of students, such as religion, art, creativity, communication, values, and various intelligence dimensions that are suitable for students and needed by society, nation, and humanity in a globalized world. Minister of Education and Culture Regulation No. 36 of 2018 [10] states that the purpose of the 2013 curriculum is to prepare Indonesian people to have the ability to live as individuals and citizens who are faithful, productive, creative, innovative, affective and able to contribute to the life of society, nation, state, and world civilization. This is also supported through the four pillars of education presented by Langer [11], namely learning to know, learning to do, learning to live together, and learning to be which are still relevant to current educational interests and can be developed according to the interests of the 21st century. According to a study conducted by Trilling and Fadel [12] there are several skills that are still not possessed by students who graduated from high school and university, such as oral and written communication, critical thinking and finding solutions to a problem, work ethics and professionalism, working in teams and collaborating, working in different groups, using technology, and project management and leadership. So that 21st century skills are also very important to be taught to students, especially in the field of science. Collaborative learning is needed to prepare students to face the 21st century [13]. However, nowadays it is still very rare to develop a 21st century skill measurement model, so it is necessary to develop test instruments to measure 21st century skills. This is as stated by Utari, *et al.* [14] that the development of test instruments to measure 21st century skills in Indonesia is still very open by paying attention to the clarity of the instrument in describing real phenomena and complete data as material for problem solving.

There are three essences of physics, namely physics as a product, process, and attitude whose study focuses on matter and energy so that learning in schools is expected not only to refer to students' cognitive abilities but also to the 21st century skills of students in making decisions to solve problems related to physics [15]. However, according to Kartika *et al.* [16], presenting physics learning in a meaningful way and making the younger generation fascinated and interested in learning it is a very big problem for teachers to face. According to Hafsyah *et al.* [17], physics learning in some schools rarely uses physics concept exploration procedures, laboratory activities, or simulations and models. Laboratory activities are very helpful for students in analyzing the effect of natural phenomena and verifying existing theoretical models by designing and controlling the desired state [18]. A laboratory is a place used to carry out activities consisting of observations, tests, and experiments conducted by students [19], [20]. Subhan & Rahmawati [21] states that in order to provide certainty or corroborate information, determination of cause and effect relationships, show symptoms, verify (concepts, theories, laws, formulas), develop process skills, solve problems using the scientific method, and carry out research can be done in a place called a laboratory.

According to Rahmawati *et al.* [22], experimental activities that involve students directly in learning will make learning physics more memorable and feel real. Experimental activities are systematic and planned activities to prove the truth of a theory, etc. Experimental activities are real experience activities in finding various answers or problems faced by students during structured and scheduled learning [23]. Therefore, experimental activities are real experience activities carried out by students in proving the truth of a theory, seeking and finding solutions to problems, analyzing phenomena that occur, etc. which are carried out in a structured and scheduled manner. Based on the description above, it is necessary to develop a multiple choice test based on experimental activities to measure the 21st century skills of students in heat and heat transfer topics.

The previous research conducted by Ramdani *et al.* [24]. This study aims to develop a science learning evaluation tool in junior high schools that is expected to develop students' 21st century skills. This research includes development research in four stages, namely: decide, design, develop, and evaluate. The results of this study show that the tools developed by the teacher are already in the complete category, the learning objectives are clear, although the stages still partially need to be improved. The learning evaluation instruments developed by the teacher have met the principles of assessment, the presentation is in accordance with the curriculum, the sentences in the questions are quite communicative, use good and correct language and do not cause double interpretation.

2. RESEARCH METHOD

Based on the problem in this research that has been developed, the type of research used is research and development research and development (R&D) which produces a product in the form of multiple choice

Create multiple-choice tests based on experimental activities to assess students' 21st ... (Sherlin Illene)

tests based on experimental activities to measure students' 21st century skills in heat and heat transfer topics. One of the stages that can be used in development is by adapting the analyze, design, develop, implement, and evaluate (ADDIE) development model. The ADDIE development model has five main stages, namely analysis, design, development, implementation, and evaluation [25], [26]. The research carried out includes the stages of analysis, design, development, implementation and evaluation, as shown in Figure 1.

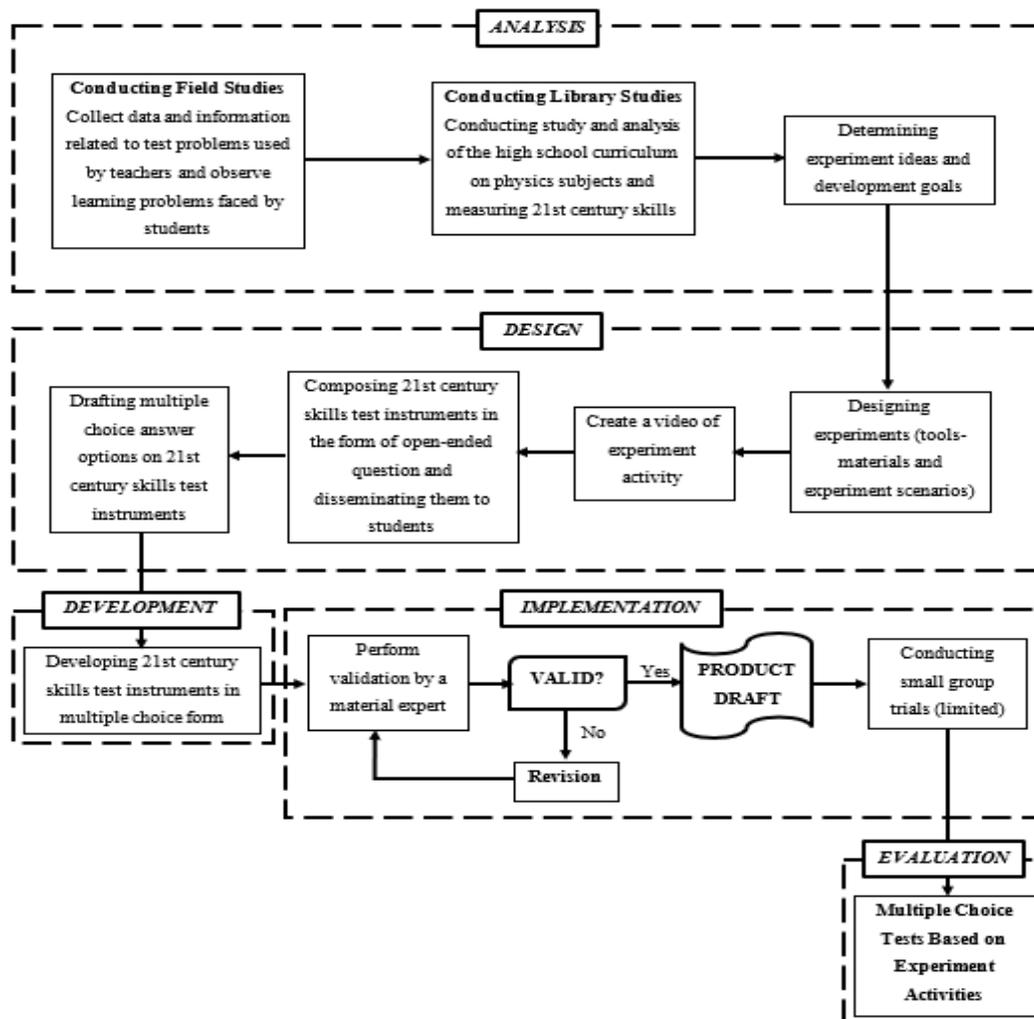


Figure 1. The steps of the research carried out to develop multiple choice test instruments based on experimental activities to measure students' 21st century skills in heat and heat transfer topics

2.1. Analysis stage

The analysis aims to identify possible causes for the emergence of performance gaps [27]. Therefore, it is necessary to conduct field and literature studies. Participants in the analysis were divided into two groups, namely three high school physics educators in the city of Bandung and high school students in grade 11 science in the City of Bandung.

2.1.1. Field study

The field study was conducted with the aim of collecting data and information related to the test problems used by physics educators for 11th grade by utilizing a needs analysis instrument in the form of a questionnaire. The questionnaire questions that are disseminated contain educators' knowledge regarding teacher-made tests and standardized tests, tests used by educators to conduct assessments, and what abilities are tested on students during assessments. The researcher observed the learning that was followed by the students to find out the learning problems faced by the students.

2.1.2. Literature study

A literature study is carried out with the aim of obtaining information about the research to be carried out by reviewing theories from several sources, such as books, scientific journals, studies of research results related to the development of multiple-choice tests, regulation of the Indonesian Minister of Education and Culture (Permendikbud). The researcher conducted a study and analysis of the high school science curriculum on physics subjects and the measurement of 21st century skills.

2.1.3. Deciding experimental ideas and development goals

Based on the results of the literature study and field studies that have been carried out, the next step is to determine the experimental idea and the purpose of developing a multiple-choice test based on experimental activities to measure the 21st century skills of students on the topic of heat and heat transfer. Development objectives need to be set in order to meet learning needs and objectives as a guide and basis in structuring and developing multiple-choice tests based on experimental activities to measure students' 21st century skills on the topic of heat and heat transfer. There are four designs of experimental activities, namely making the thermometer itself, changing the shape of objects, calorimeter experiments, and determining the right pan material by utilizing the heat transfer process by conduction.

2.2. Design stage

If you plan to develop learning tools, such as learning models, learning media, test instruments then the developer needs to design according to what is being researched [28]. Therefore, the researchers designed experiments, made videos of experimental activities, compiled 21st century skills test instruments in the form of open-ended questions and distributed them to students, and compiled multiple-choice answer options on 21st century skills test instruments. Participants in the design stage research were high school students in grade 12 science in Java. A total of five students with a participant age range of 17-18 years filled out open-ended questions to be analyzed as answer options.

2.2.1. Designing experiments (tools and materials and experimental scenarios)

The experimental design was carried out based on the experimental idea that had been determined at the analysis stage. The steps in designing the experiment are: i) Determining the problem related to the heat and heat transfer topics; ii) Determining the experimental objectives of the problem taken; iii) Drawing the experimental design to be carried out; iv) Determining the tools and materials used for the experiment to be carried out; v) Preparing the tools and materials needed for the experiment to be carried out; and vi) Compiling an experimental scenario in the form of experimental steps that are used as a guide for making videos.

2.2.2. Create videos of experimental activity

Create videos of experimental activities is carried out based on the design of experiments that have been made. The steps in making a video of experimental activities are: i) Preparing the tools and materials needed in making videos (mobile phones, audio recording devices, Inshot applications, as well as laboratory tools and materials); ii) Making settings on cellphones and audio recording devices which can be done using devices; iii) Simultaneously recording video and audio, starting from the introduction to the experimental step; iv) Editing video and audio using the Inshot application; v) Finishing the video of experimental activities; and vi) Uploading experimental activity videos to YouTube.

2.2.3. Develop 21st century skills test instruments in the form of open-ended questions and distribute to students

Based on the experimental activity video, the researcher made questions in the form of open-ended questions and distributed them to 12th graders science who had studied heat and heat transfer by using the google form platform. The instrument provided consists of 16 questions related to making the thermometer itself and 16 questions related to determining the right pan material by utilizing the heat transfer process by conduction. The questions given consist of four questions each of the skills of critical thinking, collaboration, communication, and creativity (4Cs).

2.2.4. Preparation of multiple-choice answer options on 21st century skills test instruments

From the answers given by the students, the researcher made alternative answers to the multiple-choice test by analyzing from several sources. For critical thinking skills use references from White [29]. There are four levels of critical thinking skills, namely: i) Not engaging with data at all (level 1); ii) Not engaging with data critically (level 2); iii) Critical analysis of data, including at least one ambiguity (level 3); and iv) Critically analyze all data (level 4). For collaboration skills use references from Cuberro [30]. There are four levels of collaboration skills, namely: i) Students do not work together in pairs or groups (level 1); ii)

Students work together, but they do not share responsibilities (level 2); iii) Students have shared responsibilities but they are not making important decisions together (level 3); and iv) Students have shared responsibilities and they make important decisions together (level 4). For communication skills, we use references from Spector-Levy [31]. There are four levels of communication skills. For creativity skills, we use a reference from Setyadin *et al.* [32]. There are four levels of creativity skills.

2.3. Development stage

The development aims to realize the design that has been compiled to become a product in the form of a multiple-choice test instrument based on experimental activities to measure the 21st century skills of students. The product consists of 16 questions related to making the thermometer itself and 16 questions related to determining the right pan material by utilizing the heat transfer process by conduction. The resulting product is still in the form of an initial draft that cannot be widely used, so a follow-up trial is needed by material experts and students.

2.4. Implementation stage

Implementation aims to implement products that have been widely developed. At this stage, results will be obtained whether the multiple-choice test based on experimental activity to measure 21st century skills is valid and reliable. The component assessed in the validation process by material experts is the relevance of the questions made to the skill indicators of the 21st century. Furthermore, the questions were tested on 63 high school students in grade 11 science who were taken randomly in two classes at one of the high schools in Bandung City. This trial was carried out by utilizing the google form platform.

2.5. Evaluation stage

Evaluation is carried out during the process of developing and implementing multiple-choice tests based on experimental activities. After conducting an evaluation, a better and more feasible product will be produced compared to the previous product draft. So that the product produced multiple choice tests based on experiment activities to measure students' 21st century skills (4Cs) in heat and heat transfer topic.

3. RESULTS AND DISCUSSION

3.1. Analysis stage

3.1.1. Field study

Field studies were carried out in the early stages of research on educators with the aim of collecting data and information related to the test problems used. At the time of assessment, educators make more questions with types of calculations and everyday phenomena. As for problem-based questions, concepts, principles, and theories are rarely raised. From this, educators tend to doubt whether the test can measure the 21st century skills of students or not.

Field studies are also carried out by observing student learning with the aim of knowing the learning problems faced by students so that researchers can analyze the needs in developing standardized tests. Based on the results of observations made at one high school in Bandung, physics learning is carried out in class or virtual meetings by explaining the material in theory. Laboratory activities have not been carried out due to circumstances that are not yet possible. In fact, laboratory activities also help students in real learning.

3.1.2. Literature study

Literature study was conducted in the early stages of research with the aim of obtaining information about the needs of researchers in developing assessment instruments, especially multiple choice tests. In addition to the multiple choice test, a literature study was also conducted on the science high school curriculum in physics, especially the subject of heat and heat transfer, as well as 21st century skills by reviewing theory from several sources, such as books, scientific journals, research studies.

Based on the Utari *et al.* [14], 21st century skills include: i) Critical thinking and problem solving abilities, namely giving scientific reasons, making decisions, and finding solutions to problems; ii) Innovative and creative, namely getting ideas to find solutions to problems using various techniques and achieving real and useful contributions in various fields by conveying creative ideas; iii) Collaboration, namely working effectively and systematically with diverse group members, actively involved in achieving goals by exercising flexibility and awareness, as well as appreciating and respecting the contribution of each group member; and iv) Communicating effectively, namely utilizing various types of media and technology and using verbal, written, non-verbal communication skills in various forms and contexts to convey ideas or idea.

According to the Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 37 of 2018 [33] the subject of heat and heat transfer is taught in subjects physics class XI with the

following basic competencies (KD): i) KD 3.5: Analyzing the effect of heat and heat transfer which includes thermal characteristics of a material, capacity, and heat conductivity in daily life; and ii) KD 4.5: Designing and conducting experiments on the thermal characteristics of a material, especially related to heat capacity and conductivity, along with the presentation of experimental results and their use.

3.1.3. Deciding on an experimental idea

Before determining the idea of the experiment, the researcher first made an outline design to carry out experimental activities on the subject of heat and heat transfer. There are 4 designs of experimental activities, namely making the thermometer itself, changing the shape of objects, calorimeter experiments, and determining the right pan material by utilizing the heat transfer process by conduction. After going through several considerations, an experiment was chosen to make a thermometer by itself and determine the right pan material by utilizing the heat transfer process by conduction because the experiment has included one chapter.

3.2. Design stage

3.2.1. Designing experiments (tools and materials and experimental scenarios)

There were two experiments carried out on the subject of temperature and expansion, namely making the thermometer itself and the expansion of solids. While the experiment was carried out on the subject of heat transfer, namely determine the right pan material by utilizing the heat transfer process by conduction. The experiment was carried out by heating butter laid out on some metal.

3.2.2. Create videos of experimental activity

Create videos of experimental activities is carried out based on the experimental design that has been carried out. The steps in creating a video of the trial activity are as follows: i) prepare the tools and materials needed in making video (mobile phones, audio recording devices, Inshot applications, and laboratory tools and materials), ii) setting up cellphones and audio devices that can be done using other devices, iii) perform the video and audio recording process simultaneously, starting from the introduction to the experimental step, iv) editing video and audio by utilizing the Inshot application, v) finishing video of experimental activities, and vi) upload a video of the experiment to YouTube. Video of temperature and expansion sub-material experiment activity with the link: https://youtu.be/_HKGXNmDEXc. Video of heat transfer sub-material experiment activity with the link: <https://youtu.be/AR-B5qsRifc>.

3.2.3. Develop 21st century skills test instruments in the form of open-ended questions and distribute to students

After making a video of experimental activities, the researchers developed a 21st century skill test instrument based on experimental activities on the subject of temperature and expansion and heat transfer. Before being compiled into a multiple-choice test, researchers made it in the form of open-ended questions based on indicators developed by Boss [34] and distributed it to five students in grade 12 science. From the answers given, it will be analyzed to create alternative answers to multiple-choice tests with rubrics of 21st century skills from various sources.

3.2.4. Preparation of multiple choice answer options on 21st century skills test instruments

From the answers given by the students, the researcher made alternative answers to the multiple choice test by analyzing from several sources. Examples of analysis results as shown in Tables 1-8.

Table 1. Analysis of critical thinking skills number 1 on the subject of temperature and expansion

Answers	Level
Precisely because everything has been produced well and in accordance with the procedures	1
Already, because he did it according to the chemical procedure	1
Yes, the steps taken are just right	1
Already, because it can be obtained data and can already be compared	2
The steps taken are all right and the proof is that the artificial thermometer can function properly and the results are also correct	2

Table 2. Analysis of critical thinking skills question number 2 on the subject of heat transfer

Answers	Level
Set up a variety of different tools to be measured and compared	1
Heating the material to be tested and measuring the ability to drain the heat current of each metal material so that it knows which one is the best	4
The most effective step is to use copper material when the spiritus is ignited and drain the heat to the butter stored on top of the material	3
The most effective step is to burn butter using copper, zinc, lead, and iron	2

For collaboration skills, examples of the analysis results are:

Table 3. Analysis of collaboration skills number 6 on the subject of temperature and expansion

Answers	Level
Work together and study fellow members	2
Working together	2
Always communicate with each other so that if there are obstacles can be overcome together	4
Work according to the division of each task with good coordination	4
Communication must be delivered by the members so that there is no misunderstanding, especially when conducting the experiment. In addition, it must reach an agreement together so that it must be discussed in the group so that everything agrees	4

Table 4. Analysis of collaboration skills question number 7 on the subject of heat transfer

Answers	Level
Copper, because it can be studied again why the temperature used for butter is the smallest	1
The material that can conduct the best heat current is the one that can deliver it in the shortest time	3
B	1
Distance made not too close e.g. 7.0 to 7.5 in my opinion this is interesting.	2

For communication skills, examples of the results of the analysis are:

Table 5. Analysis of communication skills question number 9 on the subject of temperature and expansion

Answers	Level
That is what affects the project	1
Thermometer	3
Experiment thermometer filler	2
Expansion	3
Thermometer making	3

Table 6. Analysis of communication skills question number 12 on the subject of heat transfer

Answers	Level
Different specific heat	1
Depending on the ability of each metal to conduct heat because each material is different	4
Because the nature of each ingredient must be different so it is not the same	4
Because the initial time on copper and iron is different so that it causes the time to drop the lighter and melt the butter differently	2

For creativity skills, examples of the results of the analysis are:

Table 7. Analysis of creativity skills question number 15 on the subject of temperature and expansion

Answers	Level
It could be because it's not just one	1
It could be, we can replace it with solid liquids such as oil, yoghurt, etc.	2
Yes, for example thermocouple	4
No, because metals don't have indicators for their temperature measurements	2
Can not, because the fluid is already the best and best thermometer filler based on the previous video so that the fluid is the best	2

Table 8. Analysis of creativity skills question number 14 on the subject of heat transfer

Answers	Level
Chocolate bar	1
Cheese, because it is an ingredient similar to butter. Oil can also, but it will be difficult in its experiments because later it will fall apart and it will be difficult in determining conclusions.	3
Cheese	1
Cheese is because it is almost similar to butter when heated and safe for experimentation	3

3.3. Development stage

Based on the results of the analysis in preparing the answer options, the researcher developed a multiple-choice test instrument based on experimental activities. It is to measure 21st century skills on the topic of heat and heat transfer. The data is shown in Table 9 and Table 10 (see in Appendix).

3.4. Implementation stage

3.4.1. Temperature and expansion

To get multiple choice test based on experimental activity to measure 21st century (4C) skills on the subject of temperature and expansion, there are several stages that need to be carried out, namely:

a. Conducting validation by experts

The component assessed in the validation process by experts is the relevance of questions made with 21st century skill indicators with 'yes' and 'no' answers. The results of the validation were then analyzed using content validity ratio (CVR) and content validity index (CVI). According to Lawshe [35], content validity ratio (CVR) is a statistical item that is useful in accepting or rejecting a particular item. Here are the results of CVR and CVI analysis from validation by experts shown in Table 11.

Table 11. CVR and CVI analysis results from multiple choice test based on experimental activities on the subject matter of temperature and expansion validation by experts

No.	Relevance of question items to 21st century skills indicators (4C)			n_e	N	CVR	Category	Description
	Yes/No							
	V1	V2	V3					
1	1	1	1	3	3	1.00	Very relevant	Used
2	1	1	1	3	3	1.00	Very relevant	Used
3	1	1	1	3	3	1.00	Very relevant	Used
4	1	1	1	3	3	1.00	Very relevant	Used
5	1	1	1	3	3	1.00	Very relevant	Used
6	1	1	1	3	3	1.00	Very relevant	Used
7	1	1	1	3	3	1.00	Very relevant	Used
8	1	1	1	3	3	1.00	Very relevant	Used
9	1	1	1	3	3	1.00	Very relevant	Used
10	1	1	1	3	3	1.00	Very relevant	Used
11	1	1	1	3	3	1.00	Very relevant	Used
12	1	1	1	3	3	1.00	Very relevant	Used
13	1	1	1	3	3	1.00	Very relevant	Used
14	1	1	1	3	3	1.00	Very relevant	Used
15	1	1	1	3	3	1.00	Very relevant	Used
16	1	1	1	3	3	1.00	Very relevant	Used
	CVI				1.00		Very relevant	Used

b. Conducting small group trials (limited)

This stage is carried out to test the feasibility of multiple-choice tests based on experimental activities that have been validated by experts. At this stage, the 21st century skill test was tested on 63 high school students in grade 11 science who were taken randomly in two classes in one of the high schools in Bandung City, consisting of 26 male students and 37 female students. The test instrument was tested using the google form platform. The results obtained will be analyzed with Anates 4.0. software as shown in Table 12.

Table 12. Limited test results of multiple-choice test based on experimental activities on the subject matter of temperature and expansion

Question item	Differentiating power	Description	Difficulty level	Description	Validity	Description	Reliability	Description
1	0.59	Good	0.33	Moderate	0.49	Enough		
2	0.00	Not good enough	0.52	Moderate	0.14	Very low		
3	-0.29	Bad	0.22	Hard	-0.22	Invalid		
4	0.65	Good	0.24	Hard	0.60	Enough		
5	0.59	Good	0.81	Easy	0.62	High		
6	0.65	Good	0.75	Easy	0.54	Enough		
7	0.76	Very good	0.44	Moderate	0.54	Enough		
8	0.59	Good	0.62	Moderate	0.51	Enough	0.60	High
9	0.53	Good	0.67	Moderate	0.43	Enough		
10	-0.12	Bad	0.09	Very hard	-0.11	Invalid		
11	0.59	Good	0.54	Moderate	0.51	Enough		
12	0.41	Good	0.29	Hard	0.45	Enough		
13	0.65	Good	0.49	Moderate	0.37	Low		
14	0.47	Good	0.62	Moderate	0.42	Enough		
15	0.24	Good enough	0.25	Hard	0.20	Very low		
16	0.24	Good enough	0.33	Moderate	0.23	Low		

3.4.2. Heat transfer

To get multiple choice test based on experimental activity to measure 21st century (4C) skills on the subject of heat transfer, there are several stages that need to be carried out, namely:

a. Conducting validation by experts

The component assessed in the validation process by experts is the relevance of questions made with 21st century skill indicators with 'yes' and 'no' answers. The results of the validation were then analyzed using CVR and CVI. Here are the results of CVR and CVI analysis from validation by experts shown in Table 13.

Table 13. CVR and CVI analysis results from multiple choice test based on experimental activities on the subject matter of heat transfer validation by experts

No.	Yes/No			n_e	N	CVR	Category	Description
	V1	V2	V3					
1	1	1	1	3	3	1.00	Very relevant	Used
2	1	1	1	3	3	1.00	Very relevant	Used
3	1	1	1	3	3	1.00	Very relevant	Used
4	1	1	1	3	3	1.00	Very relevant	Used
5	1	1	1	3	3	1.00	Very relevant	Used
6	1	1	1	3	3	1.00	Very relevant	Used
7	1	1	1	3	3	1.00	Very relevant	Used
8	1	1	1	3	3	1.00	Very relevant	Used
9	1	1	1	3	3	1.00	Very relevant	Used
10	1	1	1	3	3	1.00	Very relevant	Used
11	1	1	1	3	3	1.00	Very relevant	Used
12	1	1	1	3	3	1.00	Very relevant	Used
13	1	1	1	3	3	1.00	Very relevant	Used
14	1	1	1	3	3	1.00	Very relevant	Used
15	1	1	1	3	3	1.00	Very relevant	Used
16	1	1	1	3	3	1.00	Very relevant	Used
	CVI				1.00		Very relevant	Used

b. Conducting small group trials (limited)

This stage is carried out to test the feasibility of multiple-choice tests based on experimental activities that have been validated by experts. At this stage, the 21st century skill test was tested on 63 high school students in grade 11 science who were taken randomly in two classes in one of the high schools in Bandung City, consisting of 26 male students and 37 female students. The test instrument was tested using the google form platform. The results obtained will be analyzed with Anates 4.0. software as shown in Table 14.

Table 14. Limited test results of multiple-choice test based on experimental activities on the subject matter of heat transfer

Question item	Differentiating power	Description	Difficulty level	Description	Validity	Description	Reliability	Description
1	0.29	Good enough	0.13	Very hard	0.35	Low		
2	0.53	Good	0.51	Moderate	0.42	Enough		
3	0.53	Good	0.70	Moderate	0.49	Enough		
4	0.71	Very good	0.62	Moderate	0.51	Enough		
5	0.53	Good	0.79	Easy	0.55	Enough		
6	0.65	Good	0.59	Moderate	0.55	Enough		
7	0.12	Not good enough	0.13	Very hard	0.14	Very low		
8	0.65	Good	0.63	Moderate	0.48	Enough	0.49	Moderate
9	0.47	Good	0.30	Very easy	0.33	Low		
10	0.59	Good	0.57	Moderate	0.49	Enough		
11	0.00	Not good enough	0.24	Hard	0.04	Very low		
12	0.35	Good enough	0.48	Moderate	0.28	Low		
13	0.35	Good enough	0.65	Moderate	0.30	Low		
14	0.35	Good enough	0.40	Moderate	0.30	Low		
15	-0.06	Bad	0.17	Hard	0.00	Very low		
16	0.29	Good enough	0.52	Moderate	0.25	Low		

3.5. Evaluation stage

From the results of the analysis, multiple-choice tests based on experimental activities on the subject matter of heat and heat transfer are better than the previous draft. Test instruments on temperature and expansion materials have high reliability, while in heat transfer materials have moderate reliability. However, it is necessary to revise the test instrument because there are some questions that are not yet valid.

4. CONCLUSION

Based on the results and discussion, it is concluded that the multiple choice test based on experimental activities to measure students 21st century skills (4Cs) in heat and heat transfer topic has been developed based on the results of the analysis of open-ended questions. In particular, the conclusions obtained from this study are: i) At the analysis stage of the development of multiple choice tests based on experimental activities to measure 21st century skills on the subject of temperature and expansion and heat transfer, namely that learning is currently carried out in classrooms and virtual meetings by explaining the material in theory, without any experimental activities. So far, educators tend to doubt whether the tests created can measure 21st century skills or not; ii) From the results of the research that has been done, it is hoped that every school and educator of physics subjects will try to develop multiple choice tests based on experimental activities to measure 21st century skills on the subject of temperature and expansion and heat transfer. Equipped with 21st century skills, students are able to adapt to the world they will live in after graduating from school; and iii) The product of this research can also be used for educators and students for independent learning activities or as an example for compiling multiple choice tests based on experimental activities to measure 21st century skills in other physics materials and other subjects. In further research, experiments can be made involving students (not only experimental videos) so that students can try themselves and feel challenged.

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APPENDIX

Table 9. Multiple choice tests based on experimental activities to measure 21st century skills on the subject of temperature and expansion

4Cs	Questions
Cri 1	<p>Here is a video that is done to make a simple thermometer.</p> <p style="text-align: center;">VIDEO</p> <p>Based on the video above, is the person taking the right steps?</p> <p>a. It is appropriate, the steps or procedures in making a simple thermometer are good and appropriate.</p> <p>b. Not yet precise, a simple thermometer should be tested in boiling water and ice water to determine the upper and lower fixed points.</p> <p>c. It is correct, the steps or procedures in making a simple thermometer are correct and can function properly, the results are also correct.</p> <p>d. Not yet precise, a simple thermometer should be hung on a stand and clamps so that better data can be obtained.</p> <p>e. That's right, the addition of temperature shown on the graph is linear.</p> <p>Answer key: b</p>
Col 2	<p>You already have a team that will work on a simple thermometer making project and there has been a division of tasks that has become a mutual agreement. In order for the team to work well, the thing that must be done is....</p> <p>a. Work in accordance with the division of each task that has been selected by the group leader with good coordination</p> <p>b. Work together on projects and examine fellow members</p> <p>c. Work in accordance with the tasks that have been divided according to their respective characteristics, carry out good communication, and must reach an agreement together</p> <p>d. Work individually first and then discuss in groups</p> <p>e. Work together so that all members understand the steps that must be completed</p> <p>Answer key: c</p>
Com 1	<p>Based on project you are working on, some information that can be obtained via the internet to support the making of project to be carried out is by entering the keyword</p> <p>a. The concept of temperature, how the thermometer works, the characteristics of the thermometer, the concept of expansion, the concept of heat, and buoyancy</p> <p>b. Concepts of temperature and heat, characteristics of thermometers, concepts of expansion, and coefficients of expansion of liquids and solids</p> <p>c. The concept of temperature, the workings of a thermometer, the upper and lower fixed points of a thermometer, the characteristics of the thermometer, the concept of expansion, the coefficient of expansion of liquids and solids, and the concept of heat</p> <p>d. The concept of temperature and heat, how the thermometer works, characteristics of the thermometer, the concept of expansion, the concept of heat transfer, and buoyancy</p> <p>e. The concept of temperature, how a thermometer works, the upper and lower fixed points of a thermometer, the characteristics of the thermometer, the concept of expansion, and the coefficient of expansion of liquids and solids</p> <p>Answer key: c</p>
Cre 3	<p>Can we find thermometers with fillers other than fluids?</p> <p>a. No, metal doesn't have an indicator to measure its temperature.</p> <p>b. Yes, such as thermocouples and fixed volume/pressure gas thermometers, etc.</p> <p>c. Can't, that fluid has become the best and best thermometer filler based on the video.</p> <p>d. It can, such as an alcohol thermometer and a mercury thermometer.</p> <p>e. No, the most accurate is a thermometer with a fluid filler. We can replace the fluid with oil, yogurt, etc.</p> <p>Answer key: b</p>

Cri: critical thinking skill, Col: collaboration skill, Com: communication skill, Cre: creativity skill

Table 10. Multiple choice tests based on experimental activities to measure 21st century skills on the subject of heat transfer

4Cs	Questions
Cri 2	<p>The material that is suitable to be used as a frying pan is the one that can flow the heat per unit meter per unit kelvin the best. The most effective step that can be taken to conduct an experiment is....</p> <p>a. Heats the metal material to be tested, then compares the ability to conduct heat current per unit meter per unit kelvin so as to find out which one is the best</p> <p>b. Testing a variety of different objects, such as wood, plastic, and metal to be measured and compared</p> <p>c. Using copper material when the burner is turned on and flowing heat per unit meter per unit kelvin to the butter which is stored on top of the material</p> <p>d. Metal materials need to be tested to heat ingredients other than butter so that the data is more accurate</p> <p>e. Burn butter using copper, zinc, lead, and iron</p> <p>Answer key: a</p>

Table 10. Multiple choice tests based on experimental activities to measure 21st century skills on the subject of heat transfer (*continued*)

4Cs	Questions
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Col 3 The following are the results of an experiment in determining the correct ingredients for a frying pan by melting butter and dropping a matchstick.



- a. The time it takes the heated iron to melt all the butter and drop all the matchsticks
 - b. The time it takes the heated copper to melt all the butter and drop all the matchsticks
 - c. The time it takes the heated zinc to melt all the butter and drop all the matchsticks
 - d. The time it takes for heated lead to melt all the butter and drop all the matchsticks
- Based on these data, the discussion that needs to be developed or improved to obtain materials with heat current flow per unit meter per kelvin unit is best.
- a. Materials that are suitable for frying pans are those that can deliver the best heat flow in the fastest time
 - b. It is necessary to change the distance that is not too close e.g., 7.0 cm to 7.5 cm
 - c. The metal used for the experiment should have the same size so that this factor is not taken into account
 - d. Copper is a material that can be investigated again why the temperature used to heat butter is the lowest
 - e. The heated material can be varied in order to get more varied data as well
- Answer key: c

Com 4



1. Besi						
m = 20 g		d = 4 mm		d = 1 mm = 0.1 cm		
Temp	Waktu Awal	Waktu Akhir	Waktu	Waktu	Waktu	Waktu
	(s)	(s)	(s)	(s)	(s)	(s)
1	0.0	10.00	10.00	10.00	10.00	10.00
2	0.0	11.00	11.00	11.00	11.00	11.00
3	0.0	12.00	12.00	12.00	12.00	12.00
4	0.0	13.00	13.00	13.00	13.00	13.00

2. Tembaga						
m = 20 g		d = 4 mm		d = 1 mm = 0.1 cm		
Temp	Waktu Awal	Waktu Akhir	Waktu	Waktu	Waktu	Waktu
	(s)	(s)	(s)	(s)	(s)	(s)
1	0.0	10.00	10.00	10.00	10.00	10.00
2	0.0	11.00	11.00	11.00	11.00	11.00
3	0.0	12.00	12.00	12.00	12.00	12.00
4	0.0	13.00	13.00	13.00	13.00	13.00

- Iron and copper have the same size (mass and thickness). Why are the times for melting butter and dropping matchsticks different?
- a. Iron and copper have different specific heat values, so the time to drop the match and melt the butter is different.
 - b. The initial heating time of the copper and iron is different, so the time to drop the match and melt the butter is different.
 - c. The distance between butter and matches placed on iron and copper is different, so the time for dropping the match and melting the butter is different.
 - d. The chemical properties of iron and copper are different, so the time for dropping a match and melting butter is different.
 - e. The ability of iron and copper to conduct heat is different, so the time to drop a match and melt butter is different.
- Answer key: e

Cre 2 The laboratory has provided a number of objects that you can use to heat up in conducting experiments to determine the right pan material.



1) Oil 2) Honey 3) Cheese 4) Ice cubes 5) Chocolate bar

- Based on the tools and materials provided, the right choice for you is ...
- a. cheese, because cheese is almost similar to butter when heated and is safe for experiments.
 - b. chocolate bars, because it is easier to divide the chocolate bars so there is no need to weigh again and you can see the change in state from solid to liquid
 - c. oil, because oil has the same function as butter, but the experiment will be messy
 - d. ice cubes, because of their solid shape and the process of changing shape can be seen, but there are other factors, namely air that affects the melting of ice cubes
 - e. honey, because of its thick texture so that it can be observed well
- Answer key: b

Cri: critical thinking skill, Col: collaboration skill, Com: communication skill, Cre: creativity skill

BIOGRAPHIES OF AUTHORS

Sherlin Illene    was born in Bandung, 3rd of March 2000. She is one of the students of the 8th semester of the Physics Education Study Program, Department of Physics Education, Faculty of Mathematics and Science Education, Universitas Pendidikan Indonesia, Bandung-Indonesia. Her research interests are: physics education, 21st century skills, instruments in physics concept, and development of physics learning media. Some of the awards that have been obtained are getting a silver award in the International Invention and Innovation Competition Series 2/2021 and a bronze award in the Malaysian Invention and Innovation Expo 2022 event. She can be contacted by email: sherlin.yasa00@upi.edu.



Selly Feranie    was born in Bandung, 8th of November 1974. She is a Physics Education Lecturer in the Faculty of Mathematics and Science Education, Indonesia University of Education, Bandung-Indonesia since 1999. She completed her Bachelor of Physics Education in 1998 at Indonesia University of Education and completed her Masters in 2002 and her doctoral studies in 2011 in Physics at Bandung Institute of Technology. Her research interests are: science education, soil and rock mechanics. She can be contacted at email: feranie@upi.edu.



Parsaoran Siahaan    was born in Pematang Siantar, 1st of March 1958. He is a Lecturer in Physics Education in the Faculty of Mathematics and Science Education, Indonesia University of Education, Bandung-Indonesia. He completed his Bachelor of Physics Education in 1981 at IKIP Bandung and completed his Masters in Science Education at Indonesia University of Education. He was appointed as a Lecturer in Physics Education Study Program in 1981. His research interests are: Physics Education and Science Education. He can be contacted at email: parsaoceansiahaan@upi.edu.