Game Open Online Physics Instructional (GOOPI) for technology improving 21st-century careers

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Abstract. Physics is fundamentally formed from scientific processes that take place continuously and sustainable through experimental stages known as the scientific method. The scientific method will give a positive meaning if the Instructional Physics can be applied in learning through online games to improve 21st-century careers. This study aims to Development of Open Online Physics Instructional Games (GOOPI) for improving 21st Century Careers. The research method used was ADDIE (Analysis, Design, Develop, Implement, and Evaluate). The results showed that Development of Open Online Physics Instructional Games for improving 21st Century Careers.

1. Introduction
The university should adjust to building a mindset towards students and the academic community in preparing students to face internal and external challenges at 21st-Century Careers [1]. The challenge is in the form of educational demands which must still refer to the National Education Standards. Other challenges include global issues the transformation of the education sector towards the industrial revolution 4.0 [2,3]. This demand is in line with the target of learning achievement in the curriculum of higher education based on learning achievement must include aspects of attitude and values, knowledge, and utilize science and technology in their fields [4].

Physics learning that explains natural phenomena is formed when there is an interaction between matter and energy [5]. For example, in everyday life there is an observed phenomenon that is the increase in temperature of the substance when heated [6]. If the concept of physics can be understood through visual activities, it will be easy to understand. The concept of physics can be easily understood if it is done with fun and trains critical thinking and problem solving, communicating, collaborating, and being creative innovative and creative thinking [3]. It focusses on creativity, critical thinking, communication and collaboration which are referred to as 21st-century skills which are very important to prepare students for a more complex life and work environment [7]. Teachers themselves should be able to...
design, implement and evaluate creative ideas, provide learning experiences that will attract students and enhance learning, enrich professional experiences as teachers of the 21st century [8]. This study aims to Development of Open Online Physics Instructional Games (GOOPI) for technology improving 21st Century Careers.

2. Methods

The research method is research and development (R&D) oriented to product development. This research design refers to several stages of the development research model. This ADDIE model is an abbreviation for the five stages of the development process, namely Analysis, Design, Develop, Implement, and Evaluate. The ADDIE model relies on each stage carried out in the order given, but with a focus on reflection and iteration. This model gives you an approach that focuses on providing feedback for continuous improvement. The results of applying e-learning information technology with ADDIE Model can, among other things, enrich the instructor's pedagogy in learning activities and can overcome the constraints of interaction in teaching and learning activities. In the distribution of learning materials can be done more effectively and the teaching and learning process is also not constrained by the problem of time and place while there is good internet network connectivity, can interact using chatting facilities, can utilize audio conference facilities when interacting in the learning process [9].

![ADDIE model design for GOOPI.](image)

The initial step to find out the mastery of the concept at the beginning of lectures, initial measurements. Furthermore, the results of these initial measurements are analyzed which parts of the concept still occur microscopically. Qualitative data when it is measured can be collected through field notes and documentation in the form of sound recordings and videos which are then transcribed to see the types of creative thinking. The detailed information gathering was also carried out by semi-open interviews after initial measurements. The results of the analysis of creative thinking in the initial measurement, then students are treated in the form of learning with GOOPI which focuses on the construction of scientific conceptions on microscopic material to change and improve the creative thinking experienced by students. After the treatment the final measurement is given with a final test to see if there are changes in creative thinking that can be effectively reduced by GOOPI. To establish an analysis of his creative thinking, a semi-open interview was also conducted after the final measurements were made. To see changes, in creative thinking used an instrument of creative thinking in the form of description to see how much creative thinking change. The research method used was ADDIE (Analysis, Design, Develop, Implement, and Evaluate) with the research implementation subjects being 90 students aged 21-25 years. The flowchart of GOOPI development as showed in Figure 2.
3. Results and discussion

3.1. GOOPI development

The initial stage of making instructional media is to identify and analyze existing physics learning. The analysis was carried out in the form of literature study and field study. (1) Literature Study, the first stage of the analysis is the literature study conducted by identifying the basic competencies of the revised 2013 curriculum and understanding the depth and breadth of the component to be developed. The basic competence in the transformation of matter is in class XI i.e. analyze the effect of heat and heat transfer which includes the thermal characteristics of a material, capacity, and heat conductivity on daily life. (2) Field Study, the next stage is by conducting a preliminary study by giving an observation sheet to the teacher. The learning process is dominated by teacher centered learning or the teacher as a learning center which means that in learning the teacher conveys information and students only listen. Although there is potential in schools, namely the existence of adequate facilities and infrastructure for learning, including Physics laboratories, computer laboratories, and LCD, but their use has not been maximized. In addition, in some bookstores there are also learning media available for material changes in the form of substances, but which includes simulation games have not been found.

3.1.1. Design GOOPI. The basic competence in the transformation of matter is in class XI standard competency is analyzing the effect of heat and heat transfer which includes the thermal characteristics of a material, capacity, and heat conductivity on daily life. The analysis of the material obtained is about changes in the form of substances contained in the 2013 curriculum and there are 2 indicators. Media
that is often used in learning physics are textbooks and pictures. They more often listen to explanations and do worksheets. Though teachers want a more varied learning media so students are more interested in learning.

3.1.2. Development GOOPI. After the analysis phase is completed the next stage is media development. Media development begins with making a flowchart. Flowchart is made in the form of a chart to show the presentation of learning materials and learning media flow in general. Flowchart does not depend on programming language, it is usually described in the form of graphic symbols that show the direction of the flow of activities consisting of 3 display menus, namely the menu of basic competencies, goals and games.

Furthermore, based on the flow chart that has been made, data collection of various information is collected. Data collected by the researchers includes the collection of material changes in the form of substances, animation and images that support the making of physics learning game media. The data are used as a reference in developing game media. Based on the data obtained, the storyboard is made. The storyboard is a draft outline of the physics learning game media content. The process of developing GOOPI as shown in Table 1.

### Table 1. GOOPI development content.

| Screen Section | Explanation of the Process on Screen |
|----------------|-------------------------------------|
| Physics Game  | Is the title of the game media, appears after 3 seconds of all displays and flickering |
| Learning      | A column that can be input name |
| Name          | Navigation button, if clicked it will go to the game menu |
| Login         | The column you can enter in your name |
| Username      | The column that can enter any number |
| Password      | Navigation buttons, if clicked, will go to the display containing this media information |
| About         | Navigation buttons, if clicked, will go to the settings view |
| Settings      | Navigation button, if clicked, it will exit the game |

Based on Table 1 the information GOOPI development content for Storyboard that is made using a text in the form of a grooved picture accompanied by information on each screen design that is displayed one of the designs can be seen in Figure 3.

![Figure 3. The designs GOOPI.](image-url)

Based on figure 3, in the storyboard design the display that appears after logging in is the main menu. The main menu consists of 3-tab menus. On the basic competency tab, students can see the competencies that will be implemented. On the goals tab there are objectives to be achieved by students. Students can enter the game on the game tab in which there are 3 Game consisting of Game 1 (the process of melting...
and freezing), Game 2 (the process of evaporating and condensing) and game 3 (the process of sublimating and crystallizing). The final part of the media consists of the completion of all missions and thanks. After designing a design in the form of a flowchart and storyboard, the next step is the creation of physics learning game media. The tools needed in making physics learning game media consist of software and hardware. The software used is Macromedia Flash 8 software and Corel Draw X7. Macromedia flash 8 is an application program aimed at designers or programmers who intend to design animations for business and learning processes. This program can save files in swf format to make it easier to run this media without installing the software, but can be used on a flash player. Corel Draw X7 software in this media is used to create and edit buttons and images as needed. The use of this software can help the process by making physics game learning media because the application is easy to use for beginners who want to design or create an animation program that is needed and the software can be downloaded for free. The hardware used in making physics learning game media is Laptops with Intel Core i3 RAM 4GB. Games in physics learning game media are designed in the form of simulation games. The resulting media development consists of three parts, namely the beginning, core and end. The initial part of the media consists of home (login menu), basic competencies, goals, author, settings, and the game menu. After the finished media product is created in swf media format it is ready to be validated by experts according to their fields.

3.1.3. Implementation GOOPI. GOOPI Product trials in the physics learning game media that have been validated and revised based on criticism and suggestions from a team of media experts and material experts are then subjected to limited trials. This limited trial was conducted to determine the readiness of the product before the large-scale trial and student responses to the media that had been made. In this trial students were given a questionnaire consisting of three aspects, namely material, graphics and language.

3.1.4. Evaluation GOOPI. After the media are finished making, it is ready to be validated as well as product trials. Validation is carried out by validates who are competent in their fields. The product GOOPI of evaluation results are shown in the following figure.

![Game 1](image1)
![Game 2](image2)
![Game 3](image3)

**Figure 4.** Display GOOPI menu.

Based on Figure 4, the display above shows that there are characters who provide information about the simulation that will be used by the user on mission 1, which is melting and freezing. There is a play button if clicked, then it goes to the melting screen. Home when clicked, will return to the main menu, the arrow keys return to the permissions menu and the X button to exit the media. The display above shows that the tab key has evaporated and condensed. There are several components of the image in the middle, namely a thermometer, a test tube as an ice cube container, a stove, a buffer tube and an image of ice cube particles. When the user has selected the mass and clicked on the start button, the evaporation
process starts, the stove lights up with the temperature going up, the particles move quickly until the bonds are released and the shape of the water changes. The screen display above shows camphor in the test tube with a neat arrangement of particles. The user moves the fire parameters before starting to run the simulation and click start to begin the process of changing the form of camphor. After the process is running, the longer the shape of mothballs shrink and disappear, accompanied by the movement of particles that get faster and release into the air. When all the mothballs are gone the stove goes out, click the repeat button to try again.

4. Conclusion
Physics learning that explains natural phenomena is formed when there is an interaction between matter and energy. The concept of physics can be understood through visual activities, it will be easy to understand. The 21st-century skills which are very important to prepare students for a more complex life and work environment so it needs to be practiced creative thinking. These conclusions of this research are the GOOPI for improving 21st-century careers of creativity.

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References
[1] Waite A M and McDonald K S 2018 Exploring Challenges and Solutions Facing STEM Careers in the 21st Century: A Human Resource Development Perspective Advances in Developing Human Resources 21(1) 3-15
[2] Wamsler C, Brosn pamph J, Hendersson H, Kristjansdotir R, McDonald C and Scarampi P 2017 Mindfulness in sustainability science, practice, and teaching Sustainability Science 13(1) 143–162
[3] Swiecki Z, Ruis A R, Farrell C and Shaffer D W 2020 Assessing Individual Contributions to Collaborative Problem Solving: A Network Analysis Approach Computers in Human Behavior 104(2) 105876
[4] Huda M 2018 Empowering application strategy in the technology adoption Journal of Science and Technology Policy Management 10(1) 172-179
[5] Melko R G, Carleo G, Carrasquilla J and Cira J I 2019 Restricted Boltzmann machines in quantum physics Nature Physics 1 1-9
[6] Wamsler C 2019 Contemplative Sustainable Futures: The Role of Individual Inner Dimensions and Transformation in Sustainability Research and Education Sustainability and the Humanities 1 359-373
[7] Anagin Ş S 2018 Teachers’ Perceptions about the Relationship between 21st Century Skills and Managing Constructivist Learning Environments International Journal of Instruction 11(4) 825-840
[8] Chai C S, Hwee Ling Koh J and Teo Y H 2018 Enhancing and Modeling Teachers’ Design Beliefs and Efficacy of Technological Pedagogical Content Knowledge for 21st Century Quality Learning Journal of Educational Computing Research 57(2) 360-384
[9] Richey R C, Klein J D and Tracey 2019 The Instructional Design Knowledge Base: Theory, Research, and Practice (Taylor & Francis)