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The Manufacture of The *KETA Chemistry* Game for Voltaic Cells Learning Materials

The Manufacture of The *KETA Chemistry* Game for Voltaic Cells Learning Materials

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Abstract. Education games are designed to stimulate students' thinking capability and improve their concentration and problem-solving skill. The KETA Chemistry game, based on chemistry literacy, employs a virtual laboratory and hidden objects to help students learn voltaic cell materials. The purpose of this research was to develop a mobile education game as alternative media for learning voltaic cells through a simulation of real-life experiments. Research and Development method was employed. Although theoretically, the method consists of five stages, only two of them were applied in this research (define and design). The final product of the research is The KETA Chemistry, an education game, which combines 2D and 3D elements in its gameplay and the next stage of development, the media will be validated and said to be validated and said to be feasible if it meets the media's worthiness.

Keywords: chemistry literacy, game, hidden objects, The KETA Chemistry, virtual laboratory, voltaic cells.

1. Introduction

Education games are designed and developed to stimulate students' thinking capability and improve their concentration and problem-solving skill [1-2]. Generally, students' thinking capability can be stimulated with an object that attracts their interest. When they are interested in certain learning material, their focus and concentration can be developed, making them understand the material better [3]. To catch their interest, education games can be used. For example, education games are proven to be effective in motivating and boosting accounting students' understanding of their subjects [4]. Education games can also be used as a learning media in the classroom to compare students' learning outcomes [5].

Chemistry literacy, as defined by the Organization for Economic Co-operation and Development (OECD), refers to the scientific literacies that are examined in PISA (a triennial international survey that evaluates education systems throughout the world by testing skills and knowledge of 15 years old students) and consists of several aspects: 1) Context; (2) Knowledge; (3) Competencies; and (4) Attitude. Several education games are designed based on chemistry literacy to stimulate existing problems and formulate solutions [6].

Currently, numerous researches develop games as learning media [7-9]. Some of them developed Legends of Alkhimia [10-11]. The game was used as learning media in classroom learning to improve students' understanding of scientific concepts [11] and further developed to include inquiry learning and dialog between characters [10]. Legends of Alkhimia employs a virtual laboratory as learning

media and innovation [11]. Introduction about virtual laboratory can increase knowledge about real laboratory [12]. However, the game is not without flaws. First, the content of the game is too broad because it includes various chemical solutions such as acid-base, electrochemistry, electrolyte solution, colloid, etc. (Chang, Raymond, 2008). Second, its virtual laboratory does not visualize laboratory tools and chemical reactions adequately [11]. Such a flaw is critical since the success criteria for a virtual game is to stimulate real environment as close as possible, making students feel as if they were doing experiments in real life [10].

Based on the limitations of Legends of Alkhimia, The KETA Chemistry game was designed as a better version of the game. It is based on chemistry literacy, employs a 3D virtual laboratory (Praxilabs 3D Simulations of Science) and 2D hidden objects (Hidden objects framework) as new features in introducing laboratory tools in voltaic cell materials (Keenan, Charles W., 2005). The game title itself was created to reflect chemistry literacy aspects [13] which are embodied in the game's storyline: "Context" (Ind: Konteks) in daily life as presented in form of animation scene in the game, "Experiment" in form of a virtual laboratory and the way experiments are conducted in it, "Theory" or chemistry contents that must be mastered by player and "Attitude" which must be possessed by player in order to know what should be done and what should not.

2. Method

In this research, the Research and Development method ADDIE instructional model, ADDIE first appeared in 1975, it was created by the Centre for Educational Technology at Florida State University. Although the method theoretically consists of five stages (analysis, design, development, implementation, and evaluation), only two of them were performed (analysis and design). The output was the initial design of The KETA Chemistry game. The method was used because this research attempted to develop an educational game which would make use of virtual laboratory, similar to a game produced in journal "Becoming Chemists through Game-based Inquiry Learning: The Case of Legends of Alkhimia" [10-11,14]. The new game features a virtual laboratory and introduces laboratory tools presented as hidden objects wrapped in the chemistry literacy framework. Chemistry literacy is embodied in the game's storyline and missions. The research results are explained using the descriptive-qualitative method, providing a description or illustration regarding the development of The KETA Chemistry game.

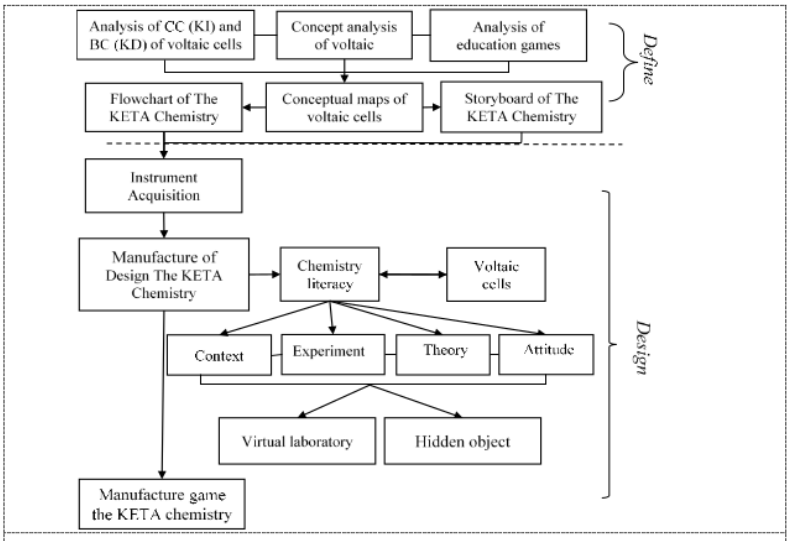

Figure 1. The Procedure of The KETA Chemistry game development

Figure 1 illustrates the conceptual framework used to embed chemistry literacy in The KETA Chemistry game. The game would be produced as a prototype since it would not be used by users but only tested regarding its functionality via use case testing.

Data sources used in this research are secondary. Data sources do not directly provide data to the researcher (Sugiyono, 2005). Data were collected via a literature review on printed/electric books and journals relevant to the research goals and objects. The data collection technique employed in this research was the document analysis technique. Content from every game design document varies and there is no formal, systematic standard for documenting game design (Bethke, 2003).

Instruments used to develop The KETA Chemistry game include Unity 3D 2018.3.3fl (Unity.cop) (a game development software), 3DS Max (Autodesk Inc.) (a 3D modeling and rendering software for designing visualization, games and animation), Adobe Photoshop CC (Adobe, 1982 California) (an imaging and graphic design software), Microsoft Word and Microsoft powerpoint (Microsoft Corp., Washington, AS) (a software for creating game design document, Flowchart and Storyboard).

3. Results discussion

The two development stages of The KETA Chemistry game, namely analysis and design, are explained as follows.

3.1. Analysis stage

The initial stage of The KETA Chemistry game development was based on chemistry literacy aspects such as context, content, process, and attitude regarding voltaic cells material [13]. The KETA in a game title is an abbreviation of the four aspects [13]. It is intended to send an impression of chemistry literacy for players or students. As described by Sri Rahayu, a professor of the Mathematics and Natural Sciences Faculty of Malang State University, the introduction and application of chemistry literacy to students in the 21st century can be used as their capital in living the modern life. This idea motivated the researcher to develop a chemistry literacy-based game aimed to achieve students' learning goals.

Game design is paramount in game development since it describes the initial game plan to developers and other members so that they understand what the game will be about [15]. Generally, game design can be created in the form of a flow screen and storyboard. Storyboard for a game is different from a storyboard for animation since the first contains goals/missions to accomplish throughout the game [16].

Table 1. A brief description of storyboard for the KETA Chemistry game

Visualization	Description
Flash screen	Initial screen consisting of a logo, Core Competencies, and Basic Competencies
Main menu	Consists of Exit: if a player wants to exit from the game Setting button: if pressed, it will allow the player to adjust volume and music. Play button: if pressed, it will start the game.
Introduction	An instance of the electrochemical process used as energy storage in a battery is displayed in an animation.
Hidden objects	The player searches for hidden laboratory tools/equipment on the screen. This serves as an introduction to laboratory equipment.
Virtual laboratory	Conduct virtual experiments on voltaic cells materials
Test	A test regarding voltaic cells is given to measure a player's progress in completing missions

In table 1, the game's storyboard is described. Each scene is designed to embody the four aspects of chemistry literacy. Besides the storyboard, the game design is also presented in a flowchart or flow screen. Flow screen depicts an algorithm using special symbols [15].

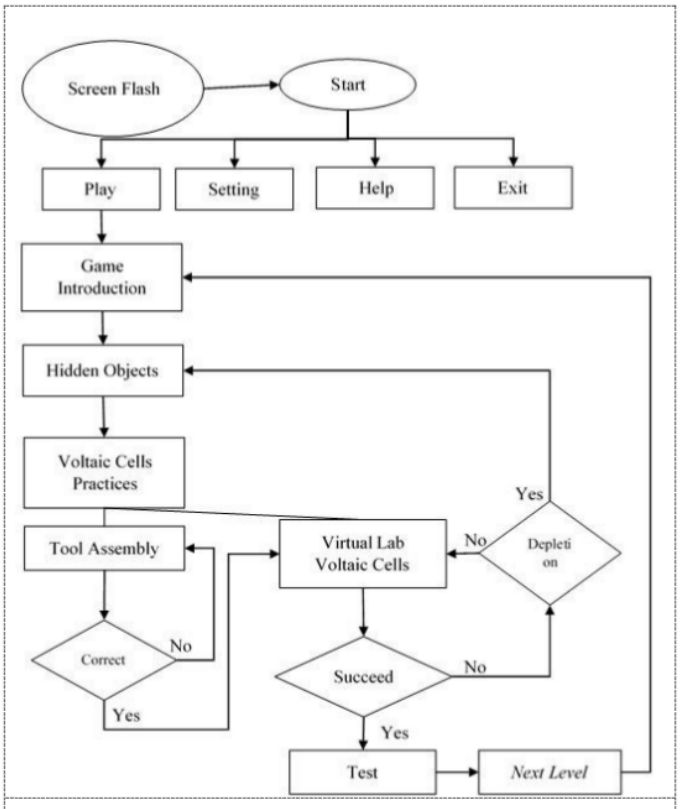

Figure 2. A flow screen of The KETA Chemistry game

The game's outline is depicted in figure 2. The player will not be able to enter the hidden object's screen before passing the game introduction screen. Similarly, the player cannot jump to the virtual laboratory screen before completing the hidden object's screen. Each screen/phase is interlinked where the peak is the virtual laboratory screen. In the final screen, a test will be given to the player to determine whether he could pass the current level or not.

3.2. Game design and development stage

In this stage, several software as instruments is needed to create materials, characters, mockup, background and small objects such as equipment used in the virtual laboratory.

3.2.1. Mockup

Mockup, besides being a visualization of conceptual design, can also serve as a real depiction of product design or preview of an idea in its real form [17].

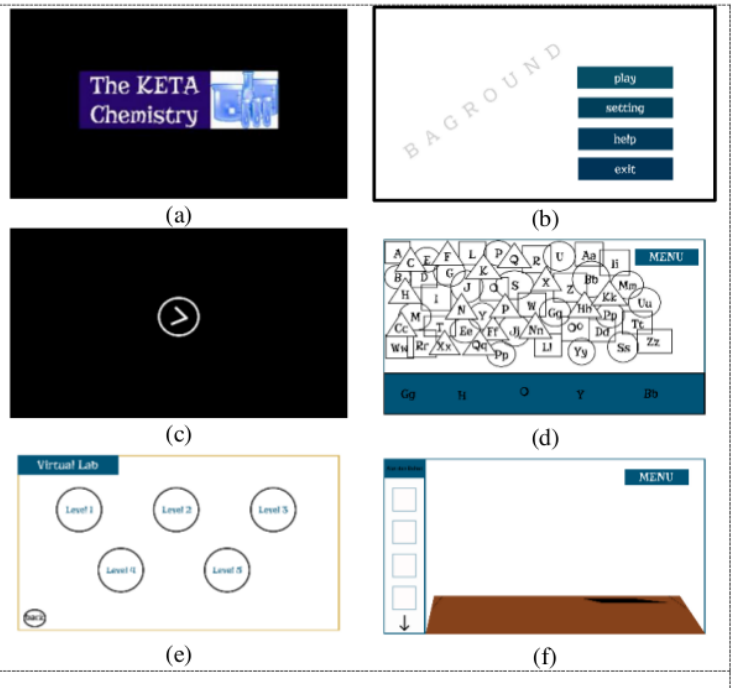

Figure 3. A mockup of The KETA Chemistry game consisting of (a) flash screen; (b) menu; (c) animation; (d) hidden objects; (e) and (f) virtual laboratory.

3.2.2. Characters

There are three characters in The KETA Chemistry game. They are the main character, the professor and the keeper of laboratory instrument and materials.

Figure 4. Main character of the KETA Chemistry game

Character animation is defined as a technique for drawing and manipulating both 2D and 3D characters, making them alive and resemble living beings [18]. The main character is designed to look like a young scientist who possesses excellent intelligence and scientific attitude. The professor is designed to look smart, intelligent and reliable. The third character, the keeper, is a supporting character who has a wide knowledge of laboratory equipment and chemical compounds. According to Fuada [19], character selection is mandatory in adventure games.

3.2.3. Hidden objects and virtual laboratory

In the hidden object's screen, one of the main missions for the player to complete is to find hidden objects [20]. Cues in the form of keywords or pictures are given to help the player find them. The player then must find the required tools and materials to be used in the virtual laboratory within a time limit. If a player is unable to find the required objects within the time limit, he is failed and unable to move on to the virtual laboratory screen.

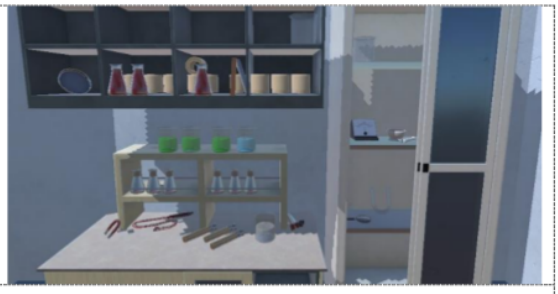

Figure 5. The hidden object in the KETA Chemistry game

A virtual laboratory is a visualization of a series of experiments conducted in a laboratory, both in physics or biology chemistry areas [21]. In this research, the virtual laboratory is designed to simulate voltaic cell materials. The final product of the initial design can be seen in figure 6.

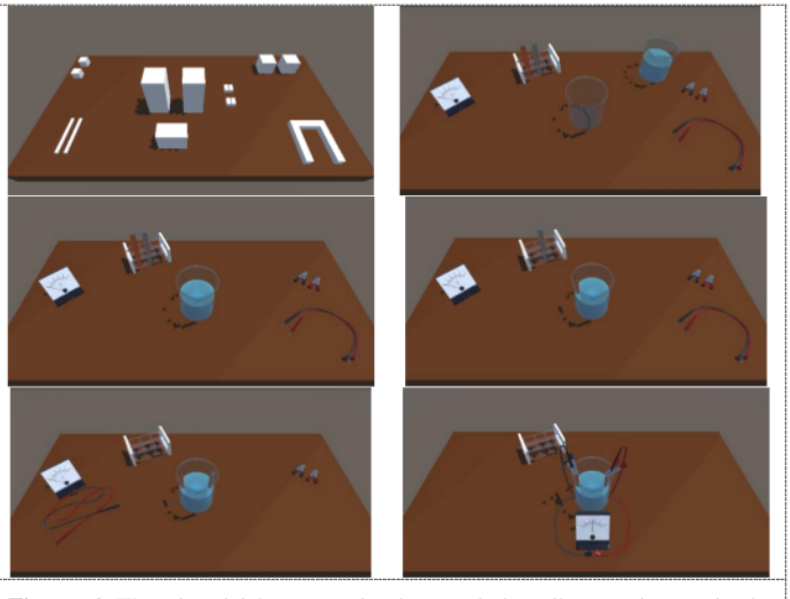

Figure 6. The virtual laboratory simulates voltaic cells experiments in the KETA Chemistry game

The rule of the virtual laboratory screen is that when the player incorrectly assembles the tools and materials, he cannot undo his actions, therefore failing the tools assembly. If the player manages to do it well and faster, he will receive bonus points.

4. Conclusion

This research generated a chemistry literacy-based education game called The KETA Chemistry. The game employs 2D and 3D elements, the former for hidden objects and the latter for the virtual laboratory. The game has three characters and four screens namely introduction, hidden object, virtual laboratory, and test. Finally, hopefully, this media can be developed further so that it is appropriate to be used as a learning medium in school.

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