The development of instructional media chemo-edutainment (CET) based chemistry ludo game on atomic structure topic for 10th grade senior high school students

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Abstract. This study aims to develop a valid and practical instructional media based on Chemo-Edutainment (CET), specifically a chemistry ludo game for atomic structure topic. This study used Research and Development (R&D) method with 4-D model, consists of Define, Design, Develop and Disseminate. This study performed validity and practicality test. The instructional media validated by three lecturers from chemistry department FMIPA UNP and two chemistry teachers from MAN 1 Payakumbuh. The validity and practicality questionnaire were used as the instruments in this study. The data collected by disseminating the questionnaire then analysed using Kappa Cohen formula. Based on the data, the validity level of the developed instructional media was 0.77 and the practicality level at 0.85 (from teachers) and 0.94 (from students). This result means that the developed instructional media can be used in learning atomic structure topic.

1. Introduction

Exercise can reinforce student’s comprehension especially in comprehending the concepts in learning process [1]. In general, teachers gave exercises based on worksheets, modules, or orally from exercises in the books or many other sources. This type of exercises was typically monotonous, unvarying, and not attractive for students. The application of these media caused students learning individual and didn’t discuss with their peers, teacher, and less active in a learning process. If the students were less active and less engaged, there was a possibility that the exercises will not be perfect and makes students cannot comprehend the concept.

It was stated in the curriculum 2013 revision 2016, that atomic structure is one of the topics in chemistry subjects for 10th grade students in first semester [2]. This topic is the foundation to learn periodic table topic. Atomic structure topic contains many factual, conceptual and procedural knowledge, so repetition and reinforcement of this topic is required through some exercises for students.

Based on the interviews to three chemistry teachers in SMAN 1 Payakumbuh and two chemistry teachers in MAN 1 Payakumbuh, there are some information acquired: teachers have been doing learning process referring to curriculum 2013, also using instructional media such as presentation, pictures and chart in atomic structure topic, but they never use game as instructional media in the learning process of atomic structure.
Based on the questionnaire result which disseminated to 12 students in SMAN 1 Payakumbuh and
12 students in MAN 1 Payakumbuh, there are some information about student’s characteristic.
Teachers has given exercises in form of questions in atomic structure to students, but not all of
students enjoy to do this exercise because it’s monotonous. Students never use game as instructional
media as variant of exercises in learning process, but eager to learn by using game.

The usage of instructional media in learning process can raise new urge and interest, motivation
and stimulation in learning activities and even bring psychological effects to students. A good
instructional media is media that can raising student’s motivation, presenting data attractively,
verifiable, and simplifying data interpretation and presenting information. Arsyad states that there are
four purposes of instructional media: attention purpose, affective purpose, cognitive purpose and
compensatory purpose [3].

Chemo is a word that representing chemistry (chemi or chemical). Chemical is an adjective that
correlated with chemistry [4]. Edutainment is a learning process which designed to integrate education
and entertainment harmonically, so learning activities can becomes enjoyable [5]. In conclusion,
Chemo-Edutainment (CET) is a learning activity about chemistry which emphasizing on enjoyment
and happiness to achieve learning purposes in the implementation. One of the instructional
medias based on CET that can be used is game.

2. Research Method
This study used Research and Development (R&D) method. The final result of this study is a product
which is a set of chemistry ludo game based on CET as an alternative for instructional media in atomic
structure topic which is valid and practical to improve students learning activities and reinforce
students’ concepts. This research was done in FMIPA UNP and MAN 1 Payakumbuh in academic
year 2017/2018. The subject of this research was three lecturers from chemistry department FMIPA
UNP, two chemistry teachers from MAN 1 Payakumbuh and 18 students from class X MIA 1 MAN 1
Payakumbuh. The object of this research is a set of chemistry ludo game based on CET on atomic
structure topic. The research instrument was validation questionnaire and practicality questionnaire.
The questionnaire will be used to determine the validity and practicality level of the chemistry ludo
game set based on CET. The research instrument was validation questionnaire and practicality questionnaire.
The questionnaire will be used to determine the validity and practicality level of the chemistry ludo
game set based on CET. The used data analysis technique is descriptive data which describing the
validity and practicality level of chemistry ludo game set as instructional media that has been
developed. The obtained data from the questionnaire will be calculated using Kappa Cohen formula,
and in the end Kappa moment will be obtained. Kappa moment will be calculated using this formula:

\[
\text{Kappa Moment } (\kappa) = \frac{\rho_0 - \rho_e}{1 - \rho_e}
\]

Explanation:
\(\rho_0\) is realized proportions.
\(\rho_e\) is unrealized proportions.

The Kappa (\(\kappa\)) moment value is ranged from 0 to 1 and interpreted according to [6] which shown
in Table 1.

| Interval | Category  |
|----------|-----------|
| ≤ 0,00   | Not valid |
| 0,01 – 0,20 | Very low  |
| 0,21 – 0,40 | Low       |
| 0,41 – 0,60 | Medium    |
| 0,61 – 0,80 | High      |
| 0,81 – 1,00 | Very High |

Table 1. The interpretation of the value of Kappa (\(\kappa\)) moment [6].
The development of these instructional media set is using 4-D model which consists of four steps, define, design, develop and disseminate [7]. This research is only performed validity and practicality level of the developed instructional media.

3. Results and discussion

3.1. Research result

This research resulted a valid and practical instructional media product, in form of a chemistry ludo game set based on CET in atomic structure topic for 10th grade class, which can be used to improve student’s learning activity and reinforced students’ concepts.

3.1.1. Define. The purpose of this phase is to determine and define learning terms.

3.1.1.1 Front end analysis. Front end analysis purposes to bring and establish basic issues faced in learning on atomic structure topic so there is need to develop instructional media. In this study, front end analysis was done by interviewed three chemistry teachers in SMAN 1 Payakumbuh and two chemistry teachers in MAN 1 Payakumbuh.

3.1.1.2 Students’ analysis. Student analysis purposes to analyze student’s characteristic. In this study, student’s analysis was done by interviewed three chemistry teachers in SMAN 1 Payakumbuh and two chemistry teachers in MAN 1 Payakumbuh, the questionnaire were also disseminated to 12 students in class X SMAN 1 Payakumbuh and 12 students in class X MAN 1 Payakumbuh.

Based on the interview result and questionnaire analysis result, some information were obtained: (1) teachers has given exercises in form of questions and students has discussed with peers in association phase, but students activity level’s range varied from not active until very active, which means students activity level not distributed evenly in learning process that has been done; (2) according to students, teachers has given exercises in form of games, so students also attracted and interested in using game as instructional media; (3) students has used chemistry ludo game as instructional media, so students also agreeing to use educative ludo game as variant in exercises in atomic structure topic.

3.1.1.3 Tasks analysis. Task analysis purposes to specify contents in teaching materials in form of outline. The analysis task was done in this topic is based on curriculum 2013 revision 2016 and contains core competencies analysis (KI) and basic competencies (KD).

For atomic structure topic, basic competencies that need to be achieved is 3.2. Understanding atomic model Dalton, Thomson, Rutherford, Bohr and Wave Mechanics; and 3.3. Understanding notation of configuration electron and pattern of outer configuration electron to every group in periodic table.

Based on the result of core competencies and basic competencies analysis from syllabus, some learning indicator can be determined. In atomic structure topic, students must achieve some indicators: 3.2.1. Explaining atomic model according to Dalton, Thomson, Rutherford, Bohr and Wave Mechanics; 3.2.2. Explaining each elementary particle that composes atom (proton, electron and neutron) and its discovery process; 3.2.3. Associating the correlation of atomic number, mass number and number of elementary particles which composes atom; and 3.3.1. Understanding principal and notation rules for electron configuration.

3.1.1.4 Concept analysis. Concept analysis purposes to identifying principal concepts in atomic structure topic which arranged systematically by correlating concepts in form of a brain map/concept map. Some concepts of this topic are elementary particles of atom, atomic model theory, quantum number, electron configuration and rules.
3.1.1.5 Learning objectives analysis. Learning objectives analysis purposes to convert the result obtained from task analysis and concept analysis into some specific learning objectives.

3.1.2 Design. Design phase purposes to prepare prototype of instructional media set. The designed prototype is a chemistry ludo game based on CET on atomic structure topic. A set of this game consists of a chemistry ludo game board, a modified die, a dice cup, four set question books (green, red, blue and yellow), 16 ludo pieces (four pieces for every color), a sheet of game rules and an assessment form sheet.

3.1.3 Develop. This phase purposes to develop an instructional media that has been revised based on some input (critics and suggestion) from various party.

3.1.3.1 Design validation by expert and revising design. Design validation of the product were done by three lecturers from chemistry department, FMIPA UNP and two chemistry teachers from MAN 1 Payakumbuh. Validity level of this product were based on four media functions, cognitive function, attention function, affective function and compensatory function. The result of this validity test can be seen in Figure 1.

![Validity Test Analysis Result](image)

**Figure 1.** Media function from validity test analysis result.

3.1.3.2 Product trial. Product trial purposes to check the validity of concepts, shapes/forms, appearance, grammar, and practicality of this media as a chemistry instructional media. The practicality level of this product was based on four media functions, cognitive function, attention function, affective function and compensatory function.

Determination of practicality level of this product were done two chemistry teachers along with 18 students from class X MIA 1 MAN 1 Payakumbuh by disseminating practicality questionnaire form. The analysis result of this practicality test from teachers and students can be seen in Figure 2.
3.2. Discussion

3.2.1. Validity level determination.

3.2.1.1 Cognitive function. Based on assessment data from validator for cognitive function of the product, kappa moment value obtained was 0.77, which can be interpreted as high in term of validity. This means that factual knowledge which contained in this product is suitable with basic competencies which students need to achieve. For example, addition of Dalton atomic model image on square number 1 in chemistry ludo game board which can be seen clearly by players and can help them imagine what an atom’s looks like.

Conceptual knowledge which contained is suitable with basic competencies which students need to achieve. For instance, knowledge about Neutron (n) in square number 10 which explain that neutron is a particle which has neutral charge and can be found in the atomic nucleus.

Procedural knowledge which contained is suitable with basic competencies which students need to achieve. For example, Aufbau Principle which can be found on square number 27 which states that electron fill atomic orbital from the lowest before the highest level.

Questions that is used is also suitable with basic competencies that students need to achieve. For instance, question about quantum number on number 32 in each question set that already correlated with basic competencies and also varied with each color set so student can understand the concept better.

According to [3], cognitive function aims to achieve learning purposes easier and to understand and remember information or messages which contained in the images. Furthermore, according to [8], instructional media in its use should be relevant with competencies that need to be achieve and the learning content itself.

Based on this theory and its relation with the factual knowledge, conceptual, procedural and questions that were used in this instructional media, it can be assumed that the developed product can be used as instructional media since it’s already fulfilled cognitive function of an instructional media.

3.2.1.2 Attention function. Based on the assessment data from validators for product’s attention function, kappa moment value is obtained is 0.82 which considered as very high in term of validity. This means that the use of Indonesian language in this product following the grammar rules of Indonesian language, and it’s also easy to understand.
Images, symbols and letters can be seen clearly and also attractively. For example, addition of Thomson atomic model image in square number 2 in game board. It can be seen clearly that the use of 3D model can be seen clearly and attractively compared to 2D model.

Font types and its sizes that were used can be seen clearly. Font types that were used in game board is Source Sans Pro with thickness varying from Light, Regular, Semi Bold and Black with font sizes varying from 8.12 pt until 53.72 pt. Whereas for questions set, font type that were used is Source Sans Pro with Light thickness and font sizes 7 and 11 pt; Raleway with Black thickness and font size 17.65 pt.

Display color is already attractive. The colour that were used is Baby Blue Eyes, Laser Lemon, Tulip dan Light Green. Gradiation color then determined, then some effects added and each square’s height varied. This need to be done so product’s display color can be more attractive rather than the other ludo game in general.

According to [3], affective function aims to make students have some interest and focused student’s attention to make them concentrate more to the lesson content which related to visual meaning which showed or subject matter text. Moreover, according to Kemp and Dayton in [9], the use of special effect in instructional media can increase the curiosity which showed that media has motivation aspect and increase the interest.

Based on this theory and its relation of language, images, symbol, fonts and colours that were used in this instructional media, it can be assumed that the developed product can be used as an instructional media cause it’s already fulfilled the affective function of an instructional media.

3.2.1.3 Affective function. Based on the assessment data from validators for the product’s affective function, the kappa moment value obtained was 0.75, which considered as high in terms of validity. This means that the chemistry ludo game can attract the interest, fun and increasing student’s activity.

According to [3], affective function of a media can be seen from student’s level of enjoyment when learning (or reading) pictorial text. The advantages of game media according to [10] is becoming a fun and entertaining thing to do, also allowing active participation from students to learn.

Based on the stated theory above and the assessment data obtained, it can be assumed that using CET based chemistry ludo game, students will be feeling happy; student’s level activity will increase; and students’ attention will increase into this instructional media and atomic structure topic that they learned about.

3.2.1.4 Compensatory function. Based on the assessment data from validators for the product’s compensatory function, the kappa moment value obtained were 0.75, which considered as high in term of validity. This means chemistry ludo game could comprehend student’s understanding.

According to [3], compensatory function aims to accommodate students who is weak and slow in receiving and understanding the content of lesson which presented verbally, therefore students can organized the information in the texts and remember the content again.

Then, it can be assumed that by using the chemistry ludo game based on CET on atomic structure topic can comprehend student’s understanding in atomic structure topic, this is because students can organize the knowledge that they obtained by their ability.

From the validity test which has been performed, it can be assumed that the developed product has fulfilled four media function: attention, affective, cognitive and compensatory. Kappa moment value which obtained for this product was 0.77 which considered as high in term of validity. So, it can be concluded that the developed instructional media valid to be used in the learning process.

The final product of this developed product can be seen on Figure 3 (a to d). To make it easier to use and bring this product to anywhere, a special box made for this product. The box made from a thick carton to make it sturdy and can be used for a long time. The box consists of bottom and top layer with slightly bigger size than the game board. The box also coated with some decorations on both layer, which consists of some model who played the game; brief description of the game; the creator; amount of players who can play this game together, and many thing else. The paper which
coated the box were made from photo/matte paper. This paper aims to make this box could stand for a long time and not easily broken by water or any other liquids that could damage or ruin the game set.
Figure 3. Final product of the development product. (a) Game board; (b) Example of question from the questions books; (c) Game rules; and (d) Assessment form sheets.
3.2.2. Determining Practicality Level.

3.2.2.1 Attention function. According to [3], attention function aims to attracting and focusing student’s attention to concentrate into the content of the lesson which related to visual meaning which presented or attached in the text of subject matter. Practicality can be assessed from the attractive content, attractive display, easy-to-understand explanation, easy-to-understand sentences and easy-to-understand images [11].

Images, writing and letters which used is clear, easy to read and easy to understand. Orbital diagram pictures that is used can be seen clearly on the game board that is being used. Writing and fonts that is used can be seen clearly and easy to read. Source Sans Pro is used as font type with size 12 pt and printed on a board with size 38 x 38.5 cm, therefore the writing and letters can be read clearly by players.

The practicality assessment data for the product’s attention function, kappa moment value obtained was 0.80 (from teachers) and 0.94 (from students). This value showed that attention function for the developed product has been fulfilled, therefore it can be concluded that the practicality value of the developed instructional media considered as high until very high.

3.2.2.2 Affective function. According to [3], affective function of a media can be seen from student’s enjoyment level when studying (or reading) text with images.

The practicality assessment data for the product’s affective function, kappa moment value obtained was 0.90 (from teachers) and 0.97 from students. This value showed that product’s affective function has been fulfilled, therefore it can be concluded that the practicality value of the developed instructional media considered as very high.

3.2.2.3 Cognitive function. According to [3] cognitive function can make student achieve the objectives and to understand and remember information or messages contained in pictures or text with images. Some aspect that determined an instructional media considered as good or not is when the media could increase student’s understanding, ease data interpretation and giving the information.

Based on this theory, and practicality assessment data for product’s cognitive function, kappa moment value obtained was 0.76 (from teachers) and 0.94 (from students). This showed that cognitive function product has been fulfilled, therefore it can be concluded that practicality level of this developed instructional media considered as high until very high.

Other than that, from the assessment result of evaluation questions after using the product, 15 of 18 students (83%) obtained the mark above the standard with average 84.03%. This means that the developed product could establish comprehend student’s factual, conceptual and procedural knowledge which means cognitive function from the instructional media has been fulfilled.

3.2.2.4 Compensatory function. According to [3], compensatory function of a media could help students whose weak in reading to acquire the information in texts and remember it again.

The shape of the developed product, this game has dimension 24 x 22 x 5 cm, so it can be bringing to anywhere, and can be used anywhere and anytime. The material that is used in this media product aims to make this developed product can be long-lasting and can be used repeatedly. This is suitable with compensatory function, which could be useful for students whose weak in reading, because this developed instructional media can be used repeatedly.

Practicality assessment data for product’s compensatory function, kappa moment value obtained was 0.95 (from teachers) and 0.92 (from students). This showed that product’s compensatory function has been fulfilled, therefore it can be concluded that practicality level of the developed instructional media considered as very high.

From the practicality test which has been performed, it can be concluded that the developed product has fulfilled four media function: attention, affective, cognitive and compensatory function. Kappa moment value obtained was 0.85 (from teachers) and 0.94 (from students), this value showed
that the developed instructional media is considered as very high. So, it can be concluded that the developed instructional media is very practice to be used in the learning process.

4. Conclusion

Based on the research, the author concluded that (1) the chemistry instructional media in form of chemistry ludo game based on CET on atomic structure topic for 10th grade high school student can be developed using 4-D model; (2) the developed instructional media have high validity level and very high practicality level, based on attention function, affective function, cognitive function and compensatory function.

References

[1] Hamalik O 2008 Kurikulum dan Pembelajaran (Jakarta: Bumi Aksara)
[2] Kementerian Pendidikan dan Kebudayaan 2016 Silabus Mata Pelajaran Sekolah Menengah Atas/Madrasah Aliyah (SMA/MA), Mata Pelajaran Kimia
[3] Arsyad A 2002 Media Pembelajaran (Jakarta: PT Raja Grafindo Persada)
[4] Allen R E, Fowler H W and Fowler F G 2011 The Concise Oxford Dictionary Of Current English (London: Clarendon Press)
[5] Fadillalah M 2014 Edutainment Pendidikan Anak Usia Dini (Jakarta: Kencana Prenada Media Group)
[6] Boslaugh S and A W P 2008 Statistics in A Nutshell, a desktop quick reference (Beijing, Cambridge, Farmham, Koln, Sebastopol, Taipei, Tokyo: O’reilly)
[7] Trianto 2012 Mendesain Model Pembelajaran Inovatif-Progresif (Jakarta: Kencana Prenada Media Group)
[8] Susilana R and Riyana C 2009 Media Pembelajaran: Hakikat, Pengembangan, Pemanfaatan dan Penilaian (Bandung: CV Wacana Prima)
[9] Sanjaya W 2012 Media Komunikasi Pembelajaran (Jakarta: Kencana Prenada Media Group)
[10] Sadiman A S, Rahardjo R, Haryono A and Rahardjito 2012 Media Pendidikan: Pengertian, Pengembangan dan Pemanfaatannya (Depok: Rajawali Pers)
[11] Alfianika N 2016 Buku Ajar Metode Penelitian Pengajaran Bahasa Indonesia (Yogyakarta: Deepublish)