THE DEVELOPMENT OF CHEM MAN COMPUTER GAME AS ATOMIC CONSTITUENT PARTICLES LEARNING MEDIA FOR 10th GRADE HIGH SCHOOL

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Abstract

This study aimed to obtain Chem Man computer game as atomic constituent particles learning media for 10th grade high school. This feasibility was viewed from the validity, practicality, and effectiveness of the game. Method of the research used the Research and Development (R & D) method with three steps, namely (1) preliminary study, (2) development (3) trial. The instruments were used game review sheets, game validity, pre-test and post-test, observation of student activities, students' responses, and students' interest in learning. The trial was conducted in one class consist of 30 students of X MIPA 7 SMAN 19 Surabaya. The results of content validity and construct validity obtained a percentage in the range between 80% - 93.33% with valid to very valid categories. The practicality in terms of observation of students' activities obtained a percentage 98.79% with a very practical category and the response of students gained a percentage 96.67% with a very practical category. The effectiveness in terms of student learning outcomes, namely classical completeness of students got a percentage 100% with a very effective category and the results of participant learning interest questionnaires obtained an overall average percentage 97.78% with high category.

Keywords: Chem Man Game, Learning Media, Atomic Constituent Particles.

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INTRODUCTION

The learning process in educational units is held interactively, inspirational, fun, challenging, motivating students to play an active role and provide sufficient space for initiatives, creativity, independence in accordance with the talents, interests, physical and psychological development of students [1]. One of the efforts of the education program is by empowering technology that are appropriate to be used when educators deliver material.

Chemistry is a branch of science that deals with the nature of matter, the structure of matter, changes in matter, laws and principles that describe changes in matter, as well as concepts and theories that interpret (explain) changes in matter [2]. Understanding of chemistry requires high activity and creativity from students as learning parties and from teachers as learning facilitators. The concepts in chemistry are generally complex which require scientific reasoning so learning chemistry is a mental activity that requires high reasoning. This has the potential to be a cause of learning difficulties for students [3]. Atomic constituent particles in atomic structure are the material taught in class X which requires reasoning in the material in the form of concepts that require understanding, memorization and counting.

Chemical phenomena are described and explained by chemists using levels of representation which include macroscopic, microscopic, and symbolic representations. The many conceptual errors that occur in chemistry derived from the inability of students to visualize structures and processes at the microscopic level [4]. Learning media provide immediate feedback on learning outcomes carried out by students to facilitate students in learning, one of the ways that can be taken is by using a computer [5].

Based on the results of the pre-research questionnaire conducted at SMAN 19 Surabaya, it showed that teachers had not used computer media as a chemical learning media. In addition, one of the factors that caused students not interested in understanding the concept of atoms was the learning media used which showed that as many as 100% of students had never studied chemistry used learning media in the form of previous games and 94.4% of students agree if Chemical material is taught using computer-based learning media in the form of games. Based on the results of interviews with chemistry teacher, the use of learning media in chemistry lessons had never used learning media in the form of Computer game to support teaching and learning activities.

Computer-based games can be interesting and fun learning media providing new experiences in the learning process and do not eliminate the essence of learning that is expected to support learning outcomes and increase interest in learning. Lessons that attract students, will be easier to learn and save by them [6]. If students have a feeling of being happy about something, these students will try to get it and will not give up before the learners get what they want. The game can work well as a tool to facilitate students' understanding in learning both on a large scale and small scale and enthusiastic about students in chemistry subjects [7]. The need for games as learning media by utilizing computer technology to solve existing problems, namely Chem Man game. Chem Man game is a game of balls placed on a labyrinth road that contains material and practice questions about atomic constituent particles in order to achieve the completeness of learning outcomes and increase students' interest in learning chemistry about atomic particles.

Based on the background described, it showed that the need to develop a computer media in the form of a game, then developed Chem Man computer game as atomic constituent particles learning media for 10th grade high school.

METHOD

The research method that used of the development of Chem Man computer game as atomic constituent particles learning media for 10th grade high school refers to the Research and Development (R & D) method which consists of three stages, namely: (1) preliminary study (2) development, (3) trial [8]. The following is an explanation of each stage of the study.

1. Preliminary Study
   Preliminary study is initial stage or preparation for game development.
a. Literature Study, this stage is carried out to study and learn concepts or theories relating to the product or model that will be developed.
b. Field survey, are used to collect data regarding planning and implementing learning using games.
c. Product Draft Preparation, Preparation of draft game products can be in the form of storyboards. In addition to compiling material and questions related to the material in the game based on learning objectives.

d. Game Review, the Chem Man game developed was reviewed by lecturers as material experts as well as media experts to provide advice and input.
e. Game improvement, comments and suggestions from reviewers will then be used as a guide to improve the draft game.
f. Game Validation, Validation was performed on the game by two lecturers and one chemistry teacher as material experts as well as media experts. Validity consists of construct validity and content validity of the game. Scores based on the Likert scale in Table 1.

Table 1. Likert Scale

Statement	Score
Very Bad	1
Bad	2
Good Enough	3
Good	4
Very Good	5

[9]

The results of the assessment data are analyzed on each indicator using the following formula.

$$\text{Percentage of Validity} = \frac{\text{total score}}{\text{criteria score}} \times 100\%$$

Information :
Criteria score = highest score in each item x number of validators

The results of the analysis are then interpreted according to the criteria in Table 2.

Table 2. Percentage of Validity Criteria

Percentage	Criteria
0% – 20%	Invalid
21% - 40%	Less Valid
41% - 60%	Valid Enough
61% - 80%	Valid
81% - 100%	Very valid

[9]

The game Chem Man is said to be valid if each aspect gets a percentage of validity $\geq 61\%$, with valid criteria.

2. Development
   The Chem Man game, which was developed after being assessed and declared valid to be used as a learning media, was further tested to obtain information on Chem Man games ready to be tested in one class of students.

3. Trial

In the trial phase, a trial of the game Chem Man was conducted. The trial was carried out by using the One Group Pre test - Post test Design, where students before conducting learning activities using the game were given a pre test in the form of questions, after which they were given a post test question. The results of the trials were analyzed to measure the practicality and effectiveness of the game Chem Man.

a. Game Practicality

Judging from the observations of the activities of students and the results of the questionnaire responses of students.

1) Results of Student Activity Observations

Observed using activity observation sheets. The
the practicality percentage can be calculated using the following formula as follows.

$$\% \text{ Practicality} = \frac{\text{percentage responses}}{\text{Number of students}} \times 100\%$$

The observation results will be used to obtain the practicality of the game Chem Man has been made using the interpretation of the scores in Table 3.

Table 3. Percentage of Practicaly Criteria

Percentage (%)	Category
0% - 20%	Very less practical
21% - 40%	Less practical
41% - 60%	Practical enough
61% - 80%	Practical
81% - 100%	Very practical

[9]

The Chem Man game is said to be practical if the assessment of the response of students is on the practical criteria which means reaching a score of ≥61%.

2) Questionnaire Results for Students' Responses

Scoring is done based on the Guttman scale score in Table 4.

Table 4. Guttman Scale Score

| Answer | Score for Statement | |
	Positive	Negative
Yes	1	0
No	0	1

[9]

The practicality percentage can be calculated using the following formula as follows.

$$\% \text{ Practicality} = \frac{\text{percentage responses}}{\text{Number of students}} \times 100\%$$

The results of this response questionnaire will be used to obtain the practicality of the game Chem Man as a learning media using interpretation of the scores in Table 5.

Table 5. Percentage of Practicality Criteria

Percentage (%)	Category
0% - 20%	Very less practical
21% - 40%	Less practical
41% - 60%	Practical enough
61% - 80%	Practical
81% - 100%	Very practical

[9]

The game Chem Man is said to be practical if the assessment of the response of students is on the practical criteria which means reaching a score of ≥61%.

b. Game Effectiveness

Judging from the results of learning and the results of the questionnaire interest in learning students.

1) Learning Outcomes of Students

Learning outcomes of students are obtained using a sheet of pre test and post test to obtain individual completeness using the following formula as follows.

$$IC = \frac{\text{Total score obtained}}{\text{Maximum number of score}} \times 100\%$$

Information:

IC = individual completeness

Individual completeness is set with a score of ≥75%. Furthermore, it can be determined the completeness value in a classical manner with the following formula as follows.

$$CC = \frac{\text{Number of students who complete}}{\text{Total number of students}} \times 100\%$$

Information:

CC = classical completeness

These results are used to obtain the effectiveness of the game being developed. Classes are declared complete classically if they get a classical completeness score of ≥85% [10].

2) Results of Questionnaire for Students Learning Interests

In the questionnaire the interest in learning the students' scores were based on a Likert scale score in Table 6.

Table 6. Likert Scale

Statement	Score
Very Agree	5
Agree	4
Neutral	3
Disagree	2
Very Disagree	1

[9]

The data obtained will be analyzed using the following calculations [11].

$$PLI = \frac{Frequency}{maximum\ score} \times 100\%$$

Information:

PLI = Percentage of Learning Interest
The percentage of each student is then calculated as a whole using the following formula.

$$PE = \frac{total\ percentages}{maximum\ total\ score} \times 100\%$$

Information:

PE = Percentage of Effectiveness
Then to obtain the learning interest categories of students then use the guidelines according to Suharsimi. The results of this learning interest questionnaire will be used to obtain the effectiveness of the game Chem Man as a learning media by using score interpretations in Table 7.

Table 7. Percentage of Effectiveness Criteria

Percentage(%)	Criteria
76-100	High
56-75	Medium
0-55	Low

[12]

The Chem Man game is said to be effective if the student's interest in learning questionnaire assessment if the total score shows a positive result that is agree and the score strongly agrees to be on the high criteria means reaching a score of ≥76%.

RESULT OF RESEARCH AND DISCUSSION

The results of the research and discussion about the development of the Chem Man computer game as atomic constituent particles learning media for 10th grade high school will be described as follows.

1. Preliminary Study

At this stage was the initial stage of preparation for the development of Chem Man game. The stages in the preliminary study will be described as follows.

a. Literature Study

Based on the 2013 curriculum currently applied which required a learning process to developed knowledge, thinking skills and psychomotor skills through direct interaction with learning resources. Besides that, it was based on learning theories that support the development of games as learning media. Learning theories that support the game were constructivism learning theory, cognitive learning theory, and information processing theory. The theory was found in the game as a learning media.

b. Field Survey

Based on the results of the pre-research questionnaire conducted at SMAN 19 Surabaya, it showed that teachers had not used computer media as a chemical learning media. In addition, one of the factors that caused students not interested in understanding the concept of atoms was the learning media used which showed that as many as 100% of students had never studied chemistry used learning media in the form of previous games and 94.4% of students agree if Chemical material is taught using computer-based learning media in the form of games. Based on the results of interviews with chemistry teacher, the use of learning media in chemistry lessons had never used learning media in the form of Computer game to support teaching and learning activities.

c. Product Draft Preparation

The material contained in the game was sub material protons, electrons and neutrons; atomic number and mass number; and isotopes, isobars, and isotons. The indicators and learning objectives that had been formulated refer to the

Core Competencies and Basic Competencies that are in the 2017 Revised 2017 syllabus applied. Basic competency used was Basic Competence 3.2. The designed storyboard was used as a reference in developing the game. In the game, there are several material videos to made it easier for students to learn the material of atomic particles.

d. Game Review

The results of the game review showed that there was a need for a language selection menu, the suitability of the sentence in the learning objectives needs to be reviewed, includes brief instructions for game users, regarding the technical if there was an error in the game.

e. Game Improvement

Comments and suggestions from reviewers were used as a guide to improve game that language option was added. The following was one example of improvement after review.

Figure 1. Before Improvement

Figure 2. After Improvement

f. Game Validation

The validator who validated the Chem Man game was two lecturers and one chemistry teacher using an assessment sheet consisting of content validity and construct validity. Details of the results of the game validity are summarized as follows.

1) Content Validity

The results of the content validity were described in Table 8.

Table 8. Results of Content Validity of the Chem Man Game

Rate Aspect	Indicator	P(%)	Category
Truth concepts	Chemical concepts in game is true	86.66%	Very Valid
Conformity of the material with the learning objectives	Material in the game in accordance with the objectives	86.66%	Very Valid

Based on Table 8, the game Chem Man which was developed as a learning media fulfilled the aspect of content validity on the assessment indicator "The concept of chemistry in the right game" gained 86.66% and the indicator "material in the game according to purpose" got a percentage of 86.66% which means that both were included in the very valid category because they were classified in the percentage range of 81% -100% because the game is said to be valid if it gets a percentage of ≥61% [9].

Assessment indicators in this aspect means that the atomic constituent material, as well as the questions in the game are in accordance with existing concepts in chemistry, especially the matter of atomic constituent particles. Learning media for its use must be relevant to the competencies to be achieved [13]. Material selection must be considered so that there were no conceptual errors.

The statement shows that the use of learning media must always look at competencies and teaching materials. Learning activities are designed to provide learning experiences that involve mental and physical processes through interaction between students, students with teachers, the environment, and other learning resources in order to achieve Basic Competence [14]. The Chem Man game can delivered learning material by being declared valid by the validator.

2) Construct Validity

The results of the construct validity were described in Table 9.

Table 9. Results of Construct Validity of the Chem Man Game

Rate Aspect	Indicator	P(%)	Category
Characteristics of science	There are Investigative activities	80.00%	Valid
Encourage developing skills	Develop basic sains process skills	86.66%	Very Valid
Conformity with the characteristics of students	In accordance with the learning style and age of students	80.00%	Valid
Have rules	There are guidelines or rules for playing	86.66%	Very Valid
Guiding Character	There are instructions for completing the game	86.66%	Very Valid
There is competition, requirements and strategies in playing	Requires a certain way to succeed	80.00%	Valid
Have a standard of success	There is a requirement to proceed to the next level	86.66%	Very Valid
Challenge and involve active students	Encourage students to play while learning	86.66%	Very Valid
There is feedback	There is a penalty for failure	86.66%	Very Valid
	There are prizes if success	93.33%	Very Valid
Has an element of decision making	Options are available in answering or stepping to play	93.33%	Very Valid
Display as a learning media	The font size used is appropriate	86.66%	Very Valid
	Animations used are in accordance with the content	80.00%	Valid
Software engineering	Ease of use and simplicity of operation	80.00%	Valid
	Easy installation	80.00%	Valid
Audio visual communication	There is a connection between narration, sound effects, backsound, and music	80.00%	Valid
	There is harmony between the background design and the placement of the text and color	80.00%	Valid

Based on Table 9, the results of the assessment indicate that the game Chem Man was declared valid. This is based on the results of the evaluation by the validator which showed that each indicator got a score range of 80%-93.33% with valid criteria to very valid. it can be saw that the material and video in the game were correct based on the questions in the game, pre test and post test, and the material and videos that were in the game according to the learning objectives to be achieved. One component in the game is the existence of certain goals to be achieved [15]. Thus, the material of atomic constituents, videos related to the atomic constituent material, as well as the questions that are in the game Chem Man were developed in accordance with the learning objectives to be achieved which are in accordance with Basic Competencies 3.2 on the syllabus and very valid as media learning. This very valid assessment is supported by Fenrich that educational games contain decision-making activities [16]. In the Chem Man game which was developed, it gave an element of choice in answer where the questions presented were in the form of answer choices that must be determined correctly.

The assessment consists of two aspects, namely construct validity or game arrangement and content validity. The assessment was carried out by three validators. The results of the assessment indicate that the game Chem Man was declared valid. This is based on the results of the evaluation by the validator which showed that each indicator got a score range of 80%-93.33% with valid criteria to very valid. The results obtained from the game validity obtained from the Chem Man game appraisal showed that the game got valid criteria with a validity percentage of ≥61%.

2. Development

This limited trial was carried out as a preliminary trial to find out the implementation of the Chem Man game which was tested limitedly covering 6 students and used as a basis for preparing a lesson plan for class trials. In this limited trial, information was obtained that at level 2 faltered and loading to enter level 3 was too long. The Chem Man game was then repaired, after it was smooth and there were no obstacles, the Chem Man game was ready to be tested in one class.

3. Trial

Trial on this game were carried out on one class consist of one class consist of one class consist of 30 students with observations by 5 observers who acted as observers of student

activation. The trial of the Chem Man game was conducted on Thursday, January 31, 2019 in 10th grade MIPA 7 SMAN 19 Surabaya to obtain the practicality and effectiveness of Chem Man game.

a. Game Practicality

In this study, the practicality of the game in terms of the observations of student activities observed during the use of the game and the results of the questionnaire responses of students after using the game. The following was a description of the results of observations of student activities and the results of the questionnaire responses of students during the trial. The details of the results are described as follows.

1) Observations of Student Activities

The following were observations of student activities results.

Table 10. Observations of Student Activities Results

| Indicator | Judgement | |
	P (%)	Category
Start the game	100%	Very Practical
Operate the game on level 1 material about protons, electrons and neutrons	96.66%	Very Practical
Operate the game on level 2 material about mass numbers and atomic numbers	97.33%	Very Practical
Operates games on level 3 material about isotopes, isobars, and isotons	100%	Very Practical
End the game	100%	Very Practical
Total average percentage	98.79%	Very Practical

Based on Table 10, it showed that the observation of the activities of students when using the game Chem Man has an indicator with the percentage of average activity in the range of 97.33%-100% so that it was categorized as very practical with a total percentage reaching 98.79%. The Chem Man game was said to be practical if the observation results of student activities are on the practical criteria which means reaching a score of ≥61%. This is in accordance with the results of the study that using appropriate media will bring out good student activities [17]. The activity of students when using the game Chem Man shows good results so that the material making up atomic

particles will enter into the long-term memory of the students. Long-term memory serves to store very large information for a long time. The information stored in it can be in the form of verbal or visual [18]. The percentage showed that the overall activity of students during playing the Chem Man game was done very well and reached the goal that students carried out the steps in the game well.

2) Students Responses Questionnaire

The following were student response questionnaire results.

Table 11. Student Responses Questionnaire Results

| Purpose | Judgement | |
	P (%)	Category
Get the attractiveness level of the Cham Man Game	94.44%	Very Practical
Get the clarity level on how to apply Chem Man game	98.89%	Very Practical
Get the ease level of Chem Man game	96.67%	Very Practical
Total Average Precentage	96.67%	Very Practical

Based on the student response questionnaire results, the Chem Man game was very practical to use because the average of all aspects gets a percentage of 96.67%. In the level of attractiveness it got 94.44%, the level of clarity gets 98.89%, and the ease of play 96.67%. All three get very practical criteria. This is supported by the statement that one of the factors considered in the selection of media is practical or easy to use [15]. Interest in learning is defined if someone who is interested in a lesson then he will have a feeling of interest in the lesson. He will diligently study and continue to understand all the knowledge related to the field, he will take lessons with great enthusiasm and without any burden in him [19]. Attention was a person's concentration on observation, understanding or the other by putting aside other things than that. So students will had attention in learning, if their soul and mind are focused on what they are learning.

b. Game Effectiveness

The effectiveness of the game in terms of student learning outcomes obtained through student learning outcomes was saw by using the sheet pre test and post test and student learning interest using questionnaires of learning interest of students observed during the use of the game Chem Man. The following was a description of

the learning outcomes of students and the results of questionnaires for students' interest in learning during the trial.
1) Learning Outcomes of Students

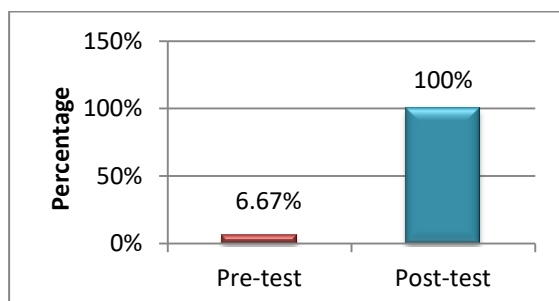The following were learning outcomes of students results.

Figure 3. Classical completeness of students

Can be saw in the graphical picture of the classical completeness of the students, there was an increase in students' mastery learning from 6.67% to 100%. The game increases student learning outcomes [20]. Thus, it can be said that 100% of students complete or reach classical completeness of 100% so that the game of Chem Man can be said to be effectively used as a learning media because it gets the percentage of classical completeness ≥85% [10].
2) The Students' Interest in Learning Questionare

The results of the students' interest in learning questionnaire who obtained the overall average percentage of the total positive percentage of each indicator, namely the statement strongly agreed and agreed to be 97.78% with students' learning interest categories high so that the Chem Man game was declared effective as a learning media. Developing an interest in something is basically helping students see how the relationship between material is expected to be learned by themselves as individuals [6]. Interest can also be interpreted as a desire from within to understand so as to give rise to new experiences [21]. interest affects three important aspects of one's knowledge, namely attention, purpose and level of learning [22]. Interest arises based on the curiosity that is inspired or influenced by the environment [23]. The Chem Man game that attracts students' interest in learning so that students can further strengthen this interest and bring more curiosity to the game Chem Man. students try to understand the learning material that is the matter of atomic constituent particles when the Chem Man game took place to be able

to finish the game to the end. In the Chem Man game students use the game individually with each of their personal computers and are able to measure the abilities of each individual. The total percentage statement was included in the criteria for high learning interest because it is in the range of 76% -100%. The Chem Man game is said to be effective if the student's interest in learning questionnaire assessment if the total percentage agrees and the score strongly agrees to be on the high criteria means to reach a score of ≥76%.

CLOSURE
Conclusion

Based on the formulation of the problem and the discussion related to the development of Chem Man computer game as atomic constituent particles learning media for 10th grade high school can be summarized as follows.
1. Chem Man computer game as atomic constituent particles learning media for 10th grade high school based on validity aspects that was declared valid, based on the results of the validator obtained percentages in the range between 80% - 93.33% with valid to very valid categories.
2. Chem Man computer game as atomic constituent particles learning media for 10th grade high school based on practical aspects that was stated to be practical, based on participant observation of student activities while using the game Chem Man by obtained an average percentage of 98.79% with very practical categories and student responses towards the Chem Man game through the questionnaire given before using the Chem Man game, the overall average percentage was 96.67% with a very practical category.
3. Chem Man computer game as atomic constituent particles learning media for 10th grade high school based on effectiveness aspects was declared effective in terms of student learning outcomes namely individual completeness of students got a score of ≥75 and classical completeness of 100% in a very effective category. The results of the student's interest in learning questionnaires after using the game Chem Man by obtained an overall average percentage of 97.78% with a high category.

Based on this description, the Chem Man computer game is worthy of being used as a chemical learning media in atomic material.

Suggestion

Based on the results of research and discussion related to the development of the Chem Man computer game as atomic constituent particles learning media for 10th grade high school can be given the following suggestions.

1. Allocation of time in the game is very necessary according to the length of time required detailed request in each level so that students can understand the material delivered in the game that is maximum and timely.

2. Managing the class with the number of trial participants The number of one student who must participate well in observing the trial of the Chem Man game because of the different levels of difficulty of the game each student makes observations of different activities.

3. The Chem Man computer game providing interest in learning that is of high interest to students who want to continue learning, so that it is expected to be used in schools as learning media.

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