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Development of the UNOChem Game to Improve Students' Critical Thinking Skills on Factors that Affect the Reaction Rate Topic

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Abstract: The UNOChem game is a development of the UNO Stacko game that has been modified and designed with chemistry materials. This research aims to develop UNOChem games to improve students' critical thinking skills on the material factors that affect the appropriate reaction rate. The feasibility of the UNOChem game is seen in its validity, practicality, and effectiveness. This research refers to 4D design with three stages: define, design, and development. The limited trial was carried out in class XI-2 of SMAN 1 Kedamean. The indicators used in this study are interpretation, analysis, and inference. The validity was obtained from the results of the game assessment by two chemistry lecturers and one chemistry teacher. Practicality was obtained from observation of student activities and a questionnaire of student responses after using the UNOChem game. Effectiveness was obtained from the student's critical thinking skills test results. The study results showed that the validity obtained in each aspect of the obtaining mode was ≥ 4. The practicality of the UNOChem game based on the results of observation of students' activities as a whole got a practicality percentage of 87.4%. Meanwhile, based on the student response questionnaire, in the aspect of describing the level of students' interest in the UNOChem game, the percentage of practicality was 100%; in the aspect of describing the level of ease of understanding the material and doing critical thinking problems in understanding the material, the percentage of practicality was 93.3%. In describing the ease of using the game in the game, the rate of practicality was 94.9%. The game's effectiveness was obtained through an n-gain test with a score of 0.72. The effectiveness of the media is supported by the Wilcoxon Signed Rank Test (a non-parametric test), which shows a Sig. A value of 0.000 means there is a significant difference, and the UNOChem game can be declared effective. Based on the research results, the UNOChem game is suitable for learning material activities related to factors that affect the reaction rate of class XI high school.

Keywords: Critical Thinking; Factors That Affect The Reaction Rate; Unochem Game.

Introduction

Education is a process of acquiring interpretive skills, knowledge, and ways of behaving according to needs based on specific methods [1]. Increasing the quality of education needs attention because it can create competent students who can compete in the current era of globalisation. The 21st-century skills are the 4Cs: communication, collaboration, creativity and innovation, and critical thinking and problem-solving [2]. Curriculum development is an important instrument that must be considered to improve the quality of education. In Indonesia, the implementation of the curriculum has undergone various changes that have led to a new independent curriculum. The independent curriculum is implemented to achieve the goal of improving the learning process through learning activities that are more meaningful, fun, and in line with the characteristics of the education unit for the formation of students with the profile of Pancasila students who are faithful, noble, independent, critical thinking, creative, cooperative, devoted to God Almighty, and globally diverse [3]. The use of an independent learning curriculum aims to carry out the challenges of education in the 21st-century era, where its application must accommodate and increase creativity, continue to innovate, skillfully collaborate and communicate, and think critically and solve problems [4]. In this study, the ability that needs to be improved is critical thinking skills.

The definition of critical thinking is a logical and reflective thought process that focuses on choosing what actions to take or beliefs to hold [5]. Critical thinking skills are divided into six indicators: interpretation, analysis, inference, explanation, evaluation, and self-regulation [6]. Critical thinking skills can be trained in learning activities, especially science subjects. One of the subjects in the field of science is chemistry. Chemical materials, including reaction rate material, are essential to learning [7]. Reaction rate is defined as the rate of a chemical reaction that occurs and is measured based on the speed of the product formation or the reduction rate of the response [8]. Students are expected to be able to understand and explain aspects of the rate by making observations, asking questions, and making predictions, as well as by analysing and processing data and information and communicating the results. This is based on the learning outcomes in phase F of chemistry subjects. [9]. The preliminary study conducted at SMAN 1 Kedamean Gresik stated that 34% of students could interpret, 14% could analyse, and 31% could infer. In addition, the results of interviews with Chemistry Teachers in the preliminary study at SMAN 1 Kedamean Gresik stated that learning media must be more varied to improve students' critical thinking skills.

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Learning media provides the student's knowledge and interest in learning [10]. Game media is one of the learning media that can give a sense of fun and convey knowledge. An educational game should encourage the development of specific skills and can help teach various skills [11]. Based on previous research, using uno staco chemistry media on hydrocarbon material as a learning medium is feasible, with an average percentage of 90% [12]. Learning by using UNO games can improve students' critical thinking skills by developing UNO games with analysis questions [13].

Based on the description above, this research aims to develop the UNOChem game as a medium for learning chemistry reaction rate material, especially the subchapter on factors that affect the reaction rate, which can solve the problem of students' lack of critical thinking skills. This UNOChem game media is adopted from the UNO Stacko game. UNO Stacko is a block-stacking game that can be played in groups. The difference between the UNO Stacko game and the UNOChem game lies in the game rules and the addition of question cards. On the available question cards, students will be asked to observe, make conjectures, analyse, and draw a conclusion on a phenomenon. Based on the above description, this article will present the research results on the validity of the games that UNOChem has developed. UNOChem was created with the hope of helping students to increase the value of critical thinking skills.

Research Methods

This research and development research refers to the 4D development model design with three stages of activities carried out: define, design, and development [14]. The research was conducted in the Faculty of Mathematics and Natural Sciences' Chemistry Education Study Program. Universitas Negeri Surabaya. The limited trial stage was conducted at SMAN 1 Kedamean Gresik from May 8, 2024, to May 15, 2024.

In the 4D development procedure, the problem and needs analysis stages are first carried out to develop UNOChem games as learning media and formulate the desired learning. This step consists of four phases: curriculum analysis, learner analysis, concept analysis, and task analysis. After that, the design stage of the UNOChem game, the desired learning medium, was carried out. The UNOChem game consists of UNOChem blocks and UNOChem question cards. The question cards were made of art paper 9.5x13 cm in size. The front side shows the writing UNOChem and the back side contains questions with critical thinking indicators that students must do. The question card consists of three different colours: in green, there are interpretation questions. In blue, there are analysis questions, and in red, there are inference questions. At the development stage, it consists of three stages, namely review, validity, and trial. The validity results by two chemistry lecturers, student response questionnaires, student activity observation, and student pretest and posttest results all demonstrate the viability of the UNOchem game.

Validity tests determine how much the measuring device (questionnaire) measures what is desired [15]. Validation sheets, observation sheets, student response surveys, and test questions designed to gauge students' critical thinking abilities were used in this study to collect data. Data analysis for the validation of the UNOChem game uses the mode method. The UNOChem game is declared valid if it gets a mode ≥ 4. The results of the activity observation and the student answer questionnaire, which are computed using the following formula, can be used to determine the applicability of the UNOChem game:

$$\%\ \text{practicability} = \frac{\Sigma\ \text{activities performed}}{\Sigma\ \text{overall activities}} \times 100\%$$

[16]

The results of the student's responses were analysed using the following formula, which refers to the Guttman scale:

$$\%\ \text{practicability} = \frac{\Sigma\ \text{data collection results score}}{\Sigma\ \text{criteria score}} \times 100\%$$

[16]

Based on the percentage results, the UNOChem game can be stated as practical if it gets a score ≥ 61%, which refers to the score criteria in Table 1.

Table 1. Score Criteria

Percentage	Criteria
0% - 20%	Very Less
21% - 40%	Less
41% - 60%	Simply
61% - 80%	Good
81% - 100%	Very Good

[17]

To see the effectiveness of the UNOChem game, a test of students' critical thinking skills was conducted, which was declared to have increased if the value obtained from the posttest results was higher than the value of the pretest results. The increase in students' critical thinking skills can be analysed using the n-gain method, with the following steps:

$$\text{N-gain} = \frac{Posttest - Pretest}{100\% - Pretest}$$

[18]

The n-gain obtained was interpreted using the n-gain score in Table 2.

Table 2. N-gain rate criteria

Interval	Criteria
(g) > 0.7	High
0.7 ≥ (g) > 0.3	Medium
(g) ≤ 0.3	Low

[18]

After the n-gain test, a normality test was conducted. Determining whether data originates from a regularly distributed population is called a normality test. When using SPSS for decision-making, data is usually distributed if the significance value is more significant than 0.05 and non-normally distributed if it is less than 0.05. In this study, the data showed no normal distribution, so the Wilcoxon Signed Ranks Test (non-parametric test) will be carried out with the following categories:

Table 3. Wilcoxon Signed Rank Test Categories

Interval	Criteria
Sig. (2-tailed) < 0.05	Significant
Sig. (2-tailed) > 0.05	Non-significant

Results and Discussion

An assessment of development research is based on four criteria: validity of contents, validation of construction, practicality, and effectiveness [19]. The development stage starts from the defining stage by conducting observations and interviews as a needs analysis in the study.

According to the findings of the observations and interviews, SMAN 1 Kedamean Gresik has been using an independent curriculum. Based on an analysis of student data, it was found that while students in class XI-2 SMAN 1 Kedamena Gresik are eager to study, teachers only utilise school-provided worksheets as a learning tool, and no learning resource is available to help students develop their critical thinking abilities. The analysis of concepts and tasks is adjusted to the learning outcomes of phase F in the independent curriculum regarding the subject matter of factors that affect the reaction rate and are associated with the needs of students. Furthermore, learning objectives were formulated based on the needs and curriculum applied.

The medium and formats are chosen during the design phase, and the UNOChem game's basic design—including its physical form, rules and guidelines for play, and learning activities—is created. After the design at the design stage is completed, the UNOChem game is made according to the procedures set out at the design stage.

The development phase evaluates the viability of the UNOChem game. This step enhances students' critical thinking abilities regarding the elements determining the reaction rate.

Review stage

After the game is completed, the UNOChem game will be reviewed first to obtain suggestions from lecturers regarding its shortcomings. Improvements to the game were made based on suggestions and comments on the results of the game review that had been carried out. The game that has been made, namely Draft 1, is reviewed, and then improvements are made to produce Draft 2. The following is an example of the results of the game review before and after being improved:

Figure 1. Game short description display before revision

Figure 2. Game short description display after revision

Validation

After the review stage and obtaining suggestions and input, the next stage is the validation stage, carried out by two UNESA chemistry lecturers and one SMAN 1 Kedamean Gresik chemistry teacher. The assessment consisted of two aspects: content validity and construct validity. Content validity is related to the correctness of the knowledge concept. Construct validity includes a) the characteristics of science, b) suitability for the characteristics of students, c) having rules, d) there are aspects of guiding, e) there are standards of success for students, f) challenging and actively involving students, g) providing feedback, h) there are aspects of decision making, i) colour display, graphic size and animation. The assessment results showed that the UNOChem game was declared valid. This is predicated on the validator's assessment results, which indicate that every aspect receives a mode 4 rating using appropriate criteria.

The UNOChem game that has been declared valid for use was implemented on students of class XI-2 SMAN 1 Kedamean Gresik for a limited trial. This trial aims to determine the practicality and effectiveness of the developed UNOChem game. The number of subjects for this trial was 24. The practicality of the UNOChem game was obtained from observing students' activities and responses. In contrast, the effectiveness of the UNOChem game in improving students' critical thinking skills was obtained from the pretest and posttest results.

Observation of Students' Activity

Six observers in all monitored a total of twenty-four students during this observation. The results of learner activity as a whole get a percentage of activity of 87.4% with efficient criteria. The percentage of activity shows that the overall activities carried out by students while playing the UNOChem game are good because all students can complete the game's stages until the game is finished according to research expectations.

Two learners needed help maintaining the blocks during the game, and some were not active in group discussions when working on problems. Nevertheless, the learners completed the game until the final stage.

Learner tasks in the UNOChem game to improve critical thinking skills are outlined in Table 4.

Table 4. Students' confidence influences critical thinking indicators when answering post-test questions. Piaget thought every child had the same developmental sequence but at different speeds. [20]

The response questionnaire results regarding the level of ease of use of the game obtained an average practicality percentage of 94.9%, so the UNOChem game was declared practical.

Students' Critical Thinking Skills Test

The effectiveness of the UNOChem game was developed based on the findings of the examination of the students' pretest and posttest results, namely the proportion of the outcomes from the critical thinking skills test that are complete, which was examined using the n-gain test and the Wilcoxon non-parametric test. The data of pretest and posttest scores were analysed using the n-gain formula to find out whether there was an increase in the results of critical thinking skills, and an n-gain result of 0.702 was obtained, which included a range of ≥ 0.7 with the "high" category, which can be seen in Table 6.

Table 4. N-Gain Score Results

Descriptive Statistics

	N	Min	Max	Mean	Std. Deviation
Ngain_Score	24	.26	1.00	.7025	.20575
Ngain_Persen	24	25.93	100.00	70.2460	20.57472
Valid N (listwise)	24				

This supports the idea that UNOChem games effectively improve students' critical thinking skills. Good media can develop students' thinking power to help them understand the learning material [21]. Learning media functions to attract students' attention, which is a benefit of using learning media.

Furthermore, a Shapiro-Wilk normality test was conducted to determine whether the students' critical thinking skills test results were usually distributed [22]. The findings can be considered regularly distributed if the normality test yields a value larger than 0.05. The normalcy test results indicate students' critical thinking abilities have a Sig. 0.003 value. The data is deemed to be "not normally distributed" based on this. Table 6 displays the results of the normalcy test.

Table 5. Shapiro-Wilk Normality Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.134	24	.200*	.955	24	.344
Posttest	.223	24	.003	.812	24	.000

Based on the normality test results declared "not normally distributed," the next step is to conduct the Wilcoxon Signed Ranks Test (a non-parametric test) to determine the significant difference between the pretest and the posttest. The Wilcoxon Signed Rank test is a nonparametric statistical test that does not pass normal distributed data requirements [23]. The Wilcoxon test was carried out, and the result was a value of Sig. < 0.05, which is 0.000. So, there is a "significant difference" in the pretest and posttest data presented in Table 8.

Table 6. Wilcoxon Signed Rank Test Results

		N	Mean Rank	Sum of Ranks
Posttest - Pretest	Negative Ranks	0[a]	.00	.00
	Positive Ranks	24[b]	12.50	300.00
	Ties	0[c]		
	Total	24		

Based on the information gathered from the creation of UNOChem games for students in grade XI, it is possible to conclude that the media is appropriate for use in the educational process based on the outcomes of tests for validity, practicality, and efficacy. Learning is more effective in helping students improve understanding, presenting interestingly and reliably and facilitating interpretation and condensing information [10]. This is supported by previous research that shows that games as learning media are effective in increasing interest in learning, so student learning outcomes also increase [24].

Conclusion

Based on the analysis of the research data results and the discussion of the research data, it can be concluded that the UNOChem game developed is declared worthy of review based on several criteria. The UNOChem game, which improves students' KBK on the material of factors that affect the reaction rate, is declared valid based on content and construct validity aspects. The UNOChem game obtained a mode score of 4 with the valid category. The UNOChem game to improve students' KBK on the material of factors that affect the reaction rate is declared practical based on the results of observations of students' activities and student response questionnaires. The results of the observations of student activity showed that the UNOChem game obtained an overall average of 87 4% in the three aspects observed in the practical category. In the student response questionnaire results, the UNOChem game obtained an overall average percentage of 94.9% on three factors that had to be filled in by students with practical criteria. The UNOChem game to improve students' KBK on the material of factors that affect the reaction rate is declared effective based on the students' KBK test. The n-gain value obtained was 0.7025 with a high category. It is based on the Wilcoxon Signed Rank nonparametric test of 0.000, indicating a significant difference between the pretest and posttest scores.

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