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The development of acrylic board game "Cytozzle" as a learning media on cells subject

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ABSTRACT

The use of learning media is known to improve students' thinking skills. The interview conducted at SMP N 9 Salatiga indicated that the students had some difficulties in learning about cells. This study aimed to develop learning media "Cytozzle" and determine the media's feasibility in teaching and learning. The research employed the modification of Borg and Gall development model that was consist of: 1) research and information collection, 2) planning, 3) develop a preliminary form of product, 4) preliminary field testing, 5) main product revision, 6) main field testing, 7) operational product revision, 8) operational field testing and 9) final product revision. The N-Gain test measured the effectiveness of the product. The validation results of the media experts, material experts, and pedagogy experts were 91.6% (very feasible), 85.7% (very feasible), and 80% (feasible), respectively. Also, educational practitioners' and students' responses were 86.6% (excellent) and 82.41% (good), respectively. The students learning with "Cytozzle" media showed an improved cognitive score, based on N-Gain test analysis, compared to learning with other media. In conclusion, the" Cytozzle" learning media is feasible to be used in learning about cells.

Introduction

Learning in the classroom is an essential factor in developing student learning abilities; besides the teacher's learning model, instructional media can help students empower their thinking skills. In line with Indriana (2011) opinion, learning media can support students in improving learning outcomes, including students' thinking abilities, because students obtain information verbally and gain experience directly. The use of learning media can improve the quality of learning.

Based on the interviews with the Natural Science (IPA) teacher at SMP N 9 Salatiga, there were obstacles in learning, namely students' difficulties in learning cell material. In the cell material, students have difficulty remembering the organelles' names due to using foreign terms. Students have a problem identifying the structure of cell organelles and their functions. This condition is in line with the research results by Hidayah and Nurtjahyani (2017), which states that there are several difficulties students have when learning science on cell material because there are many foreign terms in the names

of organelles. Besides, the microscopic cell size makes the material abstract because, during the cell observation practicum, not all parts of the cells are seen. Based on these problems, the use of media in learning is essential. This is because learning media can clarify the presentation of concepts and information and can overcome the limitations of senses, space, time, and small objects (Ariyanto, Priyayi, & Dewi, 2018; Trianto, 2007).

The observations show that the teacher's media in learning is limited to textbooks, charts, or cell pictures. Teachers have not developed other innovative media because they experience obstacles, especially in limited time, making tools cost and materials. The use of information technology is also still constrained by limited facilities and infrastructure in schools. Prastowo (2011) revealed that students often feel bored because the learning media used are monotonous and less innovative. Teachers must organize subject matter and innovate in learning to stimulate and challenge students to learn and lead to positive attitudes towards science subjects (Kurniawan, Astalini, & Kurniawan, 2019; Kustandi & Sutjipto, 2011).

Based on these problems, it is essential to develop learning media to support the student learning process. Indriana (2011) states that several factors must also be adjusted in selecting media, such as conformity to teaching objectives, the material taught, supporting facilities, student characteristics, and the theory used. Students at the junior high school (SMP) level are at the transitional stage from the children to the adolescent's level. Students are in the early stages of formal operational development, according to Piaget's theory of development. Students at this stage have the ability to think abstract, proportional, combinatorial, and reflective. The ability to think logically and systematically in problem-solving has also developed, also on this age, a student like challenging things (Dahar, 2011; Wendari, Badrujaman, & Sismiati S., 2016). In this regard, learning media in games can be an alternative to be applied in learning (Jordi, Faisal, & Ahdi, 2017).

Kusuma (2013) research results show game media's application to be a practical step in improving student learning outcomes and motivation because it allows active student participation in learning and a pleasant learning experience. The application of games in education can also accommodate students' different learning styles, develop thinking, concentration and collaboration skills (Tang, Hanneghan, & El Rhalibi, 2009). The application of games can support the learning process according to the concept of learning based on cognitive learning theory, namely, information processing theory (Zirawaga, Olusanya, & Maduku, 2017). According to this theory, a person's retention ability can be improved through stimulation from their environment. Stimulation from the media can be done by focusing attention, using verbal and visual symbols, and carrying out meaningful activities in problem-solving and concept discovery (Rehalat, 2014).

One of the game media that can be developed is board game media. Board games are non-electronic games that use the board as the main component plus other components and are played according to specific rules. The use of board games that emphasize reasoning and strategy has the potential to be used in education. Board games can support the development of a person's skills, thinking abilities and knowledge. Board games also create a fun learning environment (Huang, Liu, Liu, & Lin, 2012; Jordi et al., 2017; Treher, 2011). The media board game that will be developed is combined with a puzzle game. The puzzle is a game that consists of pieces of pictures, boxes, shapes, letters, or numbers arranged into a game that has an appeal. This game motivates students to learn by assembling puzzle pieces correctly and quickly (Armiati & Pahriah, 2015; Srianis, Suarni, & Ujianti, 2014). Puzzle media is useful for increasing student creativity, activeness, and student curiosity to increase student knowledge. Puzzle media is a learning medium that provides a sense of comfort in thinking through games and creates more exciting learning activities to make students more interested (Sari, 2016). Besides, puzzle games are following the development of students' thinking skills.

The puzzle that will be developed is a puzzle that is modified in the form of a board game. The board game is a game that uses a board with specific rules. The form of the board game product that will be developed will be combined with an acrylic base material. This is because in developing learning media, it is important

to consider using media effectively and efficiently. Efficient media are media that can be used repeatedly to reduce production costs. Acrylic material is durable and not easily damaged. Besides, puzzles will be accompanied by questions and pictures that aim to develop students' thinking skills. According to Tang et al. (2009) the application of games in learning can improve students' ability to remember. This ability can be increased due to the active participation of students in education. Activities developed invites students to play and introduce concepts and values to achieve learning objectives (Pho & Dinscore, 2015).

The purpose of this research is to be able to produce game learning media products in the form of acrylic board game puzzles and cell materials to determine the feasibility of the products made in empowering thinking skills as measured by students' cognitive learning outcomes. The products developed to consider the aspects of content, activity (task), and evidence in its development following the design framework proposed by (Groff, Clarke-Midura, Owen, Rosenheck, & Beall, 2015).

Method

This study uses the Research and Development (R&D) method. According to Borg and Gall (1983), the development model used is a model with the research steps presented in Figure 1.

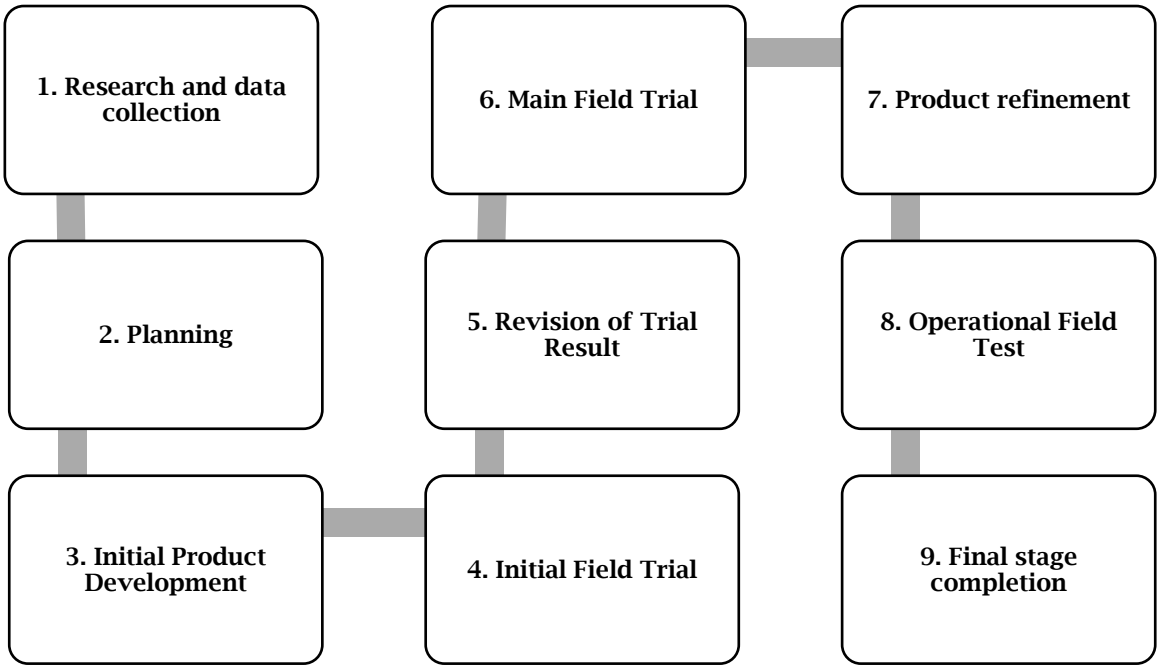

Figure 1. Modification of the Borg and Gall development model

This research was conducted from September 2019 to April 2020. The research data were obtained using observation techniques, questionnaires, validation sheets, interviews, and documentation. The subject of validation consists of experts (one media expert, one pedagogist and one material expert). Media experts assess media concepts as well as design views. Material experts are evaluating the accuracy of the material, the completeness of the material, and language. Meanwhile, pedagogists assess the media's suitability with the theoretical concepts of pedagogy and ease of use. Furthermore, validation by the practitioner was carried out by two subject science teachers., the teacher comments on the concept of media, student activity, and the ease of using the media. In the main field trial stage, the media was tested on 23 junior high school students. Students as test objects are asked to respond to the media's attractiveness, student emotional responses, student activeness in learning, learning motivation, and clarity of message delivery. The data obtained from expert and student validation were qualitative data in the form of comments and suggestions for product improvements and quantitative data in the form of a questionnaire assessment score using a

Likert scale. Furthermore, the acquisition score is changed as a percentage and categorized based on the scale range according to the product's feasibility (1).

$$score\ (\%) = \frac{score\ learned}{maximum\ score} \times 100\% \text{.....(1)}$$

Furthermore, in the operational field trial stage, the test subjects were 29 students of class VII A as a class implementing media products and 29 students of class VII B as a comparison class who applied conventional learning media used by teachers. The techniques used in the data analysis stage are quantitative and qualitative descriptive techniques, to determine the effectiveness of the application of "Cytozzle" media, students' cognitive learning outcomes were analyzed using the N-Gain test (2) and then conversion in criteria with Table 1 (Hake, 1999). The stages of research, activities, and instruments used to record data were summarized in Table 2.

$$N\ gain = \frac{posttest\ score - pretest\ score}{maximum\ score - pretest\ score} \text{.....(2)}$$

Table 1. Criteria for improving learning outcomes

Coefficient interval	Criteria
N-Gain < 0.3	Low
0.3 ≤ N-Gain <0.7	Moderate
N-Gain ≥ 0.7	High

Table 2. Stage, activities, and research instruments

Stage	Activity	Instruments
1. Research and data collection	Initial information data collection to determine problems faced in the learning process	Observation sheet, interview sheet
2. Planning	The planning stage includes the activity of making a product development design plan, which consists of the action of making a board game puzzle media prototype, which consists of the design of images, sizes, colors, and game rules, based on a predetermined framework	-
3. Product draft development	The product development stage includes identifying the concept of cell material and is followed by developing an initial product design that is ready to be validated.	-
4. Initial field trials	Preliminary field trials are carried out to obtain an evaluation of the product draft that has been made. There is a product design assessment process by experts.	Questionnaire for media experts, pedagogists, and material experts
5. Revising trial results	This stage is the stage of product improvement following input from experts.	-
6. Main field trials	Field trials were carried out by testing the revised product by conducting simulations in limited groups, namely 23 students of class VII, which subsequently received input and responses from students as users.	Student response questionnaire
7. Refinement of products from the primary field test	Results of media improvements are carried out according to input from field trials	-
8. The operational field implementation test	Furthermore, an N-Gain analysis was carried out by comparing the increase in cognitive learning outcomes between class VII A as an experimental class and class VII B as a control class that applied other media commonly used by teachers.	Cognitive learning outcomes test, teacher response questionnaire as practitioners and students
9. Final product refinement	Final product refinement is carried out based on input from operational field trials to obtain a viable product.	-
10. Dissemination and implementation	The product dissemination stage on a wide scale has not been carried out due to limited research	-

Results and Discussion

The initial stage of research and data collection was carried out by conducting interviews with teachers and students, classroom observations, and literature studies to find out problems faced in biology's learning process. The results of interviews with the teacher showed that students still had difficulties with cell material, so that students still needed guidance. One material that is considered difficult is cell material. In the cell material, students have difficulty remembering the

names of the organelles. Students also have a problem analyzing the function and structure of cell organelles properly due to their microscopic size and being studied for the first time, so they are not familiar to students. In the learning process, the teacher has used a microscope to observe cells. However, when making observations, not all of the cell organelles are visible. Rachman, Paidi, and Widowati (2018) stated that matter about cells is abstract material because the naked eye cannot observe cells. Students have difficulty imagining their bodies' structure and shape, so they need media assistance in the learning process to understand the concept more easily. Other obstacles related to the difficulty of understanding material about cells according to Rulia (2019) are: 1) the inactivity of students looking for additional pictures and explanations about cells that are not in the student handbook, 2) the low ability of students to remember the material being taught, and 3) less availability of cell props.

The results of observations show that the application of information technology is still limited because not all classes have LCDs, the use of the internet in schools is limited to teachers only so that students learn solely from book sources and explanations from the teacher. Based on these problems, teachers need to innovate in the learning process by developing learning media that is following school conditions and student character to overcome learning difficulties in cell material.

At the planning stage, the researcher designed learning media products adapted to the problems and development of students in the form of board game learning media with acrylic-based materials combined with puzzle games. Laski and Siegler (2014) stated the great potential of games to be a medium of learning. Games can train a person to know facts, concepts, and problem-solving. The design at this stage consists of designing the media's characteristics, the materials used, determining the media validation process, and the scope of learning indicators. Learning media developed are tailored to the user. That is, there is no need to use technology such as LCD or the internet.

The board game involves questions to develop students' thinking skills, both pictorial and written questions. The materials used are combined with non-perishable materials, namely, acrylic material. Later, the teacher can use this media repeatedly so that it is more effective and efficient. The use of board games as a learning medium can also foster students' interest in reading. Students can learn concepts indirectly by learning from experience or mistakes from other playmates (Prameswara & Siswanto, 2016). The boardgame product being developed is named "Cytozzle."

Media "Cytozzle" is developed based on a design framework that considers what aspects of knowledge or skills are the target of media development (content), what students will carry out activities to achieve these goals (tasks), and what facts can be obtained as evidence that the targets have been attainable (proof). Game development in learning with this framework can make the initial design more effective (Groff et al., 2015). Details of the "Cytozzle" media design framework can be seen in Table 3.

Table 3. Aspects of the "Cytozzle" media design framework

No	Aspects of Media Design Framework	Description
1.	Content achievement	The increased learning ability of cell material as indicated by improved cognitive learning outcomes according to indicators: 1) identifying various types of animal and plant cell organelles through pictures, 2) comparing differences in cell organelles found in animals and plants, 3) linking the structure of cell organelles to its function, 4) relating the role of organelles to one another, 5) selecting statements regarding cell organelles and being able to describe a supporting fact.
2.	Task	Doing challenges on walking cards, answering questions on question cards, and compiling puzzle pictures.
3.	Evidence	Can answer questions on the question card and can put together a puzzle correctly

The drafting of the initial "Cytozzle" media product draft begins with designing, game rules, and game media components consisting of 1) a basic board which is divided into an arena for playing cards and a place for putting together puzzles, 2)

game cards (sign cards, question cards, bonus cards, bomb cards), 3) road cards (containing pre-play commands, 4) jigsaw puzzle pieces, 5) game instructions, and 6) supplement books. The next stage is to develop questions according to the indicators developed in cell material. There are 32 questions designed, consisting of 19 pictorial questions and 13 short description questions. The media is given the title "Cytozzle," which is a combination of "Cytosol" and "Puzzle." Cytozzle's early prototype models were created by developing game components according to their original sizes using cardboard and printed paper. The initial product design was developed with the help of the Corel Draw application program. The initial design results can be seen in Figure 2, Figure 3, and Figure 4.

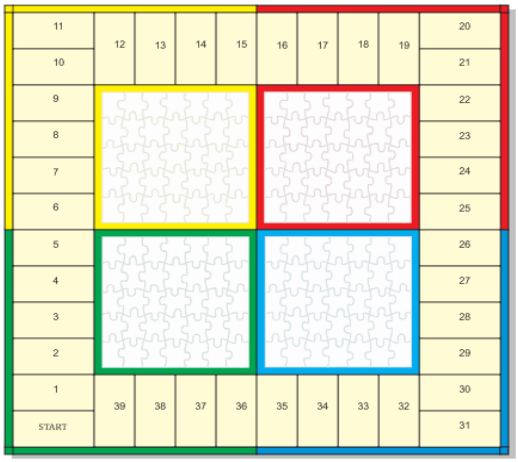

Figure 2. The game's basic board design consists of a puzzle area and playing cards

Learning media "Cytozzle" is a learning media modified from the type of game board game, in the form of a puzzle game accompanied by cards that have been designed and adapted to animal and plant cell material. This learning media is included in educational games that can help students learn cell material while playing. Its use is straightforward and also does not depend on the use of technology and the internet. In the game "Cytozzle," students can play individually or in groups to collect points that can be exchanged for puzzle pieces and arranged into a complete cell picture. Students can obtain these points after answering questions that lead to questions about animal cell and plant cell material, as well as having to do some simple challenges on the road card. Activities in using puzzle media that will be developed are designed to provide questions to build students' learning abilities, especially in training to remember images of cell structures and foreign terms for cell organelles' names. Learning methods that combine play and learning activities have the potential to help students memorize information for a long time (Amanda, Ardianto, & Erandaru, 2019).

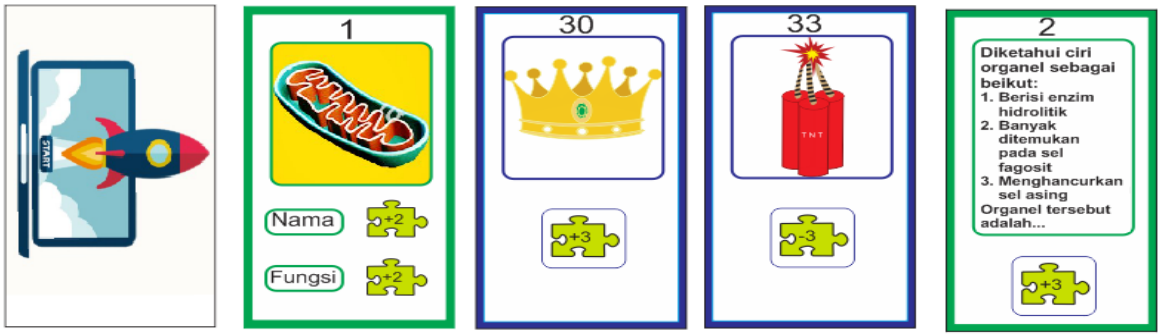

Figure 3. Examples of a front view of game cards (starting cards, picture question cards, bonus cards, penalty cards, and analysis question cards

Figure 4. Example of a back view of a playing card

The initial field trial stage consisted of expert validation and practitioner validation. Experts comprised of media experts (visual communication design lecturers), pedagogists (FKIP lecturers), and material experts (biology lecturers). Based on media experts' validation results, namely the general principles of visual media, the results were presented in Table 4. They showed that the media had met the very feasible category with a gain of 91.6%. This indicates that the media already has a concept of simplicity. The unity of media components is interrelated; there is an emphasis on the material; the balance of visual presentation is also right. The design already has attractiveness on the outer cover. The use of images is following the material, the layout of the components is good, the color selection is good, nothing is distracting, and the media size can be used for small or large groups. The clarity of the media already has color, size, the font that is easy to read. The choice of material quality and neatness is right and can be used repeatedly.

Table 4. Expert validation results

Validator	Indicator	Expert assessment (%)	Category
Media experts	The concept of media	90	Very worthy
	Design	96	Very worthy
	Media Clarity	90	Very worthy
	Material Quality	80	Worth
Pedagogist expert	Media suitability	75	Worth
	Ease of Media	80	Worth
Material expert	The completeness of the material	93	Very Worth
	Material accuracy	80	Worth
	Language	80	Worth

Suggestions and input obtained from instructional media development experts related to product design include: 1) game rules using dice can cause questions to be repeated on numbers that have been answered so that not all questions can be answered. Educational games with dice are now starting to be abandoned because they are only based on luck, so that other game rules need to be considered. 2) it is better if the number of puzzle pieces is reduced to facilitate the cutting and playing process. 3) the level of complexity of the puzzle pieces is reduced. 4) The number of members on each group should be reduced to be played individually or in groups. 5) the color of the puzzle background should be made colorful to make it more interesting. Likewise, the color of the basic board needs to be made more varied. 6) The pictures contained in the learning media should draw by themselves. 7) the reduction of points on the penalty card is too large; it can cause the game to end quickly.

Based on the results of the validation by pedagogical experts, it was found that the learning media developed were in the feasible category, with details that can be seen in Table 4. Inputs provided by pedagogists include: 1) the difficulty level of the material needs to be adjusted to the level of development of junior high school students, 2) The editorial team of writing some questions and answers need to be improved, 3) it is necessary to relate one illustration to another.

The material expert assesses the completeness and accuracy of the material and language. The assessment results show that the media is included in the very feasible category presented in Table 4. Inputs provided by the material experts include: 1) it is necessary to add material about endomembrane material so that students can connect the relation of organelle functions, 2) there are several mismatches. Picture questions with the answers on the back of the question cards, 3) there are several mistyped words in pictorial questions, 4) The standard of terms needs to be improved and needs consistency in the use of names, 5) the pretest and posttest questions need to be

corrected to make it more straightforward, 6) Need to make analogies on cell material so that students understand it more comfortable.

In the next stage, namely, revision of the test results, the learning media "Cytozzle" was improved based on the previous stage's input. Improvements made include: 1) the use of dice is replaced by using a road card system that contains challenges (Figure 6), 2) the number of puzzle pieces is reduced to 16 pieces, 3) the complexity of the puzzle is reduced and the puzzle is made square (point 1-3 can see Figure 5), 4) the game can be done by one person in each team so that it can be played individually or in groups, 5) the puzzle background is made in four colors (red, blue, green, and yellow) and the base board has been made in two colors, 6) the picture is drawn by the help of the design team, 7) the point reduction has been minimized, namely one point on each bomb card, 8) the material has been adjusted to the level of development of junior high school students, 9) the question and answer editor has been improved, 10) the material for the endomembrane system has been added, 10) the pictorial questions that cannot be replaced and corrected, 11) words that were mistyped were replaced and corrected, 12) terms that were not standard were corrected and the use of terms was similar, 13) questions were replaced by According to expert input, 14) Simplified analogy, simpler adapted material and added meaning on some important terms and a glossary.

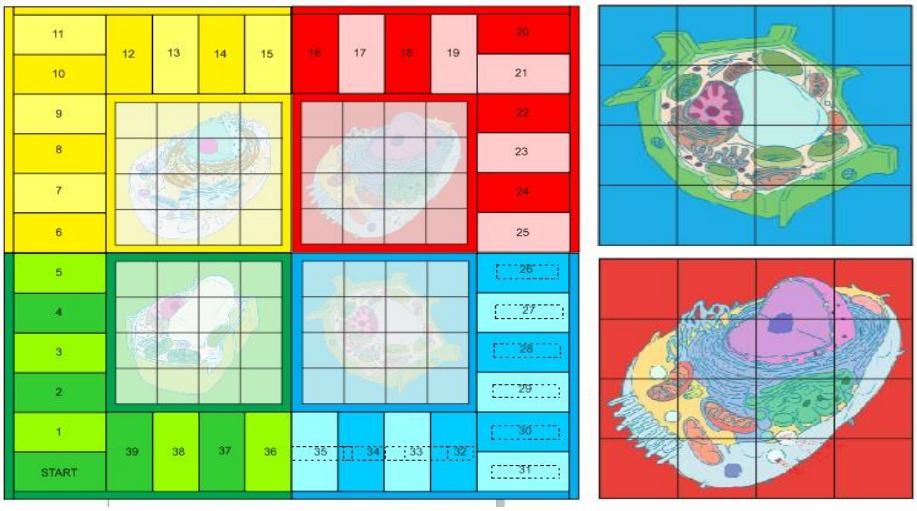

Figure 5. Baseboard repair results, and puzzle pieces

The main field trials were carried out by validating education practitioners (teachers) and small group tests (students). The validation of education practitioners by science teachers aims to obtain data in opinions, criticisms and suggestions regarding effectiveness, feasibility, depth of material and media suitability. The validator at this stage is a seventh-grade science teacher who has taught science subjects. Based on the validation results, it was found that the learning media developed were in the very feasible category. The results of validation, according to expert practitioners and the students, are presented in Table 5. The input given by the teacher as an expert practitioner is as follows: 1) the material needs to be made simpler, 2) several steps in the game guide need to be clarified.

Figure 6. Challenges card design (left), Game card improved design (right)

Figure 7. Product display *"Cytozzle"*

The main field trial subjects were 23 students of grade VII SMP. In this small group trial stage, two media packages were used. Based on the results of student responses, it was obtained a score in the good category. Some of the inputs based on the small group trial results are as follows: 1) there are too many players if each group contains four people; it becomes less effective when playing. 2) There is not enough time to study the material in the supplement book.

Table 5. Results of teacher and student responses

Validator	Indicators	Average Score (%)	Category
Teachers	Media Concepts	85	Good
	Student Activity	95	Very good
	Teacher skills in using media	80	Good
Students	Attractiveness	73.91	Good
	Student emotional response	74.63	Good
	Student activeness in learning	69.29	Quite Good
	Learning motivation	73.64	Good
	Clarity of delivery of messages	72.82	Good

In the next stage, learning media was improved based on the main field trials' results, namely in the form of input from education practitioners and small group trials (Figure 7). Some improvements that have been made include: 1) The steps in the game guide have been clarified, 2) the reduction of the members of each playgroup contains only two to three people so that one more media package is added, 3) before playing the teacher must discuss the material in the supplement book first with students. Mostowfi, Mamaghani, and Khorramar (2016) state that the application of games as learning media can be combined with other learning strategies to obtain more effective results.

After making product improvements, operational field trials were carried out by implementing the product in actual school conditions. Mostowfi et al. (2016) state that there need to be repeated trials in developing board game products in learning following the concept of educational theory. The product's effectiveness can be determined by comparing it with the application of other strategies or media. The "Cytozzle" media product is used by the teacher in learning about cell material in class VII A as an experimental class. An N-Gain analysis was then carried out by comparing the improvement in learning outcomes with class VII B as a control class that applied other media commonly used by teachers. Based on the results of the ability to analyze learning outcomes in the two treatments, the experimental class results that applied "Cytozzle" media showed that the percentage of N-Gain scores was more in the high and medium categories. Whereas in the control class VII B, the results were mostly in the medium and low categories (Figure 8). In general, the average N-Gain score in the experimental class was more significant than the control group (0.58 > 0.39). This shows that the increase in student learning outcomes in classes that apply "Cytozzle" media is better than control classes that use other conventional learning media.

Based on the results obtained when students feel attracted to a media, students also respond well. Students can actively learn and motivation to learn is also good because they can understand the material well. This is following the statement of Yudasmara and Purnami (2015), which states that in science lessons, the most important aspect is student interest. With this interest, students will be motivated to learn to improve learning outcomes. The research results by Nuriah, Marianti, and Christijanti (2013) show that through puzzle learning, students can be encouraged so that interest in learning increases.

Sari's research results (2016) that media use can be used to hone thinking power, increase collaboration skills, and train patience. Puzzle media is useful for student creativity, student activity, and stimulates student curiosity, so that student knowledge can increase. Nurrita (2018) explains that the use of learning media as a learning resource increases student motivation and interest in learning to understand the subject matter easily. Tafonao (2018) also explained that learning media can also attract students' attention and make learning more active.

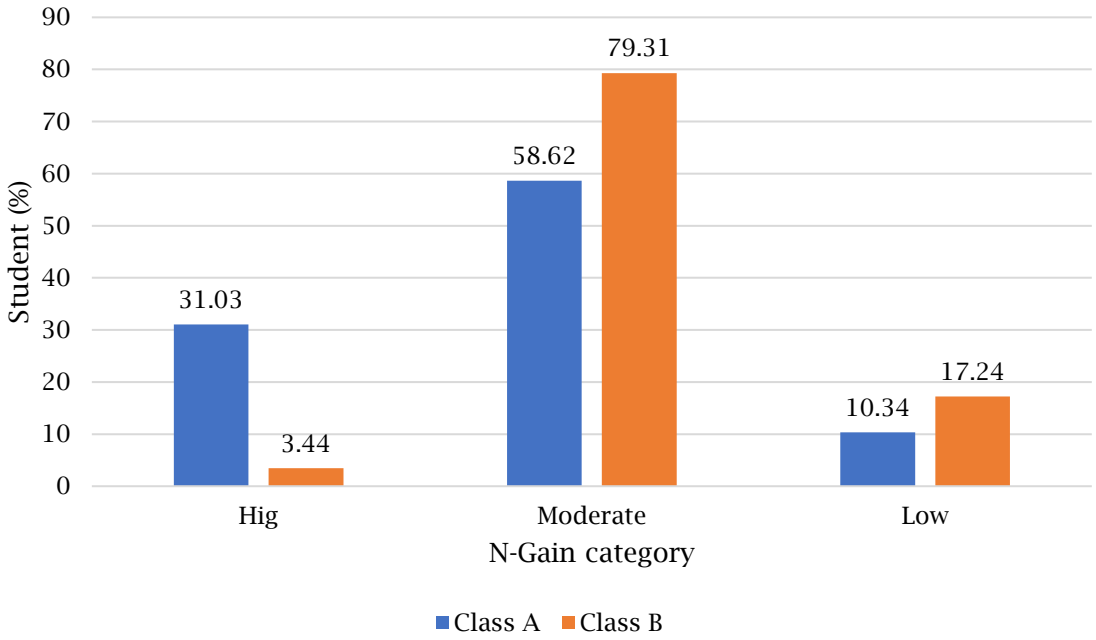

Figure 8. Comparison of N-Gain results of cognitive learning outcomes between class VII A (treatment class) and VII B (control class)

Purwantoko, Susilo, and Sutikno (2010) states that learning using puzzle media can motivate students to learn better than conventional learning. The media puzzle is designed so that the media developed can make students actively involved in learning to produce pleasant learning. Husna, Sari, and Halim (2017); Riadi and Supriyono (2014) state that learning with puzzle media can create a competitive learning atmosphere. Each student tries to be faster in compiling several pieces of the picture into a single whole so that students feel happy being able to learn while playing, discussing and competing (Febrita & Ulfah, 2019).

In the board game "Cytozzle", students are invited to understand the material first to answer the questions and be motivated to focus on following the game. Students can also play to arrange the puzzle pieces while answering the questions given. In this game media, it has been accompanied by a supplement book which contains a summary of cell material and also questions that can be used to train students' abilities. Srimulyanti (2017) explains that in developing educational puzzle media, it must also pay attention to the principle of feedback and the principle of repetition so that information and learning messages can be well received. This media has been designed with the principle of feedback, that is, students can immediately check whether the answer is correct and following seeing the response on the back of the question card. On the principle of repetition when playing, you must finish the existing question cards so that they are played again, or you can also learn by paying attention to the questions and answers received by other groups so that when they get questions that have been answered previously, students can reply again. Juita's (2018) research results on media development using material cards in puzzle development; students can learn independently by matching them with error control cards to obtain knowledge from the practice.

The interview results with the teacher show that the "Cytozzle" media that has been developed is interesting to be applied to science learning in junior high schools.

However, the teacher as a learning facilitator, must still provide assistance and guidance to students. Likewise, student responses, the "Cytozzle" media increases curiosity and makes learning more enjoyable. The results of student responses about learning media are in a good category and are described in Table 6.

Based on the teacher's validation results, it was found that the media concept was good because it increased student activity in learning and the teacher was also easy to use the media. According to Husadani (2017), puzzle learning media can help teachers explain abstract material more easily. The application of "Cytozzle" media has been well received by teachers and students so that this media is feasible and can be used as an alternative solution for a more varied learning. When compared with conventional learning, there is an increase such as the quality of learning, students become more enthusiastic about learning both in groups and during discussions.

Table 6. Results of student responses

No	Indicator	Average Score (%)	Category
1.	Attractiveness	84.77	Good
2.	Student emotional response	84.77	Good
3.	Student activeness in learning	81.03	Good
4.	Motivation to learn	81.03	Good
5.	Clarity of message delivery	80.45	Good
Average Score		82.41	Good

Rahmawati (2019) explains that the use of learning media with the principle of learning while playing is expected to make learning more meaningful and fun for students. However, there were several obstacles that were found when implementing it in class, namely that there were some students who only played with the puzzles and when answering the students, it took quite a long time, so other groups had to wait for their turn. Media "Cytozzle" as a game in the form of a board game can train students to collaborate in learning. The existence of elements of competition, interaction between players, and the importance of strategy formulation make the delivery of material more enjoyable. Apart from creating a fun learning environment, board games also have the potential to develop skills, thinking abilities and knowledge (Huang et al., 2012; Jordi et al., 2017; Treher, 2011).

The final product refinement is carried out based on input from operational field trials to obtain a feasible product to implement in the field. Improvements made include packaging of the product using a carrying bag so that the product is easier to carry. The last stage, namely the dissemination stage, has not been carried out due to researchers' limitations in mass production of media products.

Conclusion

Based on research and development results, the “Cytozzle” product is obtained as a learning medium for cell material. “Cytozzle” is a learning medium in the form of an acrylic board game accompanied by a puzzle game. The results of the evaluation of the media expert validation regarding the product obtained a value of 91.6% (very feasible), material experts of 85.7% (very feasible), pedagogical experts by 80% (feasible), while the results of responses from education practitioners obtained a value of 86.6% (very good), and student assessment of 82.41% (good). The results of the effectiveness test through the N-Gain analysis on student cognitive learning outcomes showed that students' cognitive learning outcomes in classes with the application of “Cytozzle” media were better than those using other media. It can be concluded that “Cytozzle” media is suitable for use in learning cell material.

The effectiveness of the application of instructional media in this study was tested limited to the analysis of cognitive learning outcomes. Suggestions for further research are the need for effective testing in a quasi-experimental setting by comparing other variables in a class treated with “Cytozzle” media with a class that applies conventional learning media. Besides, further dissemination stage on a wide-scale needs to be carried out. In practice, teachers are expected to continue to assist when using “Cytozzle” media and divide groups heterogeneously during the learning process so that students can work collaboratively.

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