



Evaluating the Strengths and Challenges of 3D Puzzle Modeling-Based Learning Media on Neural System Concepts: A SWOT Approach

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Abstract: The research is based on challenges in learning, especially in nervous system material, where there are often misconceptions in students about the course of neural impulses and understanding the structure of the nervous system in humans. The purpose of the research is to develop learning media in the form of 3D-MbL puzzle media to help junior high school students understand the concept of nervous system material and conduct a SWOT analysis of the learning media. The research method used is qualitative descriptive, with data collection techniques through observation, documentation, and questionnaires. The instrument used in this study is a validation sheet by two validators, namely material validation and media validation. 3D-MbL puzzle media is made using several tools and materials, with the main ingredients being made using flannel and analyzed using the SWOT method. The study's primary results show that 3D-MbL puzzle media can attract students' interest and hone creative thinking skills during learning. However, there are challenges, such as the media needing help to explain in detail the process of neural impulses and other essential concepts in the material of the nervous system. The opportunity of this 3D-MbL puzzle media can be used as an exciting anatomy of the human body, and the threat is that students do not understand how to use it if the teacher does not clearly explain the use of the media. In conclusion, 3D-MbL puzzle media for the nervous system offers innovations in delivering science learning materials. However, further improvements are needed so that this media can be more optimal in delivering learning materials.

Keywords: Puzzle, Modeling-Based Learning, Nervous System, SWOT Analysis.

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1. Introduction

Pesantren were initially established based on the community's need for educational institutions that could provide the younger generation with religious knowledge. Over time, pesantren have evolved into educational institutions that not only offer teaching and learning activities but also serve as boarding facilities for students (santri). Today, pesantren operate with an educational system similar to that of public schools, although religious subjects are given greater emphasis than general subjects. The levels of education in pesantren are categorized into basic, intermediate, and advanced levels, known respectively as Madrasah Ibtidaiyah, Tsanawiyah, and Aliyah. One of the distinctive characteristics of pesantren is the strict rules enforced, including the prohibition of communication devices such as mobile phones and laptops. This is intended to maintain the students' focus on learning and to minimize the negative influence of technological advancement and globalization (Rahmawati & Ghazali, 2023). Modern technologies in education are essential for advancing learning processes and improving students' engagement with innovative tools. This research analyzes gamification through immersive virtual reality and traditional platform games to support cognitive development, creative problem-solving, interaction, understanding, and expected performance (Escandon & Salas., 2025).

In the context of national development, education plays a strategic role in creating high-quality human resources, where instructional innovation is a crucial aspect in addressing current learning challenges, including in science (IPA) education. Science, which explores natural phenomena and involves abstract concepts, requires active student engagement, thereby necessitating innovative, contextual, and student-centered learning media that align with their characteristics and needs (Widiana et al., 2019). However, science learning still faces obstacles such as students' difficulty in understanding abstract concepts, limited availability of learning media, and a lack of supporting facilities particularly in the topic of the nervous system, which has proven to be difficult for junior high school students to comprehend (Kvello, 2024).

The junior high school level in Indonesia, biology learning is combined with physics and chemistry in integrated science subjects. In the realm of Biology, one of them is the nervous system material that is included in the chapter on the human coordination system; this material requires a deep understanding of the concept and a broad scope of the human body (Wijayanti & Isnawati, 2023). Students find it challenging to learn this material if they only use print media, for example, the mechanism of nerve impulses to send messages to the central nervous system (Hafzah et al., 2020). The material requires simplification using media that can visualize the material to help students understand concepts. In addition, students also find it challenging to understand the arrangement of the nervous system in humans (Hafzah et al., 2020)

Based on research Saputri et al., (2016) explained the results of data analysis using the Certainty Of Response Index (CRI) on the submaterial of the nervous system showed that of the 29 students, 24.71% were included in the category of knowing concepts, 38.39% had misconceptions, and 36.9% did not know concepts. The data shows that most students still have difficulty understanding nervous system material in the learning process.

Model-based learning has become an increasingly popular approach in science education, particularly in complex topics such as the human nervous system (Harasim, 2017). The nervous system, as one of the complex materials in the biology curriculum, requires a deep and comprehensive understanding. However, difficulties in visualizing and understanding abstract concepts often hinder students. One of the innovations that can overcome this problem is using 3D Puzzle (3D) as a model-based learning medium.

The Modeling-Based Learning (MBL) approach, with the supported of 3D puzzle media, provides a more interactive and engaging learning experience for students. Through this medium, students learn passively and actively assemble and understand the structure and function of the nervous system. The use of 3D models allows for more precise and concrete visualizations, making it easier for students to relate the theory to actual physical forms (Mayer, 2009).

Learning media that are attractive to students can stimulate students in the learning process. A teacher must be able to choose the appropriate and suitable learning media to use so that the teaching goals that the school has set are achieved (Nurrita, 2018). The application of media has the function of developing cognition in the form of stimulating children to carry out activities, thoughts, feelings, attention, interest in developing imagination, training sensitivity to think, and as a tool for playing (Fitria, 2019).

Puzzle media is a media or game tool in educational learning that can stimulate children's abilities. They play by disassembling puzzle pieces and then pairing them according to their partner (Mirna et al., 2022). Three-dimensional puzzles are a learning medium that is innovated in the game of dismantling, where the puzzle pattern is arranged well to form a work or artificial object in the form of a three-dimensional (Hasanah, 2020).

The researcher wants to modify 3-dimensional puzzle media combined with the MBL (Modeling-Based Learning) learning model on the human coordination system material in grade IX of Junior High School/Madrasah Tsanawiyah. The difference between this media and puzzle media, in general, is that this media can support the learning process using the MBL learning model. Students can assemble by themselves how the process of implicit stimulation in human nerves on reflex movements and conscious movements in human organs.

However, the effectiveness of using Puzzle 3D-MBL needs to be evaluated comprehensively. In this case, the use of 3D puzzle media can be a medium that can be used to increase children's interest because the knowledge gained from this game usually has more impact on children (Irwandi, 2021). One method that can be used to evaluate the advantages, disadvantages, opportunities, and threats of using this media is through SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis. The analysis allows educators to identify positive aspects that need to be maximized as well as challenges that may arise in the implementation of this learning media (Priasih & Wiyani, 2022).

Based on the explanation, the researcher is interested in making a learning media design in 3D puzzle modeling on nervous system material for junior high school students. The media can help them understand the concepts in the material and make them enjoy learning.

2. Method

The research is qualitative and descriptive, theoretically analyzing the design of 3D puzzle modeling-based learning. This study uses qualitative research with research procedures that produce descriptive data in the form of written words and usually uses interview instruments on the target person.

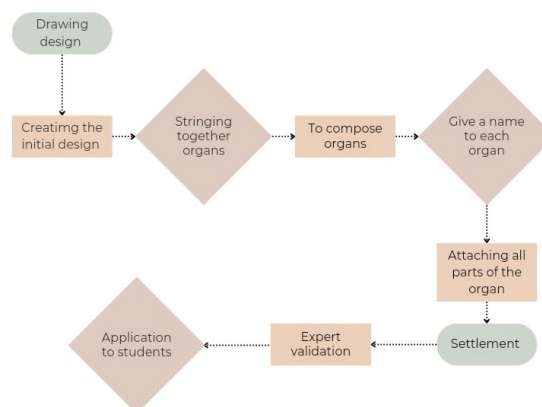


Figure 1. 3D-MbL Puzzle Design Loading Flow Chart

The results of qualitative research emphasize the meaning of generalization and tend to be more subjective depending on the reasons and perceptions of a person through focused interviews (Sary et al., 2025). This qualitative research method places more emphasis on observing phenomena and examines more deeply the substance of the meaning of these phenomena (Safarudin, 2023). At the needs identification stage, activities are carried out to define the purpose of making media, and identify data and hardware and software needs. Data needs are identified through documentation studies, internet searches, discussions, interviews and questionnaires (Lahay & Mohamad, 2020). It uses SWOT analysis to analyze the

strengths, weaknesses, opportunities, and threats (Threads) of 3D puzzle modeling-based learning to achieve this goal.

SWOT analysis is a very useful instrument in analyzing strategic matters. SWOT analysis can facilitate the formulation of strategies and can provide a clear picture in order to apply the role of internal factors to the maximum (Sodikin & Gumiandari., 2021). Descriptive research was chosen to describe the design of the learning media, namely 3D puzzle modeling on nervous system material, using SWOT analysis. The research was conducted at the Microteaching Laboratory of FKIP University of Jember. The research was implemented in the odd semester of the 2024/2025 school year. Data collection techniques include observation, documentation, and questionnaires. The instrument used is a validation sheet by two validators, namely material validation and media validation.

SWOT analysis was used to find out 1) Functional needs in the creation of 3D puzzle modeling learning media on nervous system materials; 2) Designing learning media by implementing all ideas and concepts from the learning media to be made; 3) designing the content needed to provide convenience and information delivery for students to use the learning media; 4) Evaluation of the advantages and disadvantages of the learning media made (Asruddin et al., 2020).

3. Result and Discussion

Stages of Designing 3D-MbL Puzzle Media

A media puzzle is an image divided into several pieces (Husna et al., 2017). Three-dimensional media is a group of media without projection whose presentation is virtually three-dimensional (Arinastiqmah, 2023). The 3D puzzle is a game to unite the fragments of the pieces to unite the fragments of the pieces to form a picture or text that has space and length, width, and height (Hasanah, 2020).

The 3D puzzle media is made of material from the nervous system combined with a model-based learning model. Modeling-based learning is a learning approach where students build their phenomenal scientific models, which researchers consider to contribute positively to science learning (Kadariusman et al., 2020). The researchers also said that the model derived from the MbL product is a scaffolding to support the learning process, curriculum concepts, and additional tools in supporting the science learning process and is a representation of reality that a person uses as a medium to understand better the phenomenon being studied (Kadariusman, 2020). Models made by students, both in the form of 2 and 3-dimensional models, are a form of actualization to represent knowledge in their way. Students can present abstract concepts through modeling and models to be more natural.

The 3D-MbL puzzle media is a three-dimensional puzzle media that presents organs that play a role in the nervous system's performance. It can facilitate students in modeling their understanding of the process of impregnation in the nervous system. The steps in making this 3D-MbL puzzle media design are as follows: (1) draw the initial design of the organs on a sheet of white HVS paper, (2) cut all the drawing designs that have been made to be used as a drawing print on the flannel fabric, (3) cut the pieces of the organ that have been made to be redrawn on the flannel that has been provided, (4) cut all parts of the flannel fabric that have been pasted with the image

of the organs on it, (5) sew two pieces of flannel according to the organ you want to make into one, (6) after the sewn organ is formed, leave a little part to fill the dakron into it, (7) after the dacron is fully filled, the organ can be sewn together until it is finished, (8) make two pieces of half-body flannel, (9) one piece of half the body is attached to a cardboard box that has been coated with manila paper using glue gun (10) give each one a name organs using HVS paper that has been written with the names of the organs, coated using transparent insulation and pasted using glue gun, (11) pasting the finished tubh organs with fabric adhesive on the back, (12) arranging and pasting all the finished organs on the adhesive part of the fabric using glue gun to the cardboard with a picture of half of the body, (13) to make the face part, a piece of half of the body that has been made previously is pasted with organs such as the mouth, eyes and nose to form the face, (14) apply fabric adhesive on the edges of the flannel that acts as the outer body part, (15) attach the fabric adhesive on the outer body to the cardboard.

The 3D-MbL Puzzle Media Making Stages

The creation of the 3D-MbL puzzle media project uses tools and materials consisting of scissors, HVS paper, glue gun, transparent insulation, pens, black markers, flannel fabric, cardboard, manila stickers, and paper glue. The initial stage in making this media begins by making a skeleton of the organs, such as the brain, spine, heart, and lungs, on white HVS paper. The next stage is to cut the design, which is then drawn on the flannel provided using a black marker. In the third stage, cut the flannel cloth with a picture of the organ design they made. After the flannel has been cut according to the organ, sew two pieces into one and leave a little part to fill the dacron into the organ; then, after the dacron is fully filled, sew the entire organ.

After all the organs have been completed, the next stage is to give fabric adhesive and names to each organ so that students can easily understand the organs. Cloth adhesive is placed on the back of the organ, and the front is affixed with the name of the organ. Organ naming is made by writing the name of each organ on white HVS paper, cutting it neatly, and then coating it with transparent insulation so that the name is more durable and not easily damaged. If the naming and application of fabric adhesive have been completed, the next step is to prepare a 30 x 45 cm cardboard box and layer it using manila paper. After the cardboard box is ready, two pieces of flannel should be made in the shape of half a human body, as big as the cardboard that has been prepared. Paste one and a half pieces of the human body on cardboard using a glue gun, which is then followed by attaching all the finished body organs according to the position of the organ in the anatomy of the human body.

The senses, such as the eyes, nose, tongue, skin, and ears, are located on one and a half pieces of the human body that have been made beforehand. The sense of the ear is placed on the edge of the head on the half of the body that is attached, while the senses of the eyes, nose, and mouth are placed on the second half of the body, which also acts as the skin that plays a role in wrapping the internal organs. Apply fabric adhesive to the edges of the skin to attach to the cardboard and cover the internal organs. After everything is finished, the 3D-MbL puzzle media is ready to be used as a learning tool for students on nervous system material.

A. Results

The SWOT analysis method is an analysis that uses internal factors in the form of strengths and weaknesses, as well as external factors in the form of opportunities and threats, to understand a good planning strategy (Septiana et al., 2020). Based on the results of the study, a SWOT analysis of internal and external factors was obtained as follows:

- (1) Analysis of the strengths factor, namely in terms of appearance, 3D-MbL puzzle media has a funny, unique, and exciting appearance to attract students' interest in learning. In terms of content, this 3D puzzle can be used for modeling, which means that students can assemble puzzles with various shapes so that this media can stimulate students to think creatively. When playing it, the materials used in this media are cheap, easy to get, comfortable to use, and durable, so the media can be used continuously and have good storage.
- (2) The analysis of the weaknesses factor, namely the 3D-MbL puzzle media, is not able to explain the working process of the nervous system concretely because there is no visualization of the process of the path of the nerve cell impulse, the media is still unable to cover all essential aspects of the material of the nervous system because the media is too simple, the use of media is not flexible because of its large size, It requires a large storage area, is not waterproof, and needs good maintenance so that it is not easily damaged when stored.
- (3) Opportunity factor analysis, namely 3D-MbL puzzle media, can be used as an example of body anatomy because this media consists of a series of organs in the body, such as the heart, lungs, brain, kidneys, and five senses. Students are interested in using it in learning because of its cute design, diverse colors, and unique shapes. 3D-MbL puzzle media can help teachers exemplify organ systems in the human body because the media consists of various organs that can structure one organ system.
- (4) The analysis of the threat factor, namely in using 3D-MbL puzzle media, must be explained in detail so that students are not confused about using this media, and the creation of this media is quite time-consuming and labor-consuming.

The use of 3D-MbL puzzle media in learning nervous system material at the junior high school / MTs level is quite helpful in delivering nervous system material to students. It can attract students' interest in learning nervous system material. Students can play 3D-MbL puzzle media according to their creativity and understanding of the theory learned on the nervous system material. Students can use the concept of easy-to-understand puzzle media to learn while playing so that the media is easily used in delivering material, and learning also becomes more varied by involving students in its use. (Fatmawati & Harmanto, 2019).

The 3D-MbL puzzle media can give an exciting and fun impression when learning complex nervous system material, often making students bored while learning it. In addition, by using a learning model, *Modeling-based learning*,

juxtaposed with the three-dimensional puzzle media, can make students' creative thinking more honed because they will be free to model the knowledge obtained about the nervous system into the three-dimensional puzzle game used. Based on research by Kadarusman, (2020) it was explained that learning using the MbL approach can increase students' thinking level to level three (analysis); MbL can also facilitate students' better representation of the concept of the human nervous system. This study's results also show a positive and significant correlation between thinking level and students' ability to build proposition network representations.

The use of materials that are comfortable to use, easy to get, and cheap, such as flannel, makes this media easy to make and helps facilitate student learning and make it more interesting. The use of learning media also has its characteristics, such as one of which is relatively cheap, because in making learning media, it must also think about how much budget to make the learning media so that the media is by expectations (Audie, 2019). However, the limitations of this 3D-MbL puzzle media are still very complex, so improvements must be made to support learning more optimally. The practical benefits of learning media products must be able to meet three categories, namely clarifying and facilitating information and improving learning outcomes, increasing and directing children's attention, and being able to overcome space and time limitations (Permata et al., 2017). In the results of the validation of media experts and material experts for 3D-MbL puzzle media, it is still included in the category of less valid and still needs further improvement. The concept of 3D-MbL puzzle media is still straightforward and cannot explain the work of the nervous system, especially in the process of imposing human nerves.

The 3D-MbL puzzle media can be one of the exciting and unique learning media innovations if it continues to be developed and improved because the characteristics of the media that are easy to understand and use by students make this media readily accepted by students to help the learning process. The cute and colorful shape of the body organs can make students interested in learning and playing using this media. Miniature or three-dimensional media in science learning is one of the better ways to replace real learning media for students' learning. Artificial objects that can be touched and touched can help students understand the concept of the material provided by the teacher in learning, supporting media to make 3-dimensional miniatures more interesting, namely puzzle media (Khoiro et al., 2024). As explained by Sarina and Hasanah (2022) that by using three-dimensional media, users get information that can be seen realistically and can be touched so that it is possible to remember the material taught to the maximum.

The use of 3D-MbL puzzle media in learning can experience obstacles if, at the time of use, it needs to be explained in advance; therefore, before using the media, teachers must explain in detail the steps of learning using this 3D-MbL puzzle media. In addition, the creation of this 3D-MbL puzzle media takes a long time because it requires perseverance and patience in the process of making it so that the media can be created properly.

4. Conclusion

SWOT analysis shows that 3D-MbL puzzle media has the main strength in attracting students' interest in learning and honing students' creative thinking skills when using it because of its cute, unique, attractive, and comfortable design. However, there are weaknesses, such as being unable to explain in detail the process of neural impulse and other essential concepts in the material of the nervous system. The opportunity that arises from using 3D- puzzle media is that the media can be used as an anatomy of the human body because the organs in the media can compose the organ system in the human body. The threat posed by this media is the students' incomprehension in using the media if the learning steps using this 3D-MbL puzzle media need to be explained in detail.

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