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Article

Smart Digestomap: Innovation in 3D Learning Media as an Effort to Improve Student Creativity and Thinking Skills

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ABSTRACT

Science learning is often considered abstract because many concepts are difficult for students to visualize concretely. This impacts students' low interest and creativity in understanding the material, especially the human digestive system. Therefore, innovative learning media are needed that can provide concrete, interactive, and meaningful visualizations as an interesting learning tool. Smart Digestomap is presented as a solution through three-dimensional (3D) learning media that combines concepts of biology, chemistry, and physics in one unit. This study uses the Research and Development (R&D) method with the 3D model according to Thiagarajan (1974), which includes the define, design, and development stages. The validation results were carried out by three validators from elementary/Islamic elementary and Islamic junior high schools using a Likert scale of 1–5 covering aspects of material suitability, durability, accuracy, efficiency, aesthetics, and safety. The analysis showed an average validity score of 4.60 with a percentage of 92%, including the very good category, so the media is declared valid and suitable for use. Smart Digestomap is effective in helping students understand abstract concepts visually and kinesthetically and fostering creativity and critical thinking. In the future, this media can be further developed with creative LKPD so that the learning process becomes more integrated and exploratory.

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INTRODUCTION

Science education plays an important role in shaping students' scientific, critical, and creative thinking skills. However, in practice, science education in schools still faces various obstacles, especially in conveying concepts that are not easily observed directly or are abstract. One topic that falls into this category is the human digestive system, which involves biological, chemical, and physical processes within the body.

Based on observations of learning in several schools, teachers generally still use lecture methods, question and answer sessions, and conventional media such as posters, anatomical torsos, or simple learning videos. These media are static and do not provide an interactive

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learning experience. They only help teachers explain, but without direct participation by students. As a result, students only understand the digestive system in general terms without knowing in depth the working mechanisms of each organ and the interrelationships between the organs that make up the system (Saregar, 2016). Many students are only able to name digestive organs such as the mouth, stomach, and intestines, but do not yet understand how each organ plays a role in the mechanical and chemical stages, up to the absorption of nutrients.

This condition creates a gap between learning objectives and the learning outcomes achieved by students. Both the Merdeka Curriculum and the 2013 Curriculum emphasize the importance of science learning oriented towards higher order thinking skills (HOTS), namely the ability to analyze, evaluate, and create. However, the approach used in the classroom does not fully support the achievement of these skills due to the lack of appropriate media that can connect theory with real phenomena (Arianto & Fauziyah, 2020). In this context, there is a need for innovative learning media that not only presents information but also simulates scientific processes visually, kinesthetically, and interactively.

Various studies show that the use of three-dimensional (3D) media can improve students' conceptual understanding and memory because it involves more senses in the learning process (Creswell & Poth, 2016). 3D media allows students to see the whole flow and structure, observe cause-and-effect relationships, and interact directly with learning objects. This kind of innovation is in line with the integrative science approach, which combines the concepts of Biology, Chemistry, and Physics into a single unit to make learning more meaningful and contextual.

In response to these challenges, Smart Digestomap was developed, a three-dimensional (3D) learning medium that helps students understand the human digestive system in greater depth. Smart Digestomap integrates interdisciplinary science concepts through an approach that resembles the actual workings of the digestive system. From a biological perspective, this medium displays models of digestive organs (mouth, stomach, small intestine, and large intestine) in sequential and functional order. From a chemical perspective, there is a simulation of the reaction between acids and bases using vinegar and baking soda, which illustrates the process of food breakdown in the stomach. From a physics perspective, mechanical and fluid principles are used through chewing pearls, lights, and magnets to illustrate the movement of food and peristaltic forces. The integration of these three aspects provides an interactive, contextual, and exploratory learning experience, where students not only observe but also test, predict, and draw conclusions from the simulation process. This approach supports the constructivist theory, which states that knowledge is acquired through direct experience and active involvement of learners.

The Smart Digestomap innovation also has novelty value compared to torso media or static anatomical models that are already available on the market. This media is designed from simple and economical materials such as plywood, cardboard, plastic bottles, transparent tubes, magnets, LED circuits, and so on. Despite its simplicity, Smart Digestomap still displays interesting visual and mechanical effects, such as a movable mouth, a stomach that shows chemical reactions, a small intestine that lights up to symbolize nutrient absorption, and a large intestine that shows the flow of food waste. With this design, students can learn the sequence of the digestive process in a realistic way and understand the interrelationships between organs in a complete system.

In addition, this media was developed using a Research and Development (R&D) approach with a 3D model (Define, Design, Develop) proposed by Thiagarajan (1974). The research process involved the stages of defining learning needs (define), designing media prototypes (design), and developing and validating products (develop). Validation was carried out by three expert validators from the MI/SD and MTs/SMP levels, covering aspects of material suitability, media effectiveness, durability, efficiency, and safety. The validation

results showed an average score of 4.60 with a percentage of 92%, which is in the "very good" category. This shows that Smart Digestomap is suitable for use as a valid and effective 3D visual-based learning medium to support the science teaching and learning process.

The existence of Smart Digestomap media not only provides solutions to conceptual abstraction problems, but also contributes to increasing student motivation, creativity, and critical thinking skills. By observing live simulations, students are encouraged to ask questions, analyze the differences between theory and practice, and relate scientific principles to everyday life. This type of learning activity is in line with the student-centered learning paradigm and project-based learning, where students become active subjects who construct their own knowledge.

Therefore, the development of the Smart Digestomap learning media is important in the context of science education transformation. This innovation not only focuses on cognitive aspects but also supports the development of affective and psychomotor aspects through enjoyable, exploratory, and meaningful learning experiences. By integrating the principles of interdisciplinary science and simple 3D-based technology, Smart Digestomap is expected to strengthen students' science literacy, motivate them to think creatively and critically, and prepare the younger generation to be adaptive to the developments in 21st-century educational technology.

METHOD

This study uses the Research and Development (R&D) method, which aims to produce a product and test its validity (Sugiyono, 2013). The product developed is a three-dimensional (3D) learning medium called Smart Digestomap on the subject of the human digestive system. The development model used is the 4-D (Four-D Models) model proposed by Thiagarajan (1974) in Trianto (2009), which consists of four stages, namely define, design, develop. This model is also known as the 4-P model, namely Pendefinisian (definition), Perancangan (design), Pengembangan (development), and Penyebaran (dissemination) (Trianto, 2009). This study was limited to the develop stage or 3-D due to time and scope constraints. This limitation refers to Sukmadinata's (2017) opinion, which states that development research can be simplified into three main stages, namely preliminary studies, model development, and model testing.

Tahap define dilakukan untuk menganalisis kebutuhan dan menentukan dasar media development. Activities carried out at this stage include curriculum analysis to adjust human digestive system material to learning outcomes, analysis of student characteristics to understand visualization and interactivity needs, and concept analysis to identify the relationship between biology, chemistry, and physics concepts relevant to the learning topic. The design stage focuses on the initial design of the Smart Digestomap learning media in the form of a three-dimensional (3D) model that depicts the entire human digestive system using educational materials that are lightweight, safe, and visually appealing. The media is equipped with explanations of the functions of each digestive organ in order to provide concrete and contextual conceptual understanding. The development stage includes the process of creating media prototypes and conducting validation by experts (validators) to assess the suitability of the product before it is used in learning.

The validation was carried out by three validators, all of whom were science teachers, namely Ms. Winarti (science teacher at MTsN 6 Ngawi), Ms. Sulistiowati (science teacher at MI Dukuh Lembeyan), and Ms. Ngumdatul Muawanah (science teacher at SDN Sedahkidul). Validators from the elementary/MI level were selected because the material on the human digestive system is also taught at the elementary/MI level, so that it remains relevant to the field of science. In addition, the selection also took into account the limited number of junior high school/MTs science teachers who could serve as validators during the research. Thus, the

involvement of science teachers from various levels still met the scientific criteria and the suitability of the material with the context of science teaching.

The research instrument used was a Google Form-based validation questionnaire designed using a rating scale with a score range of 1–5. This questionnaire contained six main aspects of assessment of learning media, namely (1) material suitability, (2) durability, (3) accuracy, (4) efficiency, (5) aesthetics, and (6) safety. Before filling out the questionnaire, the validators were first given access to a Google Drive link containing all supporting materials for the Smart Digestomap learning media, including photos and videos of the media, descriptions of each component's functions, and complete instructions for use. This step was intended to ensure that the validators fully understood the characteristics and functions of the media before conducting their assessments, thereby ensuring more objective and accurate validation results. Google Forms and Google Drive links were chosen because they simplify the assessment process, speed up data recapitulation, and maintain the transparency and accuracy of the validation results.

The validation data were analyzed using simple qualitative and quantitative descriptive methods. Quantitative analysis was performed by assigning scores to each indicator according to the assessment scale presented in Table 1 below.

Table 1. Scoring Rules

Score	Description
1	Very Unsuitable
2	Unsuitable
3	Sufficient
4	Suitable
5	Very Suitable

(Source: Riduwan dan Akdon, 2013)

The average value for each criterion is calculated using the formula (Arikunto, 2005:284):

$$X = \frac{\sum X}{N}$$

Description:
X = Average score
ΣX = Total score obtained
N = Number of validators

Next, the average score is converted into a suitability percentage using the formula:

$$P = \frac{Total\ Score\ Obtained}{Criterion\ Score} \times 100\%$$

To determine the length of the media suitability category interval, the following formula is used (Usman and Akbar, 2008):

$$i = \frac{R}{k}$$

Explanation:
i = Interval length
R = Data range (highest data – lowest data),
k = Number of categories

With the highest scale being 5 and the lowest being 1, then:

$$i = \frac{5 - 1}{5} = 0.80$$

The media quality criteria table can be seen in Table 1, and the percentage range and media quality criteria can be seen in Table 2 as follows.

Table 2. Media Range and Quality Criteria

Score	Criteria
4,20 – 5,00	Highly Suitable
3,40 – 4,19	Suitable
2,60 – 3,39	Fairly Suitable
1,80 – 2,59	Less Suitable
1,00 – 1,79	Not Suitable

(Source: Usman dan Akbar, 2008)

Table 3. Media Quality Range and Criteria

Skor	Kriteria
81% – 100%	Highly Suitable
61% – 80%	Suitable
41% – 60%	Fairly Suitable
21% – 40%	Less Suitable
≤ 20%	Not Suitable

(Source: Riduwan dan Akdon, 2013)

The analysis of the validation results was conducted by interpreting quantitative data into qualitative descriptions based on the categories in the table above. The learning media was deemed highly feasible if it obtained an average score of ≥ 4.20 or a percentage of ≥ 81%. This study was limited to the expert validation stage, without conducting field trials or student response tests, because the focus of the study was on assessing the suitability of the Smart Digestomap learning media product by validators, all of whom were science teachers, through a Google Form-based questionnaire and supporting Google Drive links.

RESULT AND DISCUSSION

Science education plays an important role in developing students' scientific, logical, and creative thinking skills. However, in practice, many science concepts are abstract and difficult to understand without the help of appropriate media, one of which is the material on the human digestive system. Students often only memorize the names and functions of digestive organs without understanding the scientific processes that occur within the body. Therefore, contextual, interactive, and visual learning media innovations are needed so that students can build a deeper conceptual understanding. One innovation developed to address this need is Smart Digestomap, a three-dimensional (3D) learning medium based on the integration of Biology, Chemistry, and Physics.

Define Stage

First, the define stage is the initial step in the 4D development model (Define, Design, Develop, Disseminate) proposed by Thiagarajan (1974). At this stage, researchers analyze the needs, characteristics of students, and scientific concepts to determine the basis for developing the Smart Digestomap learning media. This stage is an important foundation because it determines the direction, content, and relevance of the media to the science learning objectives, especially in the material on human digestive mechanisms.

The main focus of the define stage in this study is to analyze the curriculum to ensure that the media development is in line with the Learning Outcomes (CP) and Learning Objectives (TP) listed in the Merdeka Curriculum. Based on the Phase D Science Learning Outcomes (National Standards, Curriculum, and Education Assessment Agency, 2022), students are expected to be able to explain the structure and function of the human digestive organs and their relationship to the process of breaking down food substances into energy.

The human digestive system covers mechanical and chemical digestion processes, from the mouth to the large intestine, as well as the relationship between the structure and function of each organ in the digestive system. The focus of learning is directed so that students not only recognize the names of organs, but also understand the overall working mechanisms of the digestive system, from the process of food breakdown, nutrient absorption, to the excretion of metabolic waste. Thus, learning is more meaningful because it fosters analytical and scientific thinking skills.

Junior high school/MTs students are generally at the formal operational stage of development, where they are beginning to be able to think logically and systematically, but still need concrete help and real visualization to understand abstract concepts (Piaget in Trianto,

2013). In the context of the human digestive system, many students find it difficult to imagine internal bodily processes such as the work of digestive enzymes, peristaltic movements, or nutrient absorption in the small intestine, because these processes cannot be observed directly.

Therefore, visual, interactive, and contextual learning media are needed so that students can understand the process through concrete learning experiences. Effective learning occurs when students are given the opportunity to construct their knowledge through enactive (direct), iconic (visual), and symbolic (abstract) stages (Bruner, 1966). Learning becomes more meaningful when students actively interact with their environment and have the opportunity to construct their knowledge through direct experience (Vygotsky, 1978). Three-dimensional media such as Smart Digestomap fulfills these stages because it provides learning experiences through direct observation, visual simulation, and interpretation of scientific concepts.

In analyzing the concept of the digestive mechanism, the human digestive system involves a series of complex processes consisting of three main stages:

1. Mechanical digestion, which is the physical breakdown of food that occurs in the mouth through chewing and in the stomach through churning movements.
2. Chemical digestion, which is the process of breaking down food into simple molecules by enzymes and digestive fluids such as amylase, pepsin, trypsin, and lipase.
3. Absorption and formation of food waste, where nutrients resulting from digestion are absorbed in the small intestine, while the large intestine absorbs water and forms feces.

This entire process is controlled by the nervous and endocrine systems, so that each organ works in a coordinated and sequential manner to ensure digestive efficiency (Campbell et al., 2017). A deep understanding of this mechanism is important so that students can relate theory to physiological phenomena that occur in the human body.

Media Smart Digestomap was developed using an interdisciplinary and integrative approach, combining three scientific fields, namely Biology, Chemistry, and Physics, into a single three-dimensional (3D) learning unit. This approach is in line with the concept of integrative science learning, which emphasizes the interconnectedness of disciplines to create a holistic and meaningful understanding (Arianto & Fauziyah, 2020). The biological aspect is visualized through an anatomical model of the digestive organs that illustrates the movement of food from the mouth to the anus. The chemistry aspect is displayed through a simulation of the reaction between vinegar and baking soda as a representation of the chemical reaction between acids and bases in the stomach. The physics aspect is realized through the use of LED lights, magnets, and air pressure to illustrate peristaltic forces and the flow of food in the digestive tract.

The integration of these three aspects provides a concrete, exploratory, and participatory learning experience, so that students do not only receive information passively, but also actively observe, experiment, analyze, and draw conclusions based on the phenomena they observe. Based on initial observations in several schools, science lessons on the digestive system still mostly use conventional media such as static images, posters, or simple videos that are unable to describe the mechanisms of organ function in a comprehensive and interactive manner. The research results consist of research findings, including a description of the data collected, data analysis, and data interpretation using relevant theories.

The define stage confirms that the development of Smart Digestomap is based on real learning needs in the field and suitability to student characteristics. Through analysis of the curriculum, student characteristics, and scientific concepts of the digestive mechanism, this media is designed to bridge the gap between theory and practice. The results of this stage's analysis form the main foundation for the next stage, Design, which focuses on designing a prototype of the Smart Digestomap media in terms of visual, functional, and educational aspects. Thus, this media is expected to improve students' conceptual understanding, curiosity, creativity, and critical thinking skills regarding biological phenomena in everyday life.

Design Stage

Figure 1. Smart Digestomap Learning Media

Next, the design stage focuses on the initial design of the Smart Digestomap learning media in the form of a three-dimensional (3D) model that depicts the entire human digestive system using educational materials that are lightweight, safe, and visually appealing. The media is equipped with explanations of the functions of each digestive organ in order to provide concrete and contextual conceptual understanding.

Figure 2. Mouth and Esophagus

In Figure 2, the digestive process begins in the mouth, which is made to resemble a cavity with movable upper and lower jaws containing teeth and a tongue. The entire mouth is made of cardboard and styrofoam, which is painted to resemble the real thing. In the mouth section, chewing movements are simulated using springs from small pears to apply the concept of physics. When the jaw is moved, the springs will work. In this section, students can observe that mechanical digestion serves to reduce the size of the food we eat.

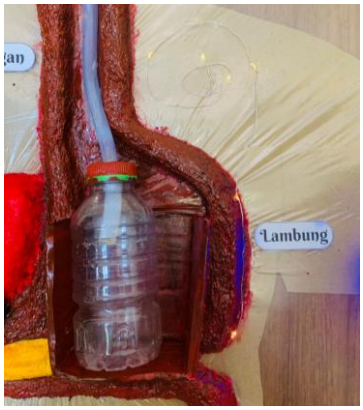

Figure 3. Esophagus, Stomach

In Figure 3, after the process in the mouth is complete, food is pushed into the esophagus and peristaltic movements or smooth muscle contractions occur, pushing food into the stomach without the aid of gravity. The esophagus is designed using a transparent and flexible tube to show the movement of food from the mouth to the stomach. Then, from the esophagus, food will be processed towards the stomach. The stomach is made using colored tissue shaped like a stomach, and in the middle there is a transparent bottle so that the process inside the stomach can be seen. When food mixed with vinegar is swallowed and enters the stomach, it will immediately react with the baking soda provided in the stomach, specifically in the transparent bottle. After that, a reaction occurs between the food and stomach acid. Through this part, students will understand that the stomach is not only a container for food, but also plays an important role in the chemical reactions of digestion (Arianto & Fauziyah, 2020).

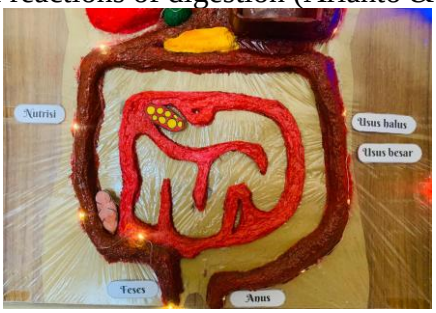

Figure 4. Small intestine, large intestine, nutrition

In Figure 4, following the process in the stomach, the process continues in the small intestine, where the small intestine is designed using colored tissue shaped to resemble a typical small intestine, but with a path in the middle of the intestine for nutrients to pass through. The nutrients are designed using HVS paper shaped to resemble nutrients and magnets are placed under the paper so that they can be moved from behind. Along the pathway, small tumbling lights are attached to symbolize that nutrients are absorbed gradually along the intestinal wall. In this section, when the lights turn on, students can understand that nutrient absorption is an active process that requires energy and occurs throughout the digestive tract, not just at one point.

Figure 5. Large intestine, rectum, anus

In Figure 5, the process continues in the large intestine, namely the formation of feces and the excretion of food waste. Like the other parts, the large intestine is made using tissue that has been colored to resemble the large intestine. In the middle, a path is provided to simulate the passage of feces. The feces are made using HVS paper that has been shaped in such a way and placed on a magnet underneath the paper so that it can be moved from behind. In the final stage, the feces moving from the large intestine are passed on to the anus. In the large intestine, water absorption and feces formation occur, and bacteria play a role in producing vitamin K and intestinal gas (Prasad, 1982). With this design, students can visually observe the final process of digestion, understand the function of the large intestine, and relate the importance of the excretory system in maintaining body balance.

The design stage resulted in the Smart Digestomap, a 3D learning medium that combines scientific and interdisciplinary principles. Each part of the digestive system, from the mouth to the anus, is simulated using mechanical, chemical, and biological approaches using simple and

affordable materials. This design not only displays anatomical forms but also visually demonstrates how the digestive system works. This medium supports constructivist learning, where students can actively engage in observing, experimenting, and drawing conclusions about scientific phenomena (Trianto, 2013).

Develop Stage

Third, during the development stage, the Smart Digestomap learning media was validated by three validators, all of whom were science teachers from elementary/MI and MTs levels. The validators assessed the suitability of the media based on six main aspects, namely material suitability, tool durability, tool accuracy, efficiency, aesthetics, and safety. The assessment was conducted through a Google Form-based questionnaire using a 1–5 Likert scale, where a score of 1 indicated the "unsuitable" category and a score of 5 indicated the "highly suitable" category.

Based on the validation results obtained, the overall average score was 4.60 out of a maximum score of 5, with a percentage of 92%, which falls into the highly suitable category. These findings indicate that the Smart Digestomap learning media has met all aspects of suitability in terms of content, appearance, and functionality. Therefore, the media is declared valid for use in the science learning process and is ready for the next stage of implementation.

Table 4. Smart Digestomap Learning Media Validation Score

No.	Assessment Aspects	Score	Criteria
1.	Material Suitability	4,55	Highly Eligible
2.	Equipment Durability	4,45	Highly Eligible
3.	Equipment Accuracy	4,50	Highly Eligible
4.	Efficiency	4,45	Highly Eligible
5.	Aesthetics	5,00	Highly Eligible
6.	Equipment Safety	4,65	Highly Eligible
Average		**4,60**	**Highly Eligible**

Table 5. Percentage of Smart Digestomap Learning Media Validation Results

No.	Assessment Aspects	Presentase (%)	Criteria
1.	Material Suitability	91,0	Highly Eligible
2.	Equipment Durability	89,0	Highly Eligible
3.	Equipment Accuracy	90,0	Highly Eligible
4.	Efficiency	89,0	Highly Eligible
5.	Aesthetics	100,0	Highly Eligible
6.	Equipment Safety	93,0	Highly Eligible
Average		**92,0**	**Highly Eligible**

The validation results show that the Smart Digestomap learning media obtained an average score of 4.60 or 92% in the very feasible category. This indicates that the developed media has met all aspects of feasibility in terms of visual appearance, material substance, and safety of use. The aspect with the highest score was aesthetics (100%), which indicates that the visual design of the media, color selection, and layout are very attractive and proportional. This finding supports Arsyad's (2010) statement that well-designed visual elements can attract students' attention and strengthen their motivation to learn by increasing the clarity of the learning message.

The aspects of safety (93%) and material suitability (91%) also showed excellent results. This media is considered safe for students because it uses lightweight and non-sharp materials, and the material is arranged in accordance with basic competencies and learning achievement indicators. This is in line with Prastowo's (2018) opinion that learning resources must be

compiled using simple language, relevant content, and an applicable appearance so that they can be used effectively at various levels of education. This view is reinforced by Mais (2016), who emphasizes that the validity of the content of learning media must measure the relationship between learning objectives, competency achievement indicators, and the substance of the material presented.

In addition, the aspects of accuracy (90%), durability (89%), and efficiency (89%) also received a very good rating. These results show that Smart Digestomap is not only conceptually accurate but also efficient and easy to use in learning activities. This media is able to convert abstract concepts of the digestive system into concrete and interactive representations through three-dimensional forms. Akbar (2013) emphasizes that effective learning media must be designed to be simple, efficient, and support the optimal achievement of learning objectives. Thus, this media meets the characteristics of functional and attractive educational media.

Overall, the results of expert validation show that Smart Digestomap has excellent quality in terms of substance, appearance, and safety. These results are in line with Arikunto's (2013) view that a learning medium is considered valid if the assessment results are in accordance with the established criteria, namely the alignment between the results obtained and the assessment standards. Furthermore, Haviz's (2016) opinion also reinforces that a learning product is considered valid if all its components are consistently related and developed based on strong theory and real learning needs.

With an average score of 4.60 (92%), Smart Digestomap is declared valid and suitable for use in science education, particularly in teaching material on the human digestive system. This medium has the potential to improve students' conceptual understanding, interest in learning, and critical thinking skills through concrete and visual learning experiences. The results of expert validation provide the basis for Smart Digestomap to be implemented in real classroom learning to measure its effectiveness empirically.

CONCLUSION

This study produced a three-dimensional (3D) learning medium, namely Smart Digestomap, which functions as an innovative tool to improve students' understanding, creativity, and critical thinking skills in human learning materials. This medium combines the concepts of biology, chemistry, and physics into a contextual whole and provides an interactive and visual learning experience. The results of validation by three experts showed an average score of 4.60 with a percentage of 92%, which indicates a fairly high category. This proves that Smart Digestomap is a reliable and effective medium for teaching, where the tool helps students understand the human thought process in more detail. This innovation also supports student-centered learning and constructivist learning in constructivist education.

However, Smart Digestomap has several limitations, including its large size, which makes it impractical to carry and use over long distances. Furthermore, this tool requires the assistance of another person to explain the function and mechanism of each component for effective learning. Therefore, Smart Digestomap is more suitable for group learning in the classroom than for independent learning.

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