Digestoville: A Multisensory and Inclusive Approach to Enhance Younger Learners' Understanding of Human Digestive System

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Abstract: Many students, particularly those from under-resourced schools, struggle to grasp complex science topics like the human digestive system due to a lack of engaging and interactive teaching tools. Digestoville is a multisensory educational intervention designed to enhance younger learners' understanding of the human digestive system. By integrating tactile, auditory, and visual elements, this approach aims to make complex biological concepts accessible to students from underserved backgrounds. This is where students can touch, see, and interact with learning aids – to make science more accessible and enjoyable. Instead of relying solely on textbooks, Digestoville introduces tools like storytelling, a special apron with detachable organs, and an educational game. These tools allow students to visualize and understand how the digestive system processes food. A mixed-methods study was conducted during STEM Teach Fest with an underprivileged school to test how effective Digestoville is in improving younger learners' understanding of digestion. The results showed that 42% of respondents were more engaged and had a better grasp of the topic. Teachers also found Digestoville helpful and adaptable to classroom settings. This study demonstrates the potential of multisensory teaching methods to bridge learning gaps, enhancing inclusivity and effectiveness in science education for younger learners. These findings underline the importance of such approaches in creating more engaging and accessible learning environments. Future research should explore the scalability of Digestoville in various educational settings.

Introduction

The human digestive system is a complex network of organs responsible for breaking down food into nutrients and eliminating waste. It is also a fundamental concept in biology. However, teaching this intricate process to young learners can be challenging. This is because the traditional methods often fall short in capturing their attention and fostering deep understanding. To address this gap, innovative approaches are essential to make the digestive system accessible and engaging for younger learners. Educators must adopt teaching strategies that address misconceptions, cater to diverse learning styles, and actively involve students. Multisensory learning, which involves stimulating multiple senses simultaneously, has been shown to enhance learning outcomes and retention (Mayer, 2020). Teachers can create a rich and immersive learning experience that makes the digestive system more tangible and relatable by incorporating visual, auditory, and tactile elements.

The Digestoville project was developed to address these challenges by adopting a multisensory and inclusive approach that engages students through tactile, visual, and interactive learning. Multisensory learning involves engaging multiple senses simultaneously during the learning process. This approach contrasts with traditional unisensory methods, which typically rely on a single sensory modality, such as visual or auditory input. With that, Digestoville aims to bridge the gap between abstract concepts and concrete experiences especially for younger learners aged 4-12 from an underprivileged school. Digestoville project consists of three main tools to reinforce the functions and relationships between digestive system components, namely (1) Digestoville story, (2) Digestive Discovery Apron model, and an educational game (3) Digest-O-Quest.

Problem Statement

Young children often struggle with abstract concepts and complex systems because the digestive system can be particularly difficult to visualize and comprehend. Besides, misconceptions about the human digestive system are also prevalent among students and can significantly hinder their understanding of biological processes. Therefore, understanding the misconceptions that primary school students have about the human digestive system is crucial for improving science education.

Research has shown that students frequently harbor misconceptions about the digestive system, such as believing it is a single, open-ended structure or that organs function independently (Cardak, 2015). Moreover, many students incorrectly include organs such as the kidneys in the digestive system or misunderstand the separation of solids and liquids after the stomach (Çuçin et al., 2020). Plus, research conducted by Harahap et al. (2019) found out that students often have incorrect beliefs about the types of food ingredients and their content, the structure and function of digestive organs, and the processes of mechanical and chemical digestion. For instance, a significant percentage of students at SMP 15 Padang showed misconceptions in these areas, with the highest being about mechanical and chemical digestion (50%) and digestive organs

(49%). Çakici (2017) also discovered that many students reduce the digestive system to a simple "tube" with the stomach as the main organ, neglecting other critical components like the intestines, liver, and pancreas. The evidence proved that the students omitted key organs and misrepresented the size and function of digestive organs. These misconceptions not only can hinder their understanding of how food is processed, nutrients are absorbed, and waste is eliminated, but also indicate a broader issue in the foundational understanding of the digestive system.

This study aims to investigate two primary research questions. The first question focuses on how Digestoville can be effectively implemented in science classrooms to enhance students' understanding of the human digestive system. It seeks to explore the methods and strategies that make Digestoville effective teaching tools for improving comprehension among young learners. The second research question examines how teachers from underprivileged schools perceive the effectiveness of Digestoville in teaching the human digestive system. This involves understanding teachers' insights, experiences, and evaluations of Digestoville as a teaching aid in their specific educational contexts.

In light of the growing need for science education that is both inclusive and engaging, this project has two main objectives. The first objective is to explore the implementation of Digestoville in science classrooms to improve students' understanding of the human digestive system. This involves analyzing how Digestoville can be integrated into existing curricula, the pedagogical approaches it supports, and its impact on student learning outcomes. The second objective is to evaluate the perceptions of teachers regarding the effectiveness of Digestoville in teaching the human digestive system. This includes gathering and analyzing teachers' feedback on its usability, adaptability, and overall effectiveness as teaching tools, particularly in underprivileged school settings.

Methodology

This study employed a mixed-methods approach to evaluate the effectiveness of the Digestoville project in enhancing younger students' understanding of the human digestive system. Integrating diverse data types can provide valuable insights and deepen the understanding of research problems (Tariq & Woodman, 2013). Mixed methods research serves as a natural complement to traditional qualitative and quantitative approaches, with pragmatism serving as an ideal philosophical foundation for this methodology (Johnson & Onwuegbuzie, 2004). Therefore, students' and teachers' experiences with the learning aids and their potential were explored through both qualitative and quantitative data collection.

Participants

There was a total of 31 participants involved in this study, including 4 teachers and 27 students from an underprivileged school. In this context, it is defined as a school that is under-resourced and faces challenges such as limited access to quality educational materials and learning opportunities, contributing to a disparity in educational outcomes.

The students were of different nationalities and aged between 4 and 12. This reflects the school's diverse demographic. All the teachers were Malaysians and participated as facilitators and evaluators. This study was conducted during the STEM Teach Fest event that was organized by a private higher education institution in collaboration with a local underserved school. At this event, Digestoville was introduced as an innovative learning aid alongside other educational tools.

Research Instruments
The instruments used to gather the data are mainly surveys and interviews to gauge students' overall learning experience using Digestoville and teachers' perceptions regarding Digestoville as a tool to teach the human digestive system with primary students and teachers who interacted with Digestoville.

Implementation
A step-by-step approach was used to introduce students to Digestoville and its components. A brief introduction to Digestoville as learning tools was provided. The flow of the session started with the Digestoville storytelling using the Digestive Discovery Apron model to narrate a simple story that aligned with the journey of food through the digestive system. The narration was accompanied by the tactile apron that featured detachable components representing the major digestive organs such as oesophagus, stomach, intestines and anus.

Students were encouraged to explore the model independently and collaboratively under the guidance of their teachers. Here, students were able to manipulate the organ components on the apron to build their understanding of the digestive process. The creators were there to provide guided support as needed to allow students to build connections through direct interaction with the model.

After students had a foundational understanding of the organ components, they were invited to participate in the Digest-O-Quest game to reinforce their learning through play. This game encouraged recall and application as students arranged digestive organs in sequence and explained the roles of each organ.

To avoid cognitive overload particularly for kindergarten and primary students, the introduction was segmented into manageable parts. Students initially focused on one organ at a time and gradually progressed to understand the system as a whole. This phased approach was necessary to support both younger students and those with limited background knowledge based on the creators' prior observations.

Data Collection Procedures
Before Stem Teach Fest was over, the survey component of the research instruments was conducted using a simplified voting system to gather students' responses. Students were asked open-ended questions verbally to facilitate simple decision-making and to allow them to express their opinions more freely. Teachers moderated these sessions to help students articulate their preferences and reasoning with questions like "Did the

learning aid help you understand the digestive system better?" and "Which learning aid did you find most fun or enjoyable?". Each student would cast a vote using stickers and paste it on a board. This allowed for immediate visual feedback.

After that, teachers were also surveyed through open-ended questions to allow them to share their impressions of Digestoville's educational value, usability, and its effectiveness in engaging students with varied learning needs. This session allowed the teachers to share detailed reflections on the project's applicability and its reception by students. This process was conducted in a quick and accessible means for gathering qualitative data while minimizing time constraints on students and teachers.

Data Analysis
The data from surveys and interviews were thematically analyzed based on two research questions below by focusing on recurring themes such as engagement, understanding, memorability, usability, and inclusivity. Teachers' feedback was also cross-referenced with student responses to validate patterns.

Results and Discussion
This study assessed the effectiveness of the Digestoville as a multisensory learning tool in enhancing primary students' understanding of the human digestive system. A total of 31 participants (27 students and 4 teachers) provided feedback through surveys and interviews conducted at the STEM Teach Fest event. This section is presented in 2 parts highlighting the key components of Digestoville – Digestoville Story, Digestive Discovery Apron and the educational game Digest-O-Quest – followed by a discussion based on the two research questions.

1. *Digestoville Story*
    The Digestoville Story played a pivotal role in enhancing student engagement and understanding of the digestive system. Through the narrative, students were introduced to key digestive organs as personified characters, each with a unique role in the digestive process. Molly the Mouth, Eddie the Esophagus, Sammy the Stomach, Izzy and Ezzy the Intestines, and Andy the Anus worked together to transform abstract biological concepts into a relatable and entertaining story. This approach not only captured students' attention but also facilitated their retention of complex information. By simplifying the digestive process through storytelling, students could visualize and remember the sequence of events more easily, making it a powerful tool for improving comprehension. The story's interactive nature, where students actively engaged with the characters, also encouraged participation and sparked curiosity during STEM Teach Fest, leading to a deeper understanding of the digestive system. This approach highlights how storytelling can be an effective strategy for fostering engagement and improving subject matter understanding, especially in a primary education setting. Figure 1 shows the Digestoville Story characters and their functions in the kingdom.
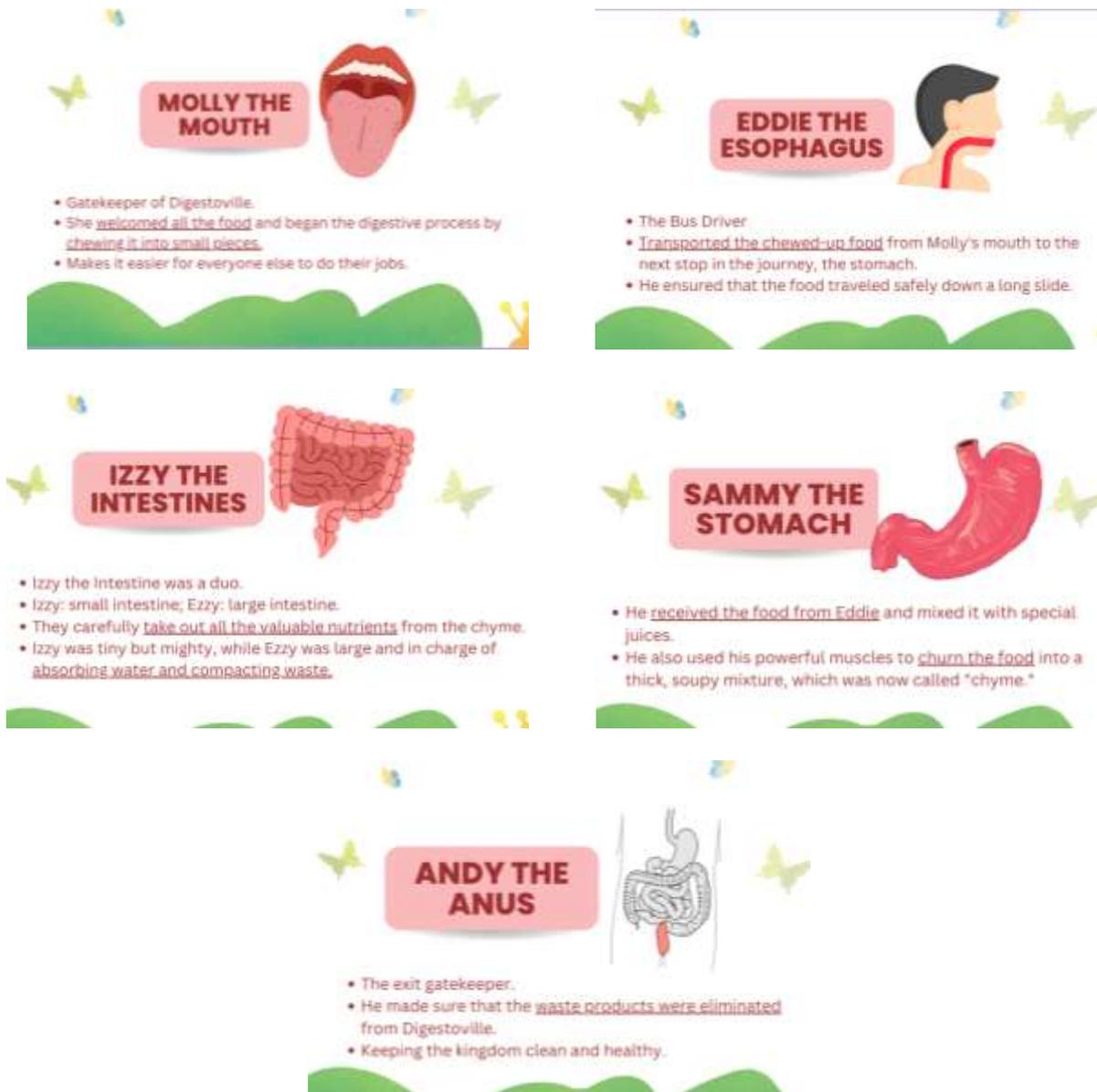
Figure 1: Digestoville Story Characters and Their Functions

2. *Digestive Discovery Apron*

The Digestive Discovery Apron was a key component of the multisensory approach employed in this study. Crafted from affordable materials, including an apron, felt fabrics in various colors, thread, velcro, strings, superglue, and cotton, the resource was designed with primary students in mind, ensuring safety and ease of use. The apron was available in two sizes—adult and child size—to cater to different learners' needs. The inclusion of a child-size apron was particularly significant, as it provided a more relatable and engaging experience for students,

fostering a stronger connection with the material. By using a learning aid that was scaled to their size, students could better interact with the educational content, enhancing both their interest and engagement in the lesson.

Providing both child and adult-size aprons also allowed for differentiated instruction, accommodating various learning styles and preferences. During the STEM Teach Fest, it was observed that some students benefited more from the child-size apron, engaging in hands-on activities that helped them internalize the digestive process through tactile experiences. Others preferred using the adult-size apron, which offered a broader visual representation of the digestive system. This flexibility ensured that all students, regardless of their developmental stage, could participate meaningfully in the learning experience.

The apron activity, where students physically placed felt digestive organs onto the apron, allowed them to visualize and understand the sequence and function of each organ in the digestive system. Teachers observed that this hands-on, interactive learning tool was particularly effective for kinesthetic learners, as it provided an opportunity to physically engage with the material. Furthermore, the collaborative nature of the activity encouraged teamwork and discussion, as students worked together to place the organs correctly, reinforcing their understanding through peer interaction. This approach was proven to contribute significantly to students' comprehension and retention of the digestive process, making it a valuable educational tool in the Digestoville project. Figure 2 presents the model for Digestive Discovery Apron:

**Figure 2: Digestive Discovery Apron**

3.   *Digest-O-Quest*

Digest-O-Quest served as the final interactive component of the Digestoville project, reinforcing younger learners' understanding of the digestive system through an engaging hands-on game. Following the Digestive Discovery Apron and Digestoville story, this activity allowed students to apply their knowledge in a practical setting. In the game, students were provided with pictures of both male

and female bodies as shown in Figure 3, along with cut-outs of the digestive organs. Their task was to correctly place each organ in its corresponding location on the body. The game could be played individually or in groups to foster a collaborative environment.

During the STEM Teach Fest event, it was observed that the students were highly motivated by the competitive element of the game, which encouraged active participation and teamwork. As students worked together to place the organs correctly, they discussed the functions of each organ, reinforcing their understanding through peer interaction.

The game proved to be an effective method for reinforcing the knowledge gained in previous activities. It allowed students to solidify their comprehension of the digestive system while also applying critical thinking to the task of identifying and placing each organ. Teachers noted that students who had previously struggled with understanding the sequence of the digestive process showed noticeable improvement after engaging with Digest-O-Quest. The game provided a memorable, interactive experience that helped students retain and apply key concepts in a fun and engaging way.
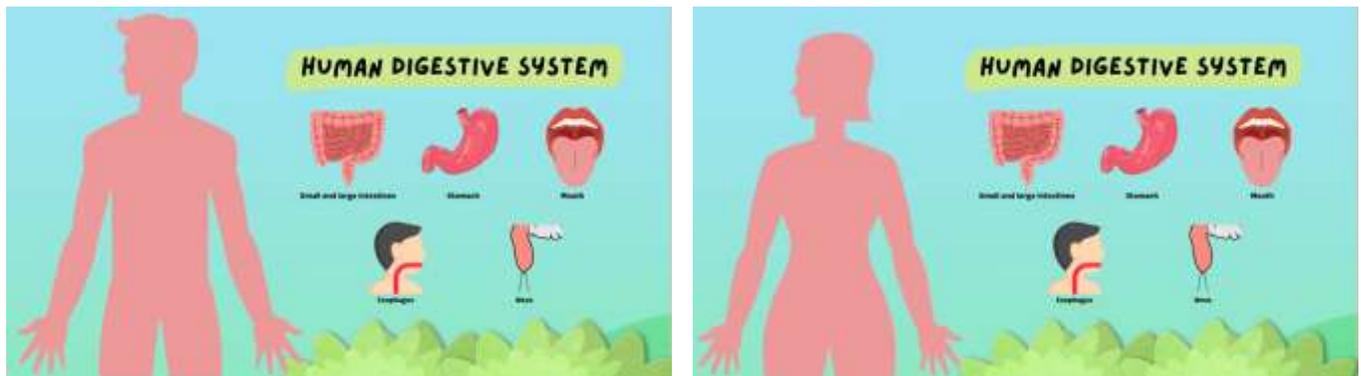
Figure 3: Templates for Digest-O-Quest Game

Research Question 1: How can Digestoville be effectively implemented in science classrooms to enhance students' understanding of the human digestive system?

The survey responses highlighted three main themes related to the use of Digestoville based on Figure 4:
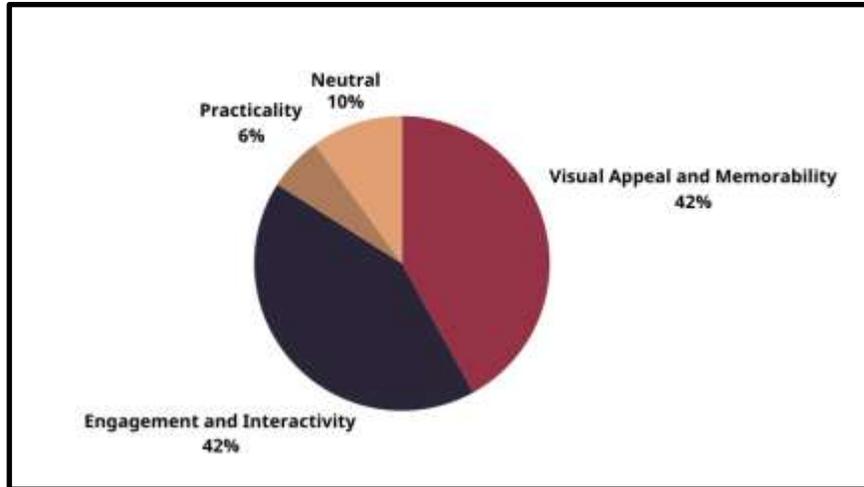
Figure 4: Pie chart of survey responses

Based on Figure 4, 42% of respondents indicated that Digestoville was engaging and interactive, highlighting its potential effectiveness in a science classroom setting. One teacher shared, *"The students were completely focused throughout the session. I was amazed at how well they learned and worked together."* This result emphasizes how multisensory, hands-on learning approaches can capture students' attention and promote active participation, particularly in a subject like human anatomy, which is often abstract and challenging for younger learners. Digestoville's design supports student motivation by giving them autonomy to learn and engage directly with manipulatives, reinforcing the benefits of active learning in complex biological concepts.

Additionally, the tool's visual and tactile features—such as those in the Digestive Discovery Apron and Digest-O-Quest game—were also rated highly, with 42% of participants noting these elements as memorable. This positive response is likely due to students' ability to physically interact with the materials—touching, squeezing, and placing digestive organs on themselves or peers while learning. These interactive experiences not only made the learning process more enjoyable but also enhanced recall, as students were able to remember the digestive organs more easily. This finding aligns with multisensory learning research, which shows that combining visual, tactile, and auditory elements aids in encoding information more effectively (Moreno & Mayer, 2016), fostering a deeper understanding and long-term retention (Mayer, 2014).

However, a smaller percentage of respondents (10%) responded neutrally, and only 6% viewed the tool as practical, highlighting some limitations. Teachers noted that while Digestoville is adaptable and easy to use, there are logistical challenges to implementing such interactive tools within a conventional curriculum, particularly due to limited manpower in the school. These insights underscore the need for additional support and resources to maximize Digestoville's impact in traditional classroom environments.

In summary, these findings suggest that Digestoville could be effectively implemented in science classrooms to enhance students' understanding of the human digestive system, provided that logistical and resource-related challenges are addressed.

Research Question 2: How would teachers from an underprivileged school perceive the effectiveness of Digestoville in the teaching of the human digestive system?

The teachers have provided feedback regarding their experiences and observations with Digestoville during the event which yielded valuable insights into its practical and pedagogical implications. Firstly, teachers reported that Digestoville effectively engaged students and supported comprehension by combining storytelling, visual, and tactile elements. They observed that students not only enjoyed the hands-on activities but also demonstrated improved comprehension by recalling and explaining digestive processes. This observation aligns with Tomlinson's (2023) principles of inclusive materials development which advocate for diverse sensory inputs to cater to varied learning styles and needs. Moreover, teachers also noted that the storytelling aspect of Digestoville helped create a calm and structured learning environment. They added that they are particularly beneficial for students with specific learning needs, such as those on the autism spectrum. This structured and predictable format aligns with evidence that consistency and clear sequencing can be effective strategies for supporting students with unique learning profiles (Rappolt-Schlichtmann, 2018).

Despite the general positive reception, some teachers indicated concerns regarding the practicality of integrating the entire Digestoville components into their science classroom setting. For example, the time required to set up, classroom management and the need for teacher facilitation to ensure that students understood each segment. However, some teachers did acknowledge that the tool's hands-on and modular structure could be adapted to suit different instructional settings with minimal adjustments particularly for students with special needs.

To summarize, the feedback from teachers highlights Digestoville's potential as an engaging, inclusive, and adaptable educational tool, though practical considerations regarding setup and classroom management may need to be addressed to fully integrate it into diverse science learning environments.

Limitations and future directions

Even though the study provided valuable insights into this project, it was limited by the relatively small sample size and the absence of longitudinal data to assess retention over time. Future studies could consider a larger and more diverse sample to validate these findings across varied educational contexts. Additionally, measuring students' understanding over a longer period could provide more comprehensive data on the effectiveness of multisensory learning aids like Digestoville.

Another limitation was the absence of detailed demographic data, such as the breakdown of participants by gender (male and female teachers, boys and girls among the students). Collecting and analyzing such data in future studies could offer a deeper understanding of how multisensory learning tools impact different groups and whether there are variations in effectiveness based on demographic factors. Moreover, classifying participants into categories, such as age, prior knowledge, or learning styles, could further

enhance the analysis by uncovering trends and patterns that may inform more tailored applications of Digestoville.

The study also lacked quantitative data to evaluate specific learning outcomes, such as the number of students who successfully arranged the digestive organs in sequence and explained their roles. Future research should address this gap by incorporating structured assessments, such as pre- and post-tests, to rigorously measure improvements in understanding and recall. Additionally, longitudinal studies could examine the long-term retention of knowledge facilitated by Digestoville, providing a more comprehensive understanding of its impact on sustainable learning.

Expanding research in these areas would strengthen the evidence base for the use of multisensory learning tools like Digestoville and guide their implementation in diverse educational contexts, ensuring they are effective, inclusive, and adaptable to various learner needs.

Conclusion

All in all, Digestoville offers a promising approach to enhance young learners' understanding of the human digestive system. It was proven that the project effectively engages students and fosters a deeper understanding of complex and abstract biological concepts by combining multisensory learning strategies including visual aids, tactile experiences, oral storytelling and interactive games. To add on, the findings of this study suggest that the Digestoville project is a valuable tool for science education as it can be used to supplement traditional teaching methods and provide a more engaging learning experience. By combining all three elements of the Digestoville, the project can spark students' curiosity and motivate them to explore scientific concepts further.

However, further research is needed to assess the long-term impact of the Digestoville project on student learning outcomes. Plus, the scalability of this project also suggests its potential for wider application in other subject areas to foster a more comprehensive and engaging learning experience. By addressing these areas, future studies can contribute to the development of innovative and effective science education.

In conclusion, the Digestoville project demonstrates the power of multisensory learning in enhancing student understanding in the human digestive system and it has the potential to inspire a new generation of young scientists.

Acknowledgements

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