Design of a 7E model inquiry-based STEM (iSTEM) lesson on digestive system for Grade 8: An open-inquiry approach

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Abstract. In this research, we integrated inquiry-based learning and the 7E model lesson planning to STEM education and used the approach called Inquiry-based STEM learning (iSTEM) in order to engage students to be active participants in the teaching-learning process. The main goal of this study is geared towards the development of a 7E model inquiry-based STEM (iSTEM) lesson specifically on the parts and functions of the digestive system for grade 8 learners. The 7E model inquiry-based STEM (iSTEM) lesson was developed through the following stages: a. Selection of topic b. Identification of learning objectives c. Designing of activity d. Assessment by the panel of experts e. Revision f. Pilot testing g. Final revision h. Ready to use 7E model inquiry-based (iSTEM) digestive system lesson. It was rated excellent by the panel of experts that was comprised of in-service science teachers. The performance of the students during the pilot testing (explore phase) was also excellent and 100% of them reached the passing standard. This implies that the developed 7E model inquiry-based STEM (iSTEM) digestive system lesson has a positive effect on the performance of the students and is ensured to have the features that can improve the teaching-learning process.

1. Introduction
In the pursuit of improving science education in the Philippines, several recent efforts have been directed to basic and teacher education levels. One of the recent efforts is articulated by the government through the Enhanced Basic Education Act of 2013[1] that mandated the implementation of the K to 12 basic education curriculum. In this curriculum, the aim of science education is to nurture scientific literacy among learners that will enable them to become participative and informed citizens that can make decisions that have social, health and environmental impacts[2].

However, there are still problems encountered in the implementation of the said curriculum such as lack of learning resources, insufficiency of varied teaching strategies and techniques and very few learning situations that develop critical thinking and problem solving skills[3]. Such problems stem from teacher-centered classes that still prevail in many Philippine schools where teachers opt to lecturing
instead of providing students with engaging and challenging activities [4]. These dilemmas demand innovative approaches in the teaching-learning process in science.

In addition, the fast changes in the field of science and technology and interdisciplinary integration STEM (Science, Technology, Engineering and Mathematics) have become one of the buzzwords in the education arena today [5]. It is one of the focus of many countries since academic performances in STEM disciplines determines a country’s competitiveness and economic development [6]. STEM combines scientific inquiry, technology, engineering design and mathematical analysis into an integrated teaching-learning paradigm [7,8]. In teaching STEM it is suggested that the utilization of challenging tasks or questions can be utilized to stimulate the students use of STEM [9]. To level up teaching and strengthen the effect of STEM teaching, scholars suggested that inquiry-based teaching must be used [10,11].

Inquiry-based activities are essential integration to the explore phase of the 7E Model especially the open-inquiry activities which lets the child create his/ her meaning is essential in the attainment of the learning competencies of the K to 12 curriculum. As stated in its conceptual framework, the K to 12 science curriculums is learner-centered and inquiry-based, emphasizing the use of evidence in constructing explanations [2]. One of the several levels of inquiry-based learning is open inquiry. It is the most complex level of inquiry-based learning, teachers define the knowledge framework in which the inquiry will be conducted, but allows the students to select a wide variety of inquiry questions and approaches (student-designed or selected) [12]. Students who participate in an open inquiry project demonstrated ownership and responsibility for determining the purpose of the investigation and the question to be investigated as a scientist would [13].

In addition, Eisenkraft proposed elicit, engage, explore, explain, elaborate, evaluate, and extend discrete elements for the 7E learning cycle where each phase provides thought-provoking questions, engaging activities and various assessment techniques to help the learners develop critical thinking skills, creativity, teamwork and collaboration and independent construction of meaning [14].

Keeping the rationale in mind behind the 7E model, inquiry-based learning and STEM education, in this research we integrated inquiry-based learning to STEM education and will use the term used by [15] called iSTEM in order to engage students to be active participants in the teaching-learning process.

The main goal of this study is geared towards the development of a 7E model inquiry-based STEM (iSTEM) lesson specifically on the parts and functions of the digestive system for grade 8 learners.

2. Theoretical Background

The 7E model lesson plan and open inquiry approach is deeply rooted to the constructivist theory of learning. The constructivist learning theory emphasizes the understanding of knowledge as an active construction process in the mind of the learner instead of being the acquisition from outsiders in an already organized form) [16]. The basic idea of constructivist learning is —knowledge is not transmitted directly from one knower to another, but is actively built up by the learner. All types of constructivist ideas meet in a common ground, the learner builds up own learning through a process, not absorbs from the outside sources [17].

Eisenkraft proposed elicit, engage, explore, explain, elaborate, evaluate, and extend discrete elements for the 7E learning cycle and said “research on how people learn and the incorporation of that research into lesson plans and curriculum development demands that the 5E model be expanded to a 7E model” [14]. The primary aim of the 7E learning cycle is to highlight the increasing importance of provoking previous understandings and transferring the concepts [18]. The proposed 7E model expands the engage element into two components—elicit where the emphasis of the elicit phase is to make students able to review their prior experiences linked with the learning situations they come across at present [19], and engage where both prior knowledge and generating enthusiasm for the subject matter will be accessed [14]. Similarly, the 7E model expands the two stages of elaborate and evaluate into three components—elaborate, evaluate, and extend.
3. Methods
The following subsections describes the development of the 7E model inquiry-based STEM (iSTEM) lesson.

3.1 Development of the 7E model inquiry-based STEM (iSTEM) lesson
The 7E model inquiry-based STEM (iSTEM) lesson was through the stages illustrated in figure 1 below:

![Diagram of 7E model stages](image)

**Figure 1.** Development of 7E model inquiry-based STEM (iSTEM) digestive system lesson.

The following stages were followed in developing the 7E model inquiry-based STEM (iSTEM) digestive system lesson:

3.1.1. Selection of topic. The topic used for the development of the 7E model inquiry-based STEM (iSTEM) digestive system lesson. The topic Structures and Functions: Focus on the Digestive System was identified based on the Science Curriculum Guide of the Department of Education dated August 2016.

3.1.2. Identification of the learning objectives. The learning objectives were anchored on the Learning Competency on the Science Curriculum Guide of the Department of Education dated August 2016 [2].

3.1.3. Designing of activities for each phase of the 7E model inquiry-based STEM (iSTEM) digestive system lesson. The primary aim of the 7E learning cycle is to highlight the increasing importance of provoking previous understandings and transferring the concepts to new contexts. The 7E model lesson plan consists of seven discrete elements which are designed to achieve the primary goal of the model. The following are the discrete elements of the 7E model lesson plan along with the implemented activities and some evaluation tools for certain elements.

3.1.3.1. Elicit. Drawing out students' prior knowledge students were shown images of food that they have eaten on the day of their class or before going to school. This was followed by asking the following questions: Which of the following are the foods you have eaten today? Why do we eat? If you feel full right now, why is it that after a few hours you feel hungry again? What happened to the food that you have eaten? These questions served as an initiator for the students' prior knowledge to come out from their own idea. Recognizing that students construct knowledge from existing knowledge, teachers need to find out what existing knowledge their students possess.
3.1.3.2. Engage. Grasp the students’ interest in order to increase their motivation to link their prior knowledge to the new learning situations. Here the activity now involved the students to learn and build concepts and ideas based on the experience provided. Students were provided with biscuits and were allowed to eat it and then observe what happened after they put the biscuit in their mouth. The teacher will ask questions until the students will mention terms related to the digestive system. These are the guide questions to be asked: What happened to the biscuit after you put it inside your mouth?; Why do you think the biscuit melted when you put it inside your mouth?; Do you think the mouth is capable of digesting the food that we eat?; Through this activity the students’ interest will be prompted and they can formulate answers to the Big questions sked by their teacher by basing it to their recent experience.

3.1.3.3. Explore. The students were exposed to different learning situations which they will observe the scientific process, create models, simulate, gather facts, develop hypotheses, organize experimental processes. The activity that was provided was an open-inquiry activity where there are no predetermined answers or solutions to the given learning situations. In the said activity, the class was divided into five (5) groups and they were instructed to do the following: What do you think happened to the biscuit after it melted in your mouth? Since we cannot see what is really happening inside our bodies, you will have to imagine what will happen to the biscuit that you have consumed; Demonstrate the process of digesting the biscuit that you have eaten lately using the following materials: Sandwich, Water, Ice candy wrapper, Zip Lock Bag, Plastic Funnel, Plastic Cup, Scissors, Plastic tray, Garbage Bag, Stockings, Rubber Band; After demonstrating the digestive process within your group, you will have to demonstrate it in front of the class.; Each group will have 15 minutes to prepare their demonstration and 5 minutes for their class demonstration; Their demonstration must include the parts of the digestive system along with its function and justify the materials that you used to represent each parts and functions of the digestive system; Their presentation will be graded using a rubric.

3.1.3.4. Explain. The students presented their group output and demonstrate in front of the class the process of digestion. In this phase, students were given the opportunity to explain their work and how they represent the parts of the digestive system using the given materials. The teacher will watch, observe, and evaluate the simulation done by the students and outputs will be rated using the rubric. She may correct any misconceptions about the digestive process as well as add the underlying concepts about the relationship between the structure and functions of the parts of the digestive system through questioning. Guide question: Why did you use this material to represent a certain part and function of the digestive system?

3.1.3.5. Elaborate. During elaboration, the teacher showed a video presentation about the digestive system and let the students take down notes. In order to verify the accuracy of their understanding, the teacher asked some follow up questions after showing the video to the students. Follow-up/guide questions: Based on the video, what happened to the food when it reaches the anus?; Can you explain the pathway of the food from the mouth to anus?; Where do you think the final digestion of food takes place?; Do you think the food will pass through inside the liver, gallbladder and pancreas?

3.1.3.6 Evaluation. Students were given 13 item short quiz. They were asked to arrange the events that occur during the digestive process by putting numbers (1-13) on the blank space provided before each assigned letter.

3.1.3.7 Extend. In this phase, in order for the student to extend their knowledge about the concept, the teacher left a task or question for the students to answer and this will be checked in the next meeting. Guide question: What would happen to your body if one of the parts of your the digestive system will malfunction? Could digestion still continue?
3.1.4. Assessment by the panel of experts (in-service science teachers). Five (In-service Science Teachers) evaluated the said material using a rubric that puts into account the different phases of the 7E learning model.

3.1.5. Revision. After the evaluation the comments and suggestions were put into account and applied to the 7E model inquiry-based STEM (iSTEM) digestive system lesson.

3.1.6. Try out. The 7E model inquiry-based STEM (iSTEM) digestive system lesson was pilot tested in a Grade 8 class from one of the public schools of the division of Iligan City. It was done in one meeting within 2 class hours. The time used for the implementation was aligned according to the class schedule of the Science subject of that particular class.

3.1.7. Final Revision. The comments and observed errors during the try out was done during this phase.

3.1.8. Ready to use 7E model inquiry-based STEM (iSTEM) digestive system lesson. The ready to use 7E model inquiry-based STEM (iSTEM) digestive system lesson is ready for implementation.

4. Results and Discussion

The developed 7E model inquiry-based STEM (iSTEM) digestive system lesson was evaluated by in-service science teachers and pilot tested in one of the public school of the division of Iligan city. The following subsections discusses the outcomes and results of the evaluation and pilot testing.

4.1. Assessment results of the 7E model inquiry-based STEM (iSTEM) digestive system lesson

The 7E model inquiry-based STEM (iSTEM) digestive system lesson was evaluated by in-service science teachers from the department of education. A rubric which was designed based on the context of the 7E model lesson and was distributed to the panel of experts. Table 1 below shows the rating of the rating of the in-service teachers.

| 7E Model Lesson Stage | Mean Rating | Descriptor |
|-----------------------|-------------|------------|
| Elicit                | 9.20        | Excellent  |
| Engage                | 8.60        | Excellent  |
| Explore               | 9.00        | Excellent  |
| Explain               | 8.80        | Excellent  |
| Elaborate             | 8.40        | Excellent  |
| Evaluate              | 9.00        | Excellent  |
| Extend                | 9.00        | Excellent  |
| **Average**           | **8.85**    | **Excellent** |

Table 1 above shows the results of the assessment of the 7E model inquiry-based STEM (iSTEM) digestive system lesson that was rated by the in-service science teachers. As shown, it was rated excellent in the Elicit stage which implies that it identifies “big ideas” and indicators appropriate for lesson. The engage stage is rated as Excellent which means that it addresses all components of this stage: captures students’ attention, accesses prior knowledge, and identifies appropriate activities. Similarly, on the explore stage and excellent rating was given that implies that addresses all components of this stage: student centered, teacher as a facilitator, interactive, inquiry-based, direct concrete experiences with concept. While the explain stage also gained excellent meaning it addresses all components of of this stage: teacher and students work together, analysis of info from exploration, teacher clarifies info and shares scientific terminology, concept is formed. The elaborate stage was rated excellent as well that signifies that it addresses all components of this stage: active learning, student centered activities to
deepen understanding of concept or apply to a real world situation. In terms of the evaluate stage, and excellent rating was given which means that appropriate formal and informal evaluations are identified throughout the lesson. Lastly the extend stage was rated excellent which implies that it shows good understanding of concepts and transfers this knowledge to new learning. As a whole the whole material was rated excellent and ready to be tested on the pilot testing.

4.2. Students’ sample output during the pilot testing
A pilot testing was conducted in one of the public schools of the division of Iligan city. One section of Grade 8 students were involved and participated during the activities in the 7E model inquiry-based STEM (iSTEM) digestive system lesson.

![Figure 2](image1.png)

Figure 2. The students during the making of their output for the explore phase.

Figure 2 depicts the explore phase where the students worked in groups to produce an output where they have to use the given materials to create a model where they can simulate the digestion process. This activity is an open-inquiry one where students have the freedom to innovate and be creative in making their model while at the same time tapping their prior knowledge and experiences and work collaboratively in designing it.

![Figure 3](image2.png)

(a) (b)

Figure 3. The students during the group presentation of their output.
Figure 3 depicts the different groups who presented their output which is a model that they have to operate in order to simulate the digestion process utilizing the materials given to them. Their outputs were assessed using a rubric.

4.3. Students’ performance during the pilot testing

During the explore phase, the students presented their outputs that was to show the digestive system model by operating it to demonstrate how the digestive system process works using the materials that were given to each of the groups. A rubric was utilized to rate the outputs of the students. Table 2 shows the result of the evaluation of this stage.

| Group | Score | Percent | Descriptor | Remarks* |
|-------|-------|---------|------------|----------|
| 1     | 20/20 | 100%    | Excellent  | Passed   |
| 2     | 17/20 | 85%     | Excellent  | Passed   |
| 3     | 19/20 | 95%     | Excellent  | Passed   |
| 4     | 16/20 | 80%     | Excellent  | Passed   |
| 5     | 16/20 | 80%     | Excellent  | Passed   |

*Department of Education Philippines passing standard at 75%

As shown in Table 2 above, all the students performed excellently and remarked as passed in terms of the Department of education passing standard of 75% which translates that 100% of the students passed during the explore stage where they are exposed to an open-inquiry activity. This demonstrates the positive effect of the 7E lesson plan integrated with an open-inquiry activity on the conceptual knowledge of the learnings regarding the Parts and Functions of the Digestive System. Such positive performance is similar to the study of [15] where they also utilized the and inquiry approach to STEM in the biology subject and found a high results on the students performance which implies a positive impact of the said approach. Similarly a study by [20] utilized an inquiry method in teaching Biology and found that it enhanced the student’s achievement in the said subject. In addition, a study which utilized the use of 7E instructional model in teaching biology found that it is more effective than the traditional instructional method in terms of students’ achievements [19].

5. Conclusion

The developed 7E model inquiry-based STEM (iSTEM) digestive system was rated excellent in all of its stages by the in-service science teachers. In addition, it has provided engaging activities from all of its phases most especially in the explore phase where an open-inquiry activity was utilized and the results of the activity were excellent and 100% of the class got the rating of 75% and higher which translates that all of them passed. This implies that the developed 7E model inquiry-based STEM (iSTEM) digestive system lesson has a positive effect on the performance of the students and is ensured to have the features that can improve the teaching-learning process.

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