

A Mathematics Lesson Designed Using 5E Learning Cycle Model

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Abstract

In 2003-2004, as “RtB Educational Solutions”, we designed mathematics lessons for the Malaysian Ministry of Education/Siemens Business Services was the undertaker and RtB Educational Solutions was the subcontractor of the project. The courseware was intended to be used as a teaching courseware for mathematics teachers. In the courseware, we applied 5E model as an instructional design to the multimedia. This courseware was prepared for grade 7 and in accordance with the curriculum for secondary schools affiliated to the Ministry of Education of Malaysia. In this paper, an application of 5E Learning Cycle model using technology in mathematics lessons that were produced for Malaysia Ministry of Education will be introduced.

Introduction

Multimedia in the Classroom

Interactivity is the heart of digital multimedia (see figure 1). With interactivity, the audience is involved in the communication process and in the navigation of the content. Lindstrom (as cited in Neo & Neo, 1994) reported that people remember 20% of what they see, 40% of what they see and hear, but about 75% of what they see and hear and do simultaneously.

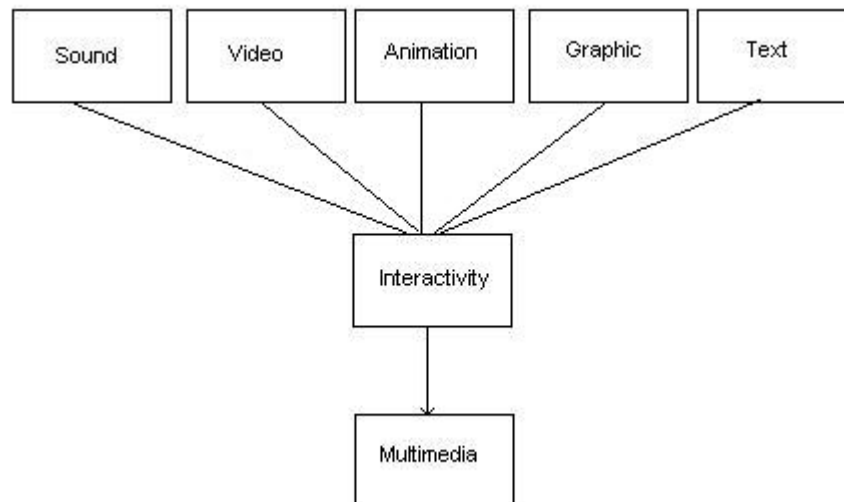


Figure 1

Therefore, interactive features in a multimedia application facilitate interactivity and the interaction between the computer and the user.

Peck (as cited in Speaker, 1999) defined multimedia instruction as a computer controlled combination of two or more media types, to effectively create a sequence of events that will communicate an idea visually with both sound and visual support. Erwin and Rieppi (as cited in Speaker, 1999) defined multimedia instruction more integratively: A lecture classroom that is internet compatible and is equipped with dual multimedia computers, dual rear projection screens, a video disc player, a VCR, CDRoms, an audio cassette player and an electronic student polling system with individual key pads.

Harris (2002), on the other hand, emphasizes that these definitions take only the basic instructional delivery system into consideration, not the constructionist methodology of use that is needed to create a superior or optimal teaching and learning experience.

A review of recent research on the implementation of multimedia application in the classroom indicates that experts have advocated it as a superior means to deliver information, promote students' interaction and graphically organize material (DiCecco and Gleason, as cited in Speaker, 2002; Kirylo and Millet, as cited in Speaker, 2000).

However Doering, Hughes, and Huffman (as cited in Speaker, 2003) state that there is a high level of teacher apprehension about incorporating multimedia technology into individual classrooms due to a lack of preservice preparation in the use of educational technologies. Government statistics from the Office of Technology Assessment (OTA) report that only 3% of teacher education graduates felt "very well prepared" to use technology in their classrooms (U.S. Congress, as cited in Speaker, 1995). In Survey of Technology in the Schools (as cited in Speaker, 1999), it is reported that only 11.3% of the nation's teachers feel they have advanced skills to integrate technology into their daily teaching. Speaker (2004) emphasizes that the value of integrating technology into classrooms at all levels has been acknowledged in many research studies in different disciplines.

Mathematics Teaching and Constructivism

The philosophy about learning which proposes that learners need to build their own understanding of new ideas has been labeled constructivism. Szesze (2001) describes constructivism as an approach to education that provides students with opportunities to "construct" personal meaning to learning. He also states that rather than the idea of giving information to students, it provides a set of experiences in which students develop and integrate understandings of the topic.

Constructivism's central idea is that human learning is constructed that learners build new knowledge upon the foundation of previous learning. Constructivism represents one of the big ideas in education. Its implications for how teachers teach and learn to teach are enormous. To date, a focus on student-centered learning may well be the most important contribution of constructivism. Two important notions orbit around the simple idea of constructed knowledge. The first is that learners construct new understandings using what they already know. They come to learning situations with knowledge gained from previous experiences, and that prior knowledge influences what new or modified knowledge they will construct from new learning experiences. The second notion is that learning is active rather than passive. Learners confront their understanding in the light of what they encounter in the new learning situation. Learners remain active throughout this process: they apply current understandings, note relevant elements in new learning experiences, judge the consistency of prior and emerging knowledge, and based on that judgment; they can modify knowledge (Hoover, 1996).

Math is a cumulative, vertically structured discipline. Moursund (2005) states that one learns math by building on the math that one has previously learned. That, of course, sounds like constructivism.

According to Kamii and Lewis (1990) in reality, no one can teach mathematics. They think that effective teachers are those who can stimulate students to learn mathematics. MSEB and National Research Council (as cited in Kamii & Lewis, 1989) report compelling evidence that students learn mathematics well only when they construct their own mathematical understanding.

Jaworski (1996) emphasizes that the power of constructivism for mathematics education is encapsulated in a principle stated by Von Glasersfeld. Glasersfeld (as cited in Jaworski, 1987) stated that coming to know is a process of adaptation based on and constantly modified by a learner's experience of the world. Jaworski notes that if there is some independent, pre-existing body of mathematical knowledge we can not know it except through our own experience, and we can only know what we ourselves have constructed and modified according to further experience.

Students need to construct their own understanding of each mathematical concept. This changes the direction of teaching from lecturing, explaining, or namely transferring mathematical knowledge, to creating situations for students that will foster their making necessary mental constructions (Kamii & Lewis, 1990). We can infer that students will be discussing and reflecting in those kinds of situations.

5E Learning Cycle Model and Constructivism

The Biological Science Curriculum Study (BSCS), a team whose Principal Investigator is Roger Bybee, developed an instructional model for constructivism, called the "Five Es" (BSCS, 2005). This learning approach can be summarized as follows: Learning something new, or attempting to understand something familiar in greater depth, is not a linear process. In trying to make sense of things we use both our prior experience and the first-hand knowledge gained from new explorations. As we begin to investigate new ideas, we can put together bits and pieces of prior explorations that seem to fit our understanding of the phenomena under present investigation. Piece by piece we build knowledge. Sometimes when the pieces don't fit together, we must break down old ideas and reconstruct them. We extend our conceptual understanding through discussions and creative efforts. We validate our theories as we solve problems. The clarity we've gained in understanding a concept gives us the ability to apply this understanding to new situations and new mysteries. It is a continuous and a very individual process. We bring each learning experience to our developmental level, our personal story and our personal style.

The 5E learning cycle model requires instruction to include the following components: engage, explore, explain, elaborate, and evaluate.

Components of 5E

Engage:

In the **Engagement** stage, students build connections with their prior knowledge and experiences. “Asking a question, defining a problem, showing a surprising event and acting out a problematic situation are all ways to engage the students on the instructional tasks” (Bybee, 2001). The activities in this section provide motivation to learn, stimulate students’ thinking and help them access prior knowledge.

The Role of the teacher:

- Poses problems, asks questions, reveals discrepancies, causes disequilibrium or doubt and assess prior knowledge of the students.
- Creates interest and generate curiosity in the topic of study; raises questions and elicits responses from students that will give an idea of what they already know.

Explore:

In the **Exploration** stage, students get directly involved with phenomena and materials and the students’ inquiry process drives the instruction during an exploration (Bybee, 2001). During this phase, students make observations and collect data.

The Role of the teacher:

- Encourages the students to work together.
- Assumes the role of facilitator, poses questions and assists students individually and in small groups (Barman & Kotar, 1989).

Explain:

In the **Explanation** stage, students begin to put the abstract experience through which she/he has gone into a communicable form (Bybee, 2001). Students are now involved in an analysis of their exploration. Their understanding is clarified and modified because of reflective activities.

The Role of the teacher:

- Introduces new terminology in his/her discussion (Bybee, 2001).
- Provides definitions and explanations using students’ previous experiences as a basis for discussion.

Elaborate:

In the **Elaboration** stage, the students expand the concepts they have learned, make connections to other related concepts, and apply their understandings to the world around them (Bybee, 2001). This stage allows students to apply their new labels, definitions, explanations and skills in new but similar situations.

The Role of the teacher:

- Consolidates and expands student thinking.
- Asks students to apply the concepts to a real-world situation.

Evaluate:

In the **Evaluation** stage, teacher determines if the students understand the concepts and knowledge (Bybee, 2001). During this stage, a wide variety of informal and formal assessment strategies are used to assess both learning and teaching. Bybee (2001) says that some of the tools that assist in this diagnostic process are: rubrics (quantified and prioritized outcome expectations) determined hand-in-hand with the lesson design, teacher observation structured by checklists, student interviews, portfolios designed with specific purposes, project and problem-based learning products, and embedded assessments.

The Role of the teacher:

- Provides opportunities for self-assessment.
- Assesses and/or evaluates student performance and/or understandings of concepts, skills, processes, and applications.
- Observes students as they apply new concepts and skills to assess students’ knowledge and/or skills, looking for evidence that the students have changed their thinking or behaviors.

Lesson Design According to Components of 5E

In this lesson, we have introduced the concept of “Pi”. Students will explore the relation between circumference and diameter of a circle and they will estimate the value of Pi.

Engagement

In the engagement page, there is a question which mentally helps students to engage for the activity. On this page, students observe inner and outer circles in the water wave. The diameter and the circumference of these circles are given.

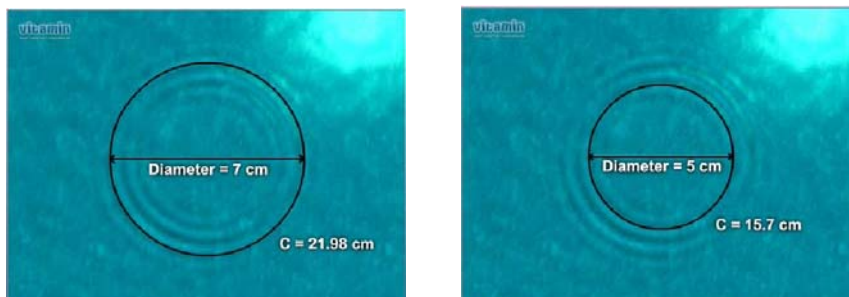


Figure 2

Then, the question about comparison between the ratio of the circumference to the diameter of outer circle and the circumference to the diameter of inner circle is asked.

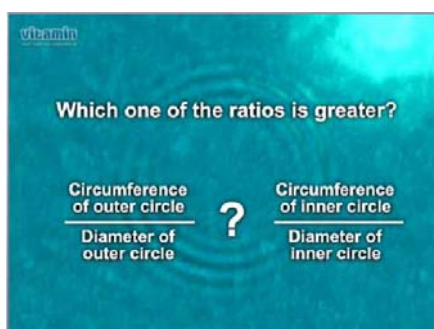


Figure 3

On this page, students observe the demonstration about the relation between the circumference and the diameter. The concepts of diameter and the circumference are related to the students' prior knowledge. This demonstration helps them to make connections with what they know and what they can do.

This page generates enthusiasm for the subject matter that is asked in the question and gets students to think about it. Also, students have an idea about what is to be taught in the next stages of the lesson.

During the engagement page, students confront with real life situation that is given to capture their attention. This situation occurs in the beginning of the engagement page in order to help them to focus on the question.

The animation is directly related with the outcome of the lesson which aims to teach the relation between the diameter and the circumference of the circle. Thus, it can be said that the main point of this page is to help to organize students thinking toward the learning outcomes of the current lesson.

Exploration

In this exploration activity, students will observe some measurements for an enclosed part of a house farm, which is a circle. The circumference, the diameter and the ratio of the circumference to the diameter will be given. By the help of a point on the circle, it is possible to enlarge or reduce the circle. Students should be informed that they will observe the change in the ratio of the circumference to the diameter as the size of the circle changes.



Figure 4

This activity provides an experience about a concept (Pi) that will be introduced in the next parts of the lesson. It is important not to mention the name of this special value at this time.

Students' job during exploration is to observe this ratio and expect that it is approximately 3.14. Then they will need to make more observations to see if their expectations are confirmed.

After students have observed, a class discussion may be held and students are encouraged to discuss their observations. They are asked whether they see a relation between the circumference and the diameter. This question is linked to the learning outcome of the lesson.

The main point of this activity is that students are making observations and they get directly involved with the phenomena. This point is especially emphasized in the literature. Students study to see the relation between the diameter and the circumference of a circle. The teacher assists the students while they are making observations and discussing about their observations.

Throughout this exploration activity, students realize they are not being tested and generally perceive the activity to be fun and not threatening. They also feel free to express their ideas and make contributions.

Explanation:

Before this explanation page, students observed the changes in the ratio of the circumference to the diameter for different circles. They observed that the ratio of the circumference to the diameter is approximately equal to 3.141, 3.142, and 3.143.

In this explanation page students are involved in an analysis of their exploration.

Students see that the last digit of the ratio of the circumference to the diameter is not always the same. Then the reason is given as it was not possible to measure the diameter and the circumference of the given circle exactly.

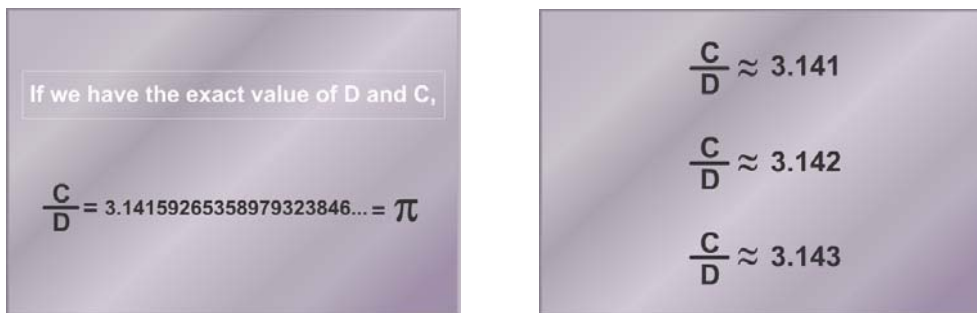


Figure 5

It is also given that if we had the exact value of the diameter and the circumference, then the ratio of the circumference to the diameter would be 3.14159 and so on. It is explained that this ratio is the same for every circle and this number is called Pi.

The main point of this page is to teach new terminology to the students. Throughout this page, we see that students learn pi. Also, they have the opportunity to define and explain pi by using their previous experiences.

This explanation page helps students to clarify where the pi comes from and what it is. At the end of the animation, students learn that the ratio of the circumference to the diameter is equal to pi and this is true for every circle

Elaboration

During their education life students should learn how to think and how to suspect. They should learn that they can not decide without thinking whether a proposition is true or not. While they think they should also suspect what they have thought. Teachers should consolidate, expand and help student thinking.

In the “Elaboration” part, our aim is to expand the concept of Pi. Students should be fully aware of the “meaning of Pi” by making connections to previous concepts. This part also allows students to apply their new knowledge about Pi.

At the beginning of this part students are asked a question which involves a shape like a circle (Figure 6).

The question is as follows: *Now students, I have created a shape. Its circumference is 10.42 cm but I have hidden most of the shape. Now, I want you to decide whether this shape is a circle or not.*

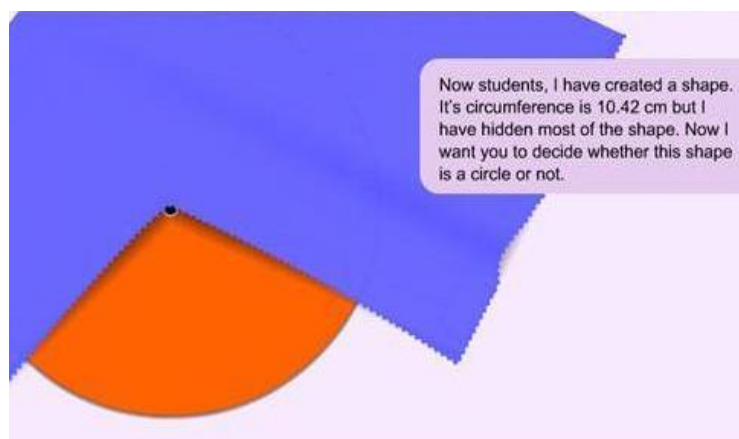


Figure 6

The system directs the user to calculate the ratio of circumference to diameter. By clicking on the “**Measure**” button the user can measure the radius of the shape. The radius of the circle is equal to 1.5 cm. Since the previous page is about Pi, at the end of the calculation, the user’s expectation regarding the ratio of circumference to diameter is that the ratio in question might be Pi.

However by clicking on the “**Calculate**” button, the user sees that the ratio of circumference to diameter is 3.47 which is not equal to Pi.

At this stage, the user should recall the meaning of Pi, interpret the result and then determine whether this shape is a circle or not (Figure 7).

After making a decision and clicking on one of the buttons, the system gives the feedback to user for him/her to see whether s/he is correct or not.

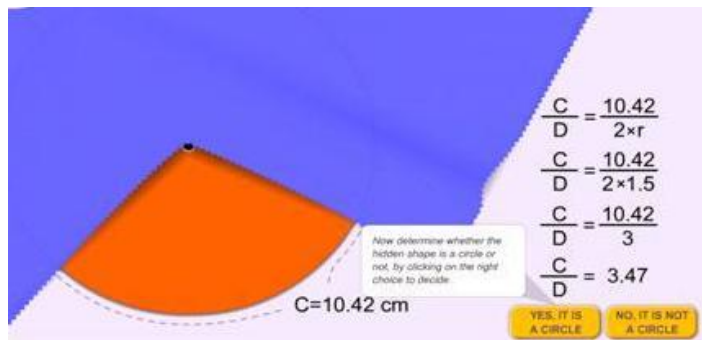


Figure 7

C/D is equal to 3.47 which is not Pi. After displaying all of the shape, the user sees a shape like a circle but not a circle.

Therefore the system gives the following feedback “*the hidden shape is not a circle because the ratio of circumference to diameter is not equal to Pi.*”

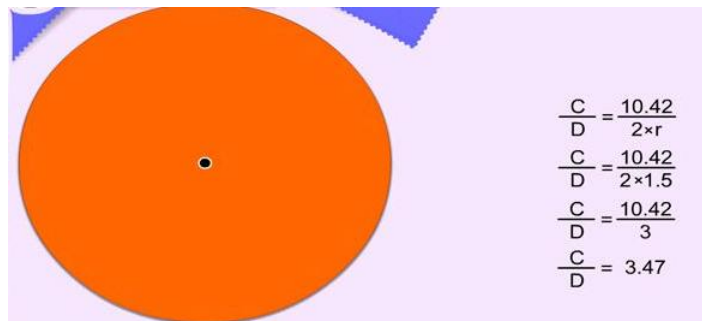


Figure 8

Evaluation

Learning requires mentally taking hold of ideas and experiences and working to make them work together as a reasonable whole. The evaluation page helps students and teachers to achieve this goal.

Evaluation and assessment occurs at all points during the instructional process. If the planned lesson reflects the stated purpose or objective, then evaluation should follow naturally.

In this evaluation page, questions are prepared to encourage students’ interest and to develop their thinking skills. The purpose is also to generate interest in the topic and bring out prior knowledge. The type of the questions that are planned in the evaluation page allows answering the question such as “What did children learn about lesson objective and how did they demonstrate that learning?”

In this evaluation page, there are two types of questions: open ended questions and multiple choice questions.

Open ended questions lead students to think analytically and critically. Also, this type of questions gives an opportunity for discussion in the classroom environment.

On this page, there is one open ended question, and either alone or in groups students try to find the answer of the question. There is a show answer button for this type of questions. When the question is read, the button becomes active and when students click on it, they can see the correct answer.

Also, there is one multiple choice question on this evaluation page. Multiple-choice items present a question and ask students to choose from a list of possible answers. The question features one correct answer, and three “distractor” choices that are not correct. After the question is read, students have opportunity to click on the choices. Then the related feedback is given. Also, there is a show answer button as well for this type of questions.

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