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How to make the engage really engaging: A framework for an instructional approach for the pre-service teachers

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ABSTRACT

The five phases of the 5E instructional model based on the constructivist learning theory encourages inquiry in the science classroom. The first, engage phase of the 5E inquiry model plays a critical role in piquing students' interest and in the pre-diagnostic assessment before beginning the lesson. In this study, 55 pre-service teachers (PSTs) enrolled into a science methods course and participated in a qualitative research study. Using the 5E instructional approach, PSTs planned and implemented peer teaching and field teaching. The data from the PSTs inquiry-based peer teaching lesson plans, field teaching lesson plans, peer teaching sessions, and PST interviews were constantly compared and analyzed. The results showed that only 56% of the PSTs planned lessons with good engage phase that relates to the objective of the lesson, with good questions to assess students' knowledge and spur their curiosity. Based on the results of this study, we came up with a framework to design a good engage phase:

- Engage phase must relate to the objective of the lesson.
- Engage phase must assess students' prior knowledge and identify their misconceptions.
- Engage phase must create curiosity among students.

Keywords: constructivism, engage, 5E inquiry model, pre-service teachers, science teaching

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INTRODUCTION AND LITERATURE REVIEW

Uno (1999) posited inquiry as "a technique that encourages students to discover or construct information by themselves instead of having teachers directly reveal the information." Inquiry in science classrooms is considered an amalgamation of "cognitive, social, and physical" practices (NRC, 2012). Inquiry-based science teaching is important for in-depth understanding of science content. According to Furtak (2006), the inquiry in science teaching happens in two forms: scientific and constructivist. The scientific form affirms that students learn science best by doing what scientists do. The constructivist form affirms that students discover and construct knowledge from their experiences. The 5E model is one such instructional method that uses inquiry to teach students about science content (NRC, 2012). The 5E instructional model pushes the students to be scientific and constructivist at the same time.

Bybee et al. (2006) established the 5E instructional model, which originated from the three phased learning cycle. In addition to the existing three phases: *exploration, concept introduction,* and *concept application*, *engage*, and *evaluate were added.* Therefore, the 5E model has five phases: *engage, explore, explain, elaborate,* and *evaluate.* The three phases of the learning cycle (*exploration* phase, *concept Introduction* phase, and *concept application* phase) align with *explore, explain,* and *elaborate* phases of the 5E model, respectively. The initial *engage* phase is a new phase during which teachers assess students for their prior knowledge and generate students' interest concerning the topic at hand.

Most teacher educators use the 5E lesson plan model as a framework to support pre-service teachers (PSTs) in professional development programs to design and teach science lessons (Duran & Duran, 2004). However, few focus on the engage phase and how students can use the engaging engage phase in truly engaging way to keep the student's attention.

The engage phase plays a vital role in assessing the student's prior knowledge, addressing misconceptions, and laying a good foundation. Bybee et al. (2006) summarized the engage phase as the activity that "makes connections between the past and present learning experiences, exposes prior conceptions, and organizes students' thinking toward the learning outcomes of current activities" (p. 2). The engage phase sets the stage for the whole lesson and allows students to learn new knowledge. The engage phase also plays a crucial role in directing students to the main idea or the objective of the lesson. Tanner (2010) posits that the teachers believe the engage phase usually happens at the beginning of the class, but that teachers can take the liberty to engage students throughout the lesson. He indicated that the engagement could also be structured through homework assignments, writing reflections, reading articles, or watching videos.

Table 1. Some examples of the engage phase

Name of PSTs & grade	Objective of lesson	Engage activity chosen	Successfully related to lesson objective (S) or failed to relate to lesson objective (F)
PST-28 & PST-29 6th grade	Students will identify parts and understand functions of an animal cell & plant cell. Students will also be able to distinguish between plant & animal cell.	Questioning: "What are different parts in an animal cell?" & "How does the animal cell differ from a plant cell?"	S
PST-13 & PST-14 4th grade	Students will understand & identify difference between complete & incomplete metamorphosis.	Reading the book "The very hungry caterpillar"	S
PST- 30 & PST-31 4th grade	Students will demonstrate & identify layers of the Earth.	Activity with Snicker bars.	F
PST-25, PST-26, & PST-27 5th grade	Students will understand concept of static electricity.	Showing a video	F

Previous empirical research mentions the benefits of the engage phase and how if implemented correctly the engage phase sets the stage for a meaningful science lesson. However, there is a paucity of research concerning a specific structure for the engage phase or what constitutes a good engage phase of the 5E model. Knowing that the engage phase is student-centered, a motivational period that creates a desire to learn more, and nudges the students to ask themselves: "What do I already know about this topic?" (Duran & Duran, 2004), we chose to investigate and create a framework for the successful planning and implementation of the engage phase.

In this study we explored the ways PSTs chose to engage students, if they asked questions, and were they able to relate the engage phase to the objective of the lesson. We argue that a successful engage phase must satisfy at least one of the following conditions:

a) its close relation to the lesson objective,

b) its ability to assess students' prior knowledge and identify misconceptions, or

c) create curiosity among students about the concept being taught.

METHOD

For this study we adopted a qualitative research method with 55 PST participants. The participants were introduced to the 5E inquiry model as part of the science methods course for elementary education. As part of the course work at a private university in North Texas, the PSTs used the 5E inquiry model to teach their peers and students in the field. PSTs' peer teaching lesson plans, field teaching lesson plans, peer teaching observations, and semi structured interviews were the data sources for this study. Rubrics for lesson plans and peer teaching sessions were designed to collect and analyze the data. The data from field teaching lesson plans, peer teaching lesson plans, peer teaching sessions, and interviews were constantly compared according to Glaser's (1965) method. The analyzed data indicated the relativity of the chosen engage phase to the objective of the lesson, types of questions PSTs asked to assess students' prior knowledge, and types of engage activities the PSTs chose to create and model curiosity in students.

RESULTS

According to the analysis of the data collected in this study, the engage phase should:

- relate to the objective of the lesson,
- assess students' prior knowledge and identify their misconceptions, and
- create curiosity among students

Relate to the Objective of the Lesson

Abrahams and Millar (2008) posit that "science involves an interplay between ideas and observation" (p. 1965). The activity, question, or a video chosen in the engage phase must develop a strong connection between the observations made during the engage phase and the big scientific ideas in the lesson objectives. The credibility of the engage activities, their relativity to the objective of the lesson, and the science inquiry appeared to be highly motivating for the students. The motivation resulted in the improved students' desire to help themselves push through any initial confusion to grasp the authentic scientific information (Schinske et al., 2008). PSTs cannot plan to guide students to link the theoretical ideas and the observations made through the activities. Students will only be able to link their observations to the big ideas if the PSTs present them with clear learning objectives.

Well planned engage activities not just help students link their ideas and observations but also motivate them to discover the underlying scientific principles.

The results showed 73% of the PSTs had an engage phase related to the objective of the lesson. In their interviews, 24% of the PSTs shared that the successful engagement at the beginning of the lesson was directly proportional to the students understanding of the lessons' objective. **Table 1** shows some examples of the engage phase that successfully relate to the lesson objective and others that fail to relate to the lesson objective.

In **Table 1**, the first example (PST-28 and PST-29), PSTs chose an engage phase related to the lesson objective. They chose to ask questions and assess student's prior knowledge about the topic. PSTs chose a good mix of open and close ended questions. The open-ended question "how does the animal cell differ from a plant cell?" promoted discussion among students, stimulated student's thinking, and allowed students to hypothesize, speculate, share their existing ideas. The close ended question "what are different parts in an animal cell?" checked whether students were able to retain and recollect previously learned information. It also helped the teacher understand if students were thinking and connecting commonly held set of ideas.

The second example shows PST-13 and PST-14 choosing to read a book as an engage activity. The activity was related to the objective of the lesson, as reading the book aloud piqued students' interest immediately. For example, while reading "The very hungry caterpillar" the students asked their peers what will the caterpillar transform into?

Table 2. Examples of types of questions asked

Name	PST-3 & PST-4	PST-15 & PST-16
Title	Matter	Kinetic & potential energy
Open	Where will the ice cube melt quicker? Closer to the flame or away from the flame? Why?	Who gets the feeling of stomach dropping or rising into your throat on the roller coaster? Why does that happen?
Closed	How are the molecules in an ice cube?	Who in the class has been on a roller coaster?
Rhetorical	What are the three different forms of matter?	Does anyone know what type of energy happens when roller coaster is about to start?

The third example in the table, PST-30 and PST-31, while teaching layers of the earth, asked students to cut the snicker bar into half. PSTs during this engage activity neither provided guiding questions nor guided students to compare it to the layers of the earth. The activity was facilitated poorly and failed to engage the students

The last example of PST-25, PST-26, and PST-27 chose to engage students by showing them a video about static electricity. The video chosen was too long (six minutes) and poorly animated for the age group, also presenting the information directly to the students. The video demonstrated the balloon experiment where the bits of paper stick to the balloon and explained the science backing it. The same experiment would have made a great explore activity for students, if followed by inquiring questions. The PSTs could have stopped the video after the demonstration and asked questions to create curiosity and check students' understanding. The engage activity failed to intrigue students or stimulate their thinking. Also, PSTs did not plan to ask guiding questions, which could have filled the gaps between the video and the topic.

Assess Students' Prior Knowledge and Identify Their Misconceptions

The results showed that only 15% of the PSTs were successful in asking good questions in the engage phase of this study. PSTs' during their interviews shared their ambiguity with the type of questions to ask in the engage phase. The results show that apart from engaging students by choosing a relevant engage activity, it is crucial to choose one, which can assess their prior knowledge about the topic. To assess what students already know about the topic, PSTs can incorporate guiding questions into activities. Engaging students can be as simple as asking them what they already know about the day's topic before you start; this strategy has the bonus of revealing what students already know (Allen & Tanner, 2002).

As this study takes the constructivist approach, we believe that knowledge is constructed from one's experiences. Students come into the classroom from diverse backgrounds with diverse experiences. When new concepts are introduced to them in the classroom, students link the concepts with their preconceived notions and life experiences. Some of those notions and experiences may lead to misconceptions. It is very important to identify the misconceptions students have regarding the topic. As Taber (2014) mentioned in his study, the good teaching practices require the teachers to acknowledge students' preconceived knowledge, existing conceptions, and misconceptions, which might affect their understanding of the scientific ideas.

Allen and Tanner (2002) opined that questioning in the engage phase initiates teaching, as the process influences the behaviors, attitudes, and reveals students' misconceptions and misunderstandings. They also believe that "when practiced artfully, questioning can play a central role in the development of students' intellectual abilities; questions can guide thinking as well as test for it" (p. 63).

Table 2 shows the examples of questions asked by the PSTs in our research study. The examples mentioned above in **Table 2** are a good combination of open, closed, and rhetorical questions, which can assess students' prior knowledge concerning the topic and guide their thinking. For example, PST-3 and PST-4 while teaching "matter" to grade 3 students asked "where does the ice cube melt quicker? Closer or away from flame?" The students answered that melting happens closer to the flame, then PSTs asked "why?"; so, the students talked about the heat making the molecules move more freely. The PSTs followed the inquiry by asking "how are the molecules in an ice cube?" for which some students answered closely packed, some said loosely packed. The PSTs addressed the loosely packed misconception in some students leading them to understand three different forms of matter.

Create and Model of Curiosity Among Children

As discussed by Millar (2010), teaching science is much more than plainly delivering the content and expecting the students to learn what the teacher intends to teach. In a recent study, Hodson (2014) posits that the teachers aiming to develop "scientifically literate students" must create curiosity in the science classroom. Curiosity often helps students to bridge the gap between what they know and what they want to know. The teacher should lead the students in their journey from "what they know" to "what they want to know". The teacher's mission should be to support students to make sense of new ideas in the light of their existing ideas and link them to experience learning (Driver, 1985).

Discussing the scientific habits of mind, Lawson (2009) explained "science as a way of thinking, a spirit of inquiry driven by a curiosity to understand nature" (p. 5). Curiosity among students sparks a desire to look for answers presenting "teachable moments" for the teacher in the classroom. The teacher should use engage phase to create such moments to set up the other phases of 5E.

To foster curiosity in the science classroom and develop students' scientific literacy, teachers must use multitudinous pedagogical approaches. Teacher's task is to provide opportunities for students to be both curious and critical in the quest for scientific literacy (Higgins & Moeed, 2017). The engage phase of the 5E inquiry model plays a vital role in creating curiosity among students in the science classrooms. According to Tanner (2010), exposing students to a challenge statement on a common misconception can help them recognize that they still have things to learn.

Table 3 shows example of good engage activities used by our PSTs. The first example in **Table 3** is a good engage activity where the teacher provides tangible materials for students to engage with and discover how some objects are attracted by the magnets and some are not. The activity was followed by questions, which guided students a little further into the inquiry as well as spark the student's curiosity. Whereas, in example two, the teachers chose to ask students an open-ended question without properly engaging them. The question was very direct and not appropriate considering the student's age. The

Table 3. Examples of engage phase activities, which piqued curiosity in students

Name of PSTs	Grade/topic	Engage activity chosen
PST-19, PST-20, & PST-21	Grade 2/magnets	Students were asked to use magnets at their table to see which objects are (sticking) attracted to magnets & which ones are not. They were asked to place in two piles, yellow pile for objects attracted to magnets & blue pile for objects repelling. Followed by inquiring questions: • Which objects did the magnet get stick to (yellow pile)? • Which objects did the magnet not stick to (blue pile)? • Why do you think objects in the yellow pile are stuck?
PST-35 & PST-36	Kindergarten/living & non-living things	Asked students what they know about living and non-living things.

teachers should practice asking quality questions, which are a vital medium for curiosity. They should allow students to tinker with materials and thoughts, which also stimulate curiosity and lead to innovative outcomes.

Curiosity can also be modeled by exploring students' interests, asking critical questions about their ideas, and inviting students to perceive their scientific questions as mysteries to be solved. Activities like engaging students in examining the scientific journals encourage students to be dedicated to the difficult scientific objectives, stay on-task, and successfully navigate and complete the assignments presented to them (Schinske et al., 2008).

DISCUSSION AND CONCLUSION

PSTs in this study used the 5E instructional model to design and teach science lessons to their peers and students during their field work. The aim of the methods of teaching science course was to encourage PSTs to design and implement lessons using the inquiry model to understand the advantages and challenges of each phase while teaching.

According to Tanner (2010), the first "engage" phase of the 5E inquiry model is often skipped or neglected by educators. In this study, 73% of PSTs successfully planned and implemented the engage phase, especially the one, which relates to the objective of the lesson. This shows that 73% of the PSTs understood the role of the engage phase and its relationship to the objective of the lesson. However, there is still a need for the PSTs to perceive engage as a critical phase to pique students' interest and assess their prior knowledge.

Assessing student's prior knowledge is another major constituent of the engage phase. Student's preconceived notions, big ideas, and misconceptions related to any topic can be assessed through questioning. According to Allen and Tanner (2002), "questions challenge students' thinking, which leads them to insights and discoveries of their own." In this study, 91% PSTs chose questioning as way to engage the students but only 15% of them were successful in asking good questions in the engage phase.

Quality questioning also plays a crucial role in fostering curiosity among students. Creating and modeling curiosity is another major constituent of an engage phase while teaching science as Luce and Hsi (2015) opined that "discipline of science requires curiosity". In this study, 40% of PSTs chose showing a video as an engage activity, but only 24% of the PSTs were successful in engaging the students through videos. Though audio visual mediums are great sources of teaching, they are distracting in the classroom with unnecessary dramatization and too much information presented at once for the students. Also, teachers must ensure the authenticity of the information in the video and recheck its suitability to the learners. In this study, only 56% of the PSTs planned lessons with a good engage phase that relates to the objective of the lesson, with good questions to assess students and pique students' curiosity. This proves that more work is required from the PSTs to design an engage phase that lays the foundation for good 5E lessons as a whole. They also require more training and support familiarizing themselves with the cognitively appropriate questions activities.

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