Better Questions: A Learning Opportunity

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Daniel Anastasio and Ella L. Ingram • Rose-Hulman Institute of Technology

Abstract

Questions form the core of both the learning experience and the teaching experience. Because of their importance in the educational enterprise, questions (i.e., their structure and use) should receive more attention from educators. The authors construct what they call productive questions (those questions that produce meaningful responses) and describe effective approaches for using them. They provide examples of productive questions from multiple disciplines and offer standard question formats, so that educators can create their own productive questions to use in their classrooms. The best practices and question formats that they present are applicable to any learning environment, be it small, discussion-focused classrooms; online courses; or large lecture-style classes. The authors conclude by outlining next steps for educators to increase and assess the impact of questions in their classrooms.

Keywords: questions, types of questions, inquiry, critical thinking, student learning

EDUCATOR. So, what did you think of the reading?
(*Students are silent.*)
EDUCATOR. Okay, so, what did the author mean? Why would he write it like that? What's the relevant historical context of this work? How does it relate to other authors inciting revolution?
(*Pause.*)
STUDENT 1. He meant to explore the reason for existence.
STUDENT 2. It's kinda like he was referring to the French Revolution.
STUDENT 3. The essay seems really convoluted.
EDUCATOR. Well, what's the most important theme in the reading?
(*Tumbleweed rolls through classroom.*)
STUDENT 4. Hmm . . . liberty?
STUDENT 5. Maybe . . . tolerance?
STUDENT 6. No, I bet it's equality?
EDUCATOR. Okay, so, then, what was the name of the author's first famous essay?
(*Students are silent again.*)

This educator has fallen into the trap of asking poorly constructed questions. For example, the opening question isn't structured enough to spark discussion, the attempt to recover provides too many things to think about, the question about themes makes students guess what's in the educator's mind, and the closer is a "gotcha" question. This educator needs help. We know—we've been this educator on more than one occasion. To help educators avoid this scenario and ones like it, in this paper we provide guidance based on the research literature regarding best practices in question construction and use.

Why Focus on Questions?

Questions fulfill a wide variety of roles in educational settings. For example, they can focus student attention on specific ideas or collect their opinions. They can prompt analysis, reflection, reasoning, and creativity. They can invite learners into the learning process and help them make connections within and outside classroom settings. They can guide disciplinary thinking, such as assessing the criteria that one might use to decide how to solve an ill-structured problem. On the other hand, questions can also confuse learners, reveal knowledge weaknesses, and create a barrier between learner and educator when students are put in the position of guessing the educator's thoughts. The positive outcomes of questions, likely desired by all educators, are thus forfeited when questions are poorly constructed and ineffectively delivered. As with many fundamental teaching skills, the ability to generate good questions and use them effectively must be developed through deliberate practice.

Many scholars have recognized the importance of questions in the educational process. Cashin's IDEA Paper 49 (1995) addressed strategies for questioning and answering in college classrooms, including creating an appropriate atmosphere. In the years since that contribution, the IDEA Paper series has included multiple papers that referenced questions in some way (e.g., Creasman, 2012; Millis, 2016; Riggs & Linder, 2016). However, because the focus of these more recent works was on other, broader topics (for example, online-course design or metacognition), these papers provide little guidance on how to formulate questions, what elements questions should entail, or how they should be used. What is needed are models that lead to the outcomes that educators desire in today's wide variety of learning environments.

To provide this guidance, we begin this analysis by describing the constraints of our approach and the reasons that we focused on questions. Then we present two models for categorizing questions, along with examples drawn from multiple disciplines. The models are research-validated approaches for increasing student engagement. Next we explore the strategic choices that educators can make to create a positive and welcoming setting for questions (what we call the questioning environment). Finally, we address reactions from students. Together, these various perspectives give educators actionable tools and approaches to positively impact student learning.

Focus and Scope

To explore how questions and questioning approaches can yield meaningful student learning, we narrowed the focus and scope of this paper. Specifically, we focus on questions rather than specific learning activities (e.g., discussion or think-pair-share) because of the universality of questions in all learning experiences. Questions form the core of a scholarly, inquiry-based approach to learning. In all disciplines, scholarship advances through questioning, and learning as professionals is prompted by exploring answers to questions. Moreover, questions can be used to further specific learning objectives. Therefore, questions are our emphasis, not activities.

We focus on the development and use of questions because educators take questions and questioning behavior for granted, and because many educators do not use effective questions in their classrooms, whether teaching in person or virtually (e.g., Della Noce, Scheffel, & Lowry, 2014; Ewing & Whittington, 2007). For scholars, the ability to form meaningful disciplinary questions either comes naturally or is developed through immersion in disciplinary experiences such as journal clubs, coursework, and informal interactions with peers and educators (Austin & McDaniels, 2006). As a result, many educators may be unaware that questions can emerge from schemes that structure learning such as Bloom's taxonomy of cognitive processing or Fink's model of significant learning experiences. Therefore, many do not use these guiding frameworks when developing questions to supplement course materials and plans.

We intentionally use research drawn from both online environments and face-to-face settings, because we found that the research in these two situations provided the same results. In reviewing the literature and recommendations on this topic, we emphasize university or college instruction and references published after 2000, to provide targeted, contemporary information. In addition, we choose to summarize research findings that apply to classroom practice rather than research that explores cognitive science or theory; in essence, we examine the specific exchange of "question leading to answer" in whatever form it occurs.

Finally, we focus on questions that go beyond recall prompts. We respectfully suggest that verbal solicitations that rely on recall prompting or otherwise testing memory (e.g., "What is the author's name?" or "Can someone define *population*?") be largely ignored as a mechanism of student engagement, because they do not naturally lead to in-depth inquiry or higher order thinking. Also, although we recognize that logistical or purely opinion questions serve an important role in learning settings (e.g., "Was everyone able to access the tutorial online?" or "Did you enjoy having the guest speaker on Friday?"), such questions are not the focus of our analysis. Together, these constraints establish fruitful boundaries within which to consider the rich literature of student and educator questions.

Creating Productive Questions

As we explored the relevant features of questions, we created a set of baseline assumptions for questions' appropriate construction and use. These assumptions emerged from our broad reading of the literature on

effective questioning practices, rather than from specific references or research efforts.

First, questions work best when they focus on something worth considering; that is, when they are nontrivial. The educator should be able to explain why they are nontrivial. For example, a question about the color of uniforms worn by British soldiers in the American Revolutionary War is trivial if the answer is a mere point of curiosity, but it is nontrivial if this topic is connected to larger issues of colloquial language use in colonial America (i.e., "redcoats").

Second, questions are more effective when they clearly address the topical focus of the course. In a senior-level mechanical engineering course, a question about how pulleys distribute load does not invite higher level thinking unless it incorporates design constraints such as manufacturability, factor of safety, or reliability.

Third, questions are more successful when they address learning objectives suited to inquiry (such as objectives leading with the verbs *interpret* or *synthesize*, not *calculate* or *sketch*). When students collectively engage in a spirited analysis of Robert Frost's poem "The Road Not Taken," using, for example, the objective "Contrast the two possible roads that Frost considers," they might answer questions such as "Which indicators in the poem support your interpretation?" or "In your opinion, is the narrator convinced that he made the right choice?" The learning that students achieved through answering these questions would result in different outcomes than if they individually read an expert's analysis of the poem and shared their summaries of the analysis (meeting the objective "Describe the core premise of David Orr's essay 'The Most Misread Poem in America.'").

Fourth, questions yield better outcomes when educators give students ample time for exploration. Questions that request 17 criteria to evaluate the quality of presidential candidates, with 11 minutes of class remaining, result in an unsatisfying experience for everyone.

Fifth, questions are most valid when they are written at an appropriate cognitive level for the learning objectives in the course. For example, an educator spending the majority of an English semantics course posing lower level questions on the mechanics of punctuation undermines students' achievement of higher level objectives.

Finally, effective questions cause a response of some kind (an answer, a returned query, a request for clarification), rather than student nonresponse, as would follow, for example, a rhetorical question.

By creating questions consistent with these six assumptions (see the Appendix for a checklist), educators can improve their questions and questioning strategy. However, the questions that educators develop can certainly exceed these minimum standards. Educators may use Bloom's taxonomy to structure questions, particularly the more familiar cognitive-processes dimension composed of *remember*, *understand*, *apply*, *analyze*, *evaluate*, and *create* (see the Anderson et al., 2001, update of the taxonomy, also summarized in Krathwohl, 2002). This approach represents the first step in improved questioning practices, particularly regarding matching course objectives to question prompts at different levels of thinking. To move beyond these baseline assumptions, we encourage educators to further enhance their impact by adopting productive questions. By "productive," we mean that questions should produce answers, and, more important, they should allow students to connect past knowledge, prior experience, and the current work being accomplished. At their best, productive questions cause deep thinking, characterized by features such as exploring ambiguity, identifying discontinuous connections, creating or moving through hierarchical patterns, and removing mental obstacles (Byers, 2014; see suggestions for developing productive questions in the Appendix). Productive questions guide students to the types and levels of thinking they might not achieve independently.

Questions with Structure and Freedom

To illustrate productive questions, we describe here two different schemes. First, Andrews's (1980) research scored the quality and quantity of classroom discussion against six question types and became the baseline scheme used by many subsequent researchers. Andrews found that the question types that produced the most student contributions shared four features that together created a "subtle blend of structure and freedom" (p. 157): *divergence* (answers

could reasonably lead in multiple directions); *higher level* (questions emerge from the Bloom's taxonomy levels *analyze*, *evaluate*, and *create*); *straightforward* (a single question is asked); and *structured* (the topic under consideration and the type of thinking desired are adequately identified).

Andrews (1980) identified three specific question types that contained these four features: *playground, brainstorm,* and *focal,* which represent different approaches to productive questioning. Playground questions explore a topic by inviting students to contribute concepts and themes. Andrews offered the following example: "Let's see if we can make any generalizations about the play as a whole, from the nature of the opening lines" (p. 146). Brainstorm questions identify possibilities that may lead to further exploration, demonstrated by the following: "What possibilities are there for refuge in *A Farewell to Arms*?" (p. 146). Focal questions encourage learners to make a decision, with the understanding that the methodology and justification is the interesting part of the discussion. The forced-choice nature of the focal question is shown in this example: "Is Ivan Ilyich a victim of society, or did he create his problems by his own choices?" (p. 147).

Andrews (1980) advised that in creating one of these three question types, educators should center the questions on an aspect of the material under consideration that is "(1) crucial or pivotal for the material under study, and (2) rich in implications and ramification" (p. 157). In other words, the material comprises complexity, consequences, and conclusions to be drawn and is otherwise worthy of serious intellectual effort. By balancing structure and freedom, playground, brainstorm, or focal questions establish the cognitive space for students to explore a topic, concept, pattern, or other course element and result in the deep-thinking outcomes desired by many educators.

Bloom's Knowledge Dimension for Questions

A second approach highlights the application of Bloom's taxonomy to question development. Tofade, Elsner, and Haines (2013) advocated for Andrews's scheme in their work relating to pharmaceutical education, but they also considered questions emerging from Bloom's taxonomy (Krathwohl, 2002), and especially relative to the lesser known knowledge dimension composed of *factual knowledge*, *conceptual knowledge*, *procedural knowledge*, and *metacognitive knowledge*. These four knowledge types are coequal ways to explore a disciplinary area, an approach substantially different than using Bloom's cognitive-processes domain.

Tofade et al. (2013) used the context of pain management to illustrate questions based on these knowledge types. Conceptual questions encourage learners to create connections among different topics and ideas; for example, "In what ways is the [World Health Organization] pain management pyramid similar to the National Comprehensive Cancer Network cancer pain guidelines?" (p. 4). Procedural questions identify how to do discipline-relevant tasks. Using the pain-management topic, Tofade et al. focused on pain assessment: "What interviewing techniques can be used to determine the severity of a patient's pain?" (p. 4). Finally, metacognitive questions highlight the thinking process and approaches to learning that students adopt. In a clinical setting, metacognition is promoted by questions such as "Given that you feel you handled the patient interaction in a less than optimal manner, what do you think would help you do a better job addressing patients' pain in the future?" (p. 4). Although Tofade et al. included factual questions in their recommendation, we do not consider factual questions to be productive, because they center on recall prompts (discussed previously). By capturing the varieties of knowledge relevant to a discipline, the knowledge dimension of Bloom's taxonomy provides the framework for developing productive questions.

The unifying feature of these two schemes is that they both rely on the premise that questions should be conceptually organized in some way that is independent of the specific content of the questions. Both Andrews (1980) and Tofade et al. (2013) make the fundamental point that, across disciplines, questions come in different types and that educators should use these various types to their advantage. Educators must create and deploy the right type of question to meet the desired learning outcomes.

We chose to highlight the works of Andrews (1980) and Tofade et al. (2013) as examples of using a scheme to improve an educator's questioning strategy, because these two schemes have immediate applications. We believe that educators can employ productive

questions to enhance learning in any disciplinary area, with the caveat that educators should plan the questions that they use (although questions can certainly be posed in a spontaneous way). To illustrate the various types of productive questions and to support educators in developing them, we provide question formats and examples of questions from four topics: ecosystems ecology, fluid mechanics, colonial Latin American history, and Irish literature (Table 1). Using disciplinary examples allows us to show how productive questions encourage disciplinary habits of mind.

In particular, we chose two science, technology, engineering, and mathematics (STEM) fields to emphasize that questions in STEM education are critical for helping students observe and develop the thought processes of a practitioner in that field. STEM students in particular often suffer under the illusion that all the answers are known. Educators, regardless of discipline, know that this is not the case. The question formats shown in Table 1 should serve as a model for educators, to bring order to their questioning approach.

Table 1
Productive Question Types with Question Formats and Examples

Question type and description	Question formats	Ecosystems ecology (biology)	Fluid mechanics (engineering)	Colonial Latin America (history)	Irish literature (English)
Playground questions (Andrews, 1980) The question seeks to explore a given arena, with a clear intent to invite students to contribute concepts and themes.	Having read [item], what interpretations come to mind? How might you view [topic]? What are your thoughts on [reading/concept /topic]?	Sutherland et al. (2013) proposes research questions that ecology must still answer. How do you interpret the state of ecosystems ecology from these questions?	Given your own experiences, what makes a substance a fluid?	What are your immediate reactions to the documentary *When Worlds Collide*?	What do you draw from the experience of Leopold Bloom on the one day captured in *Ulysses*?
Brainstorm questions (Andrews, 1980) The question seeks to identify possibilities that might lead to further exploration, usually with an identified scope or issue.	What are the ways that [topic] is represented in [item]? Given [item], how and in what ways does it incorporate the premise of [topic]?	Thinking broadly, what are the ways that energy transformations appear in the Hairston, Smith, & Slobodkin (1960) paper?	Thinking of common non-Newtonian fluids, what are some behaviors they display that cause you to believe they are non-Newtonian?	How is the premise of suffering emphasized in Bartolomé de las Casas's *A Short Account of the Destruction of the Indies*?	What common themes emerge among the stories in James Joyce's collection *Dubliners*?

Focal questions (Andrews, 1980) The question seeks to prompt a decision, supplying the options and noting that the justification for the decision is the more interesting aspect.	Of the options [choice], [choice], and [choice], which one best illustrates [premise]? Is [choice] [comparative adjective] than [choice] with respect to [context]?	Is there an independent grand unifying theme of ecology, or are ecological concepts too divergent to be unified?	Given the constraints and properties in the problem statement, what type of pump is best suited to remove water from a flooded basement?	Which group influenced colonial Latin American society and culture the most: Spanish and Portuguese colonizers, African slaves, or indigenous peoples?	Bram Stoker's Dracula is the first vampire of the modern age, but is he the most iconic, or are more recent vampires more vampire-esque?
Conceptual questions (Krathwohl, 2002) The question seeks to create connections among topics, to illuminate principles, theories, models, or other structures.	With [concept] and [concept] in mind, what pieces connect these two ideas? How is [theory] represented in [observation]? Given [observations], what groupings would you create and why?	How might you connect energy flow in ecosystems to species richness and diversity of that ecosystem?	Being mindful of the relationship between flow and frictional losses, why do frictional losses occur in all pipes, even very smooth ones?	Given your reading of disparate primary documents from the 1500s, what key features of indigenous resistance emerge?	How does Swift's choice of setting and point of view in *Gulliver's Travels* influence your reading experience?
Procedural questions (Krathwohl, 2002) The question seeks to discern how to do something, why it might be done, and the tools and techniques required.	Why is [procedure] the right choice for addressing [question]? Given your experience with [subject matter], how would you approach [question]?	What are the pros and cons of these various experimental designs for evaluating your systems-level hypothesis?	When solving problems involving frictional losses, why is it beneficial to start by calculating the Reynolds number?	What historical research strategies will be fruitful in exploring history from cultures with little formal written material?	In learning to be a critical reader, what are some mental approaches for contextualizing fiction that emerges from a different time and place?
Metacognitive questions (Krathwohl, 2002) The question seeks to identify thinking processes, self-knowledge, and approaches to learning that students adopt.	What lessons from learning [topic] apply to learning [topic]? Which of your strengths is most emphasized in [assignment]? How might you plan your approach to [assessment]? What strategies were successful during [past learning experience]?	How has your approach to learning in ecosystems ecology been similar to or different from your approach to learning in cell biology?	How has your understanding of the energy balance in fluid mechanics influenced the way you study the energy balance in thermodynamics?	How have your conceptions about colonial Latin America changed as a result of (a) your independent research project, and (b) class discussions focusing on the nature of evidence?	In what ways does your emotional reaction to the experiences of characters impact your analysis of the narrative arc and writing style?

Note. Questions prepared by authors in consultation with subject-matter experts.

The examples and the question formats shown in Table 1 conform to findings from research that tracks student response rates and other behaviors, especially those emerging from online classrooms (see especially Andrews, 1980; Kenney & Banarjee, 2011; and Della Noce et al., 2014). For example, Della Noce et al. explored the impact of *authentic* questions, which they defined as questions that express educators' sincere interest in both the topic and students' knowledge, opinions, and experiences and for which educators are unlikely to know a student's answer in advance. Authentic questions connect students' knowledge, opinions, and experiences to the objectives that are under consideration. Della Noce et al. found that students were twice as likely to respond to authentic questions (e.g., "Which aspects, if any, of your educational experience illustrate the premise of autonomy?") as to nonauthentic questions (e.g., "How did the educational theorist Dewey conceptualize autonomy?"). This premise was supported by a focus group of psychology students who confirmed that "if the teacher seems to be genuinely involved and fascinated by the topic, they feel motivated to respond and engage in discussion" (Kenney & Banarjee, 2011, p. 72).

The examples and question formats in Table 1 represent authentic questions and thus are highly likely to yield responses. The examples also contain the frequent use of *you*, meaning the student, as in, "What is *your* analysis?" This approach is consistent with the desire of students for an educator who cares, learns their names, demonstrates sincerity, and personalizes the class experience (Therrell & Dunneback, 2015). Authentic questions develop the rapport so desired by the current generation of traditional college or university students (Cashin, 2011; Price, 2009). By using elements of authenticity, educators can increase the impact of productive questions.

Outcomes of Productive Questions

Productive questions result in increased engagement in class activities and increased higher order thinking. Finkel (1999) noted that psychology students became more involved in the course when questions were used that, in students' words, "get you to think about the topic" and "help [them] feel more involved/interested in topics" (p. 44). In similar work, Bradley, Thom, Hayes, and Hay (2008) found that productive questions used in an online environment resulted in longer and more complete contributions than nonproductive questions and that productive questions generated answers demonstrating higher order thinking. These findings were affirmed by Ertmer, Sadaf, and Ertmer (2011) in 10 different courses across different disciplines, in online and blended settings, and among both graduate and undergraduate courses. In their analysis, productive questions yielded a greater proportion of higher order thinking than did nonproductive questions. In particular, they noted that 74% of answers to divergent questions were consistent with Bloom's taxonomy levels of *apply*, *analyze*, *evaluate*, and *create*. Furthermore, divergent questions "seemed to prompt students to integrate material from multiple sources and to connect relevant ideas from previous discussion posts to support their opinions or decisions" (pp. 12–13). Thus, productive questions are a tool educators can use to specifically promote engagement and higher-order thinking within the classroom.

Productive questions also help students develop skills that contribute to success in the modern age, often referred to as 21st-century skills. For instance, employers seek individuals with communication and leadership abilities, rather than individuals who can simply recall information, a task that can be assigned to a computer (Levy & Murnane, 2005). Although the specific skills listed vary by author, Saavedra and Opfer (2012) identified common categories: critical thinking, collaboration and leadership, adaptability, initiative, communication, access and analysis of information, and curiosity. Asking productive questions provides students with the chance to practice and develop these skills. For example, Finkel (1999) noted that questions and discussion generated from a specific text promoted critical thinking, with students commenting that the approach "allows [the student] to think of topics in different views" and "helps [the student] see others[']point[s] of view that I might not have thought about" (p. 44).

In a related study, Burns, Stephenson, and Bellamy (2016) compared student learning in a traditional lecture-style class to a question-rich teaching environment that followed the Socratic method of argumentative dialogue (i.e., questions that direct learners toward a known end point and challenge

learners' assumptions). Students in the question-rich environment showed greater cognitive development than their peers in the lecture-only environment. Also, they shared their opinions more frequently, expressed their understanding of others' opinions more frequently, and accepted ambiguity in problems more willingly than students who only listened to a lecture. Productive questions provide opportunities to develop habits and traits for success beyond the classroom.

Developing an Open-Questioning Environment

The manner in which educators introduce and answer productive questions is a key component of the questions' effectiveness. To encourage students to critically consider and answer questions, an educator must first ensure that he or she has prepared the classroom to be an environment where students expect to actively answer and discuss questions (e.g., an environment consistent with positive climate as described in Barr, 2016: personalized, involved, and task oriented). To this end, an open-questioning environment should be established, defined as any setting in which students and educators interact with the course material via inquiry. In such a classroom, whether in person or online, students are and feel like active participants in the learning process. Students ask and answer questions while knowing that their contributions will be affirmed and included, not dismissed or invalidated. Furthermore, students are encouraged by the educator to contribute, whether in verbal or written form. From the students' perspective, the atmosphere is positive, supportive, and nonjudgmental.

Educators can control several factors that contribute to an open-questioning environment. The first factor is their own role. Many students experience classes where the instructor is the "the sage on the stage," so they expect to receive dictated information rather than be active participants in a learning community. Educators can mitigate student hesitation to engage in questioning by establishing participation expectations early in a course. In addition, educators can ask about students' expectations for learning and participation (Fleming, 2003). These behaviors shift the role of the educator from sage to guide.

Second, educators can set the tone for the use of questions. They can remind students that questions are designed to make them think critically and that critical thinking is difficult, that not all questions have one correct answer, and that some questions will have answers unknown to the educator (like sharing opinions or experiences consistent with the authentic questions of Della Noce et al., 2014). If students are primed to expect questions, they may be more willing to accept and participate in the open-questioning environment.

A third factor that educators can address is frequency of questioning: Educators adopting an open-questioning environment should use questions frequently (likely during every class meeting). Repetition reinforces the significance of questions as part of the learning process. Educators can use approaches as simple as projecting a planned question in a slide show or writing it on a whiteboard when posing it to students. By taking the time to highlight the question visually, in addition to expressing it vocally, educators stress how critical the question is as part of the content of the day's class.

Fourth, educators are responsible for developing rapport with students, to promote an interpersonal relationship characterized by give-and-take and building of ideas (as in effective classroom discussions; see Cashin, 2011), not by trading knowledge for grades. Rapport is built through taking a personal interest in students' learning. Suggested approaches include behaviors such as querying for and using students' experiences in examples, using students' names, using and promoting active listening, providing advanced warning of questions, and shifting some decision making to students (see Fleming, 2003, for an excellent summary of rapport-building strategies). These varied strategies help educators craft an open-questioning environment.

Skilled educator facilitation promotes an open-questioning environment and is required to sustain the environment once it is established. The educator's role is to pose the questions and to moderate and encourage student answers. An educator using effective facilitation techniques demonstrates that the environment is question-and-answer friendly, while still gently directing students and the discussion toward the achievement of the desired learning objectives. Effective facilitation begins by patiently waiting for responses, then listening to all answers with interest (Cashin, 2011). One mechanism for showing interest is simply recording answers in a publicly visible form, such as on a whiteboard, or posting a summary of key points in an online discussion forum.

Additional facilitation approaches include probing student answers to productive questions by requesting the reasoning, assumptions, or limitations of the offered answers, and requesting that other students offer their contributions to these follow-up questions. Educators using effective facilitation techniques also allow students to clarify their points or provide more details; this approach demonstrates to other students that the educator values student answers. Simultaneously, educators should ensure that contributions come from a variety of students rather than from a few dominant voices. Moreover, students should be encouraged to respond to one another's answers while recognizing that conflicts among ideas may exist (Cashin, 2011). If the conflict is deeper than a simple misunderstanding, the educator should seek clarification while reminding students to treat the opinions of others with respect and to pay careful attention to their contributions. In essence, then, educators should serve as the moderator of the discussions that arise from the questions; students should understand that, in a healthy classroom environment, learning can also occur among students rather than only in educator-to-student interactions (Barr, 2016).

Finally, the facilitator role also applies to online scenarios, where facilitation helps students navigate not only discussions but the virtual classroom environment as well (Riggs & Linder, 2016). Using strong facilitation to arrive at an answer to a productive question represents a significant accomplishment and emphasizes the supportive nature of an open-questioning environment, be it online or face-to-face.

Using Productive Questions

Students' experience of questioning in any form includes their emotional responses (Pedrosa de Jesus & Watts, 2014), which might involve fear, embarrassment, interest, or even (one hopes) excitement. When educators first introduce productive questions, students might initially respond with silence. A challenge is that silence or slow postings in online settings can be difficult to interpret. Did students understand the question? Were they merely pausing because they were thinking of answers? Were they intentionally nonparticipatory, or were they having some other emotional response (Kenney & Banarjee, 2011)? Rest assured, usually someone eventually volunteers to speak after any silence. Educators can affirm this silent time by emphasizing to students that thoughts take time to coalesce into a coherent form (Gayle, Preiss, & Allen, 2006). Also, when questions transcend a simple request for facts, a different type of thinking is required to formulate an answer. This process takes longer, as it should. Educators can acknowledge meaningful wait time and give students a chance to construct a response (at least three seconds, but preferably longer at each time point, as suggested by Rowe, 1986). If persistent silence becomes uncomfortable, we recommend using the think-pair-share strategy, perhaps in combination with a short free-writing exercise: individual reflection time centering on a productive question, then testing and constructing ideas with peers, and ending with reporting to the whole class. The activation energy is lower for sharing answers with a peer than with an entire class, and, during the share time, students can offer collective answers or the answers of their peers if they have low confidence in their own answers. In sum, gentle and supportive persistence on the part of the educator helps students identify and manage their emotional response to questions.

In time, students come to expect questions, although they might not always expect to answer them. If, as we suggest, educators ask authentic questions with real educational intent, students will increasingly respond (Della Noce et al., 2014). However, a classroom with 100% participation in the questioning experience is rare. We recommend making peace with this fact. At the same time, we hope educators allow themselves to be surprised by which students choose to participate and what students contribute, even while they accept that not every student is up for the game. A notably resistant group is students high in introversion. But being present in an open-questioning environment, even if not responding themselves, still benefits introverted students and their learning in future settings (e.g., one-on-one discussions with educators or classmates, in which in-class questions can be repeated). Regarding challenging material, educators should be mindful of some students' introversion and provide the reflection time necessary for them to consider the type, depth, and level of risk they are willing to take with their answers. For example, instructors might post questions to an online discussion board or begin with small-group analyses of productive questions before large-group

discussion occurs (Kenney & Banarjee, 2011). Furthermore, productive questions spark the most intense thinking, and that thinking may be occurring in ways that are invisible to educators.

Using productive questions successfully requires the educator to understand the strengths and limitations of a given classroom setting, be it a large lecture hall, a small classroom discussion, or an online course. In some learning environments, not every student can respond vocally. Students may learn, however, from listening to the responses of their peers. In addition, several solutions allow all students to contribute ideas anonymously, thereby increasing overall participation for all students (Kenney & Banarjee, 2011). For example, polling can be used for productive questions, such as focal questions that have limited response options (an example might be "Which opera paints women in the most positive light by today's standards: Verdi's *La Traviata* or Mozart's *Don Giovanni*?"). When presented with a question, students select an answer and justify it to peers, vote after discussion, or both. Students can vote with polling software or by a simple showing of coded flash cards that they position to be visible to only the educator. The educator then reveals the results and asks additional follow-up productive questions to encourage students to consider why they responded in the way that they did. The act of committing to an answer makes students more active participants in class when they have to justify their choice to a peer (reviewed in Caldwell, 2007).

Many approaches for employing productive questions in physical classrooms can also be used in an online environment. In online settings, productive questions are excellent prompts for discussion forums or virtual office hours. Furthermore, the technologies that allow for in-class polling are also easily ported to an online platform, with many platforms allowing the integration of polling into video lectures. Despite the perceived challenges of some classroom settings, educators use productive questions effectively when they align them with content, learning objectives, and available high-tech and low-tech tools.

Educators also can use productive questions as prompts for short writing pieces to be completed either in or outside the classroom. These assignments allow all students, even those students not comfortable sharing ideas with a large group of their peers, to consider productive questions critically and provide answers. For example, online or flipped courses often rely on written responses to questions, because many questions are answered via assignments, online discussion boards, and online chats. In these settings, Bradley et al. (2008) found that playground and brainstorm questions promoted higher order thinking more often than did other types of questions. In similar work, Ertmer et al. (2011) reported that students in online settings created a high percentage of responses (greater than 70%) classified as medium- or high-level thinking when the prompts were playground questions or divergent questions or when they addressed a critical incident (i.e., a case study). Higher level questions that encouraged students to apply and synthesize knowledge also prompted more student-to-student post sequences than questions lower on Bloom's taxonomy.

Singleton and Newman (2009) recommend providing prompts to guide student journaling (e.g., a term-long journal assignment). For example, in a forensic accounting class, productive questions such as "What are your thoughts on how insurance fraud influences society?" or "Is tax evasion primarily an economic issue or a justice issue?" would be excellent prompts for a day's journal entry. Using productive questions elevates the thinking that students demonstrate in written answers and provides educators with additional flexibility in the assignments they give students.

Productive questions can also form the basis for formative assessment. In their classic compilation of classroom assessment techniques, Angelo and Cross (1993) provide numerous exercises for which productive questions are appropriate. The "minute paper" serves as one flexible model (p. 148). In this exercise, educators provide a single productive question, and students write for no more than a couple of minutes. Educators can appraise student learning rapidly by reviewing answers, and evaluation can be as simple as "Did the student submit a response?" Another version of this strategy involves using the minute paper as an exit slip for students to leave the classroom (Singleton & Newman, 2009).

The "invented dialogues" strategy is another opportunity to combine classroom assessment and productive questions (Angelo & Cross, 1993, p. 203). In this exercise, instructors pose a scenario, for which students

create the resulting conversation between at least two characters, using actual quotations or reasonably inferred statements. Productive questions could launch the scenario. For example: "Harriet Tubman, W. E. B. Du Bois, Rosa Parks, and Barack Obama meet for a long lunch to talk about civil rights for African-American citizens. What do you think are the main points of their conversation?" This productive question could be followed by supporting quotes that create the dialogue. The assessment aspect is immediate: Students identify relevant themes and attribute them to the correct individual. These examples illustrate how productive questions allow opportunities for meaningful and immediate formative assessment.

Educators may encounter situations that call for positive action, such as long silences lasting well beyond Rowe's (1986) recommendation of a minimum of three seconds of wait time. We recommend that educators ask a couple of students privately why they do not contribute answers. We also advise educators to accept student perspectives dispassionately and as truth. Research suggests that the fear of being incorrect or otherwise embarrassed is a strong disincentive to contributing answers (Kenney & Banerjee, 2011). In addition, educators might exhibit unconscious behaviors that discourage answers, creating what Tofade et al. (2013) called a "psychologically unsafe environment" (p. 6). The strategy of affirming answers in some way, as noted previously, goes a long way toward increasing the frequency and speed of future answers and the overall sense of psychological safety, consistent with an open-questioning environment.

Another problem might be answers that are inconsistent with the level of thinking desired. For example, an instructor might pose the productive question, "How might you connect Kahneman's research about decision making with Deci and Ryan's work on motivation?," only to be answered with trivial responses such as "All three authors are males" or "A lot of people are familiar with their work." Even if answers seem strange or off-topic, educators can use their disciplinary knowledge and facilitation skill to guide many of them into a usable form. In the foregoing example, the instructor could follow up: "In your opinion, what are some reasons that these two areas of psychology have permeated general awareness?," another productive question that provides an opportunity to lead back to the original point of "connection." In situations where the outcome diverges from the instructor's desired objective, the instructor must persist in valuing the open-questioning environment and student contributions, to affirm the importance of questions as a key tool of knowledge development.

We suspect that students view educator questioning with suspicion, especially in STEM courses, as they do for active-learning strategies in general (Gaffney & Gaffney, 2016; Marbach-Ad, Rietschel, Saluja, Carleton, & Haag, 2016). Particularly in introductory courses, students may wonder, "Why is class time being spent this way over just telling us what we need to know?" "What am I supposed to get from the opinions of my peers?" "Why don't you just tell me what I'm supposed to learn?" (similar to Gaffney & Gaffney's findings, "I don't enjoy [active learning], but I don't mind it" [p. 020125-8]). This disposition on the part of students presents an excellent opportunity to promote cognitive development or emphasize the creativity and inquiry inherent in STEM endeavors. For example, educators might use a productive question such as "Given your reading about the hunt for DNA's structure, is it better for biologists to be narrowly trained or broadly trained?," to launch a discussion about collaboration practices in science, intradisciplinary differences in styles of inquiry, or the role of insight in research. Questions such as this can help students move beyond the right-or-wrong, tell-me-the-answer mentality of dualism to the disposition in which differing perspectives are considered valid, and personal investment is paramount, known as multiplicity (Perry, 1970). Productive questions that explore creative problem-solving strategies, alternative interpretations of data, and the nature of scientific knowledge illustrate to students the habits of mind of STEM professionals. Questions are the force that drives disciplinary knowledge; educators can emphasize this fact, regardless of topic or field of study.

Next Steps

The critical task for educators is to carefully plan productive questions in advance, paying careful attention to several factors, including desired student outcomes, the learning environment, and anticipated student responses. One recommendation for educators who are seeking to use productive questions in the

classroom is to start by introducing new topics with a playground question to attract student attention to a new topic. Over time, as a repertoire of productive questions is developed, appropriate sequencing can be introduced. For instance, the playground question can build to several other productive questions, eventually culminating in a focal question that requires students to make a judgment call or to apply high-level critical-thinking skills. Such sequences emphasize the need for the educator to have and follow a plan when implementing productive questions in their classroom for maximum student benefit.

Productive questions form the backbone of effective inquiry-based teaching and learning. Our goal in this paper has been to provide the motivation and means for educators to enhance their teaching through the formulation and deployment of productive questions to reach specified learning objectives. Productive questions help break down barriers that arise from confusion, open students' minds to new facets of a problem or to different opinions, and help move students toward the understanding that they are seeking *a* well-reasoned solution rather than *the* correct answer. In the best-case scenario, productive questions help students develop the skills to produce their own productive questions, leading to habits of lifelong learning. Even small, planned questions can have this positive impact on student understanding and growth. Productive questions are, therefore, an essential tool for promoting learning.

Appendix. A Checklist for the Development of Productive Questions

Baseline Assumptions
(all apply)

- ☐ Can the instructor explain why the question is nontrivial?
- ☐ Does the question clearly address a topical focus of the course?
- ☐ Does the question address a learning objective suited to inquiry?
- ☐ Does the instructor provide students with ample time for exploring answers?
- ☐ Is the question written at an appropriate cognitive level for the course's learning objectives?
- ☐ Will the question elicit a student response of some kind?

First Steps Toward Improved Questions
(all apply)

- ☐ Is the question associated with higher levels of the Bloom's cognitive-process dimension?
    - *Apply . . .* show, change, illustrate, predict, use
    - *Analyze . . .* compare, contrast, select, examine, infer, separate
    - *Evaluate . . .* justify, assess, debate, critique, test, appraise
    - *Create . . .* design, invent, develop, generate, produce
- ☐ Does the question show divergence (multiple reasonable answers are possible)?
- ☐ Is the question straightforward (only one question is being asked)?
- ☐ Is the question structured (the topic and desired thinking are adequately identified)?
- ☐ Is the question authentic?

Creating Productive Questions (Andrews, 1980; and Krathwohl, 2002)
(choose one)

- ☐ Does the question explore a specified subject, with students contributing concepts or themes (Playground)?
- ☐ Does the question identify possibilities that might lead to exploration within a certain scope (Brainstorm)?
- ☐ Does the question seek to make and justify a decision (Focal)?
- ☐ Does the question seek to create connections among topics (Conceptual)?
- ☐ Does the question identify how to do something or why things may be done in a specific way (Procedural)?
- ☐ Does the question identify thinking processes, self-knowledge, and approaches to learning (Metacognitive)?

Daniel Anastasio is an assistant professor of chemical engineering at Rose-Hulman Institute of Technology. His courses include fluid mechanics, process control, and professional practice. He performs research in membrane separations and osmosis and engineering pedagogy, primarily game-based learning. His work has been published in the Journal of Engineering Education, Chemical Engineering Education, and the Journal of Membrane Science. He has earned funding from the National Science Foundation for his pedagogical research. Dan earned his BS and his PhD in chemical engineering from the University of Connecticut.

Ella L. Ingram is an associate professor of biology and the associate dean for professional development. She directs Rose-Hulman Institute of Technology's Center for the Practice and Scholarship of Education and is a member of the Making Academic Change Happen program, providing skills-development experiences and translating research to practice through consultations, workshops, and webinars. In her administrative role, she has worked with faculty nationwide to develop teaching skills and change management skills. Ella earned her BA in biology and mathematics from Augustana College (Illinois) and her PhD in biology, focusing on ecology and evolution, from Indiana University.

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T: 785.320.2400
T: 800.255.2757

301 South Fourth St., Ste. 200
Manhattan, KS 66502

Email: info@IDEAedu.org
IDEAedu.org