Learning for a Reason: Supporting Forms of Engagement by Designing Tasks and Orchestrating Environments

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Learning for a Reason: Supporting Forms of Engagement by Designing Tasks and Orchestrating Environments

This article discusses the ways that tasks and classroom cultures can be supported through the design of online immersive games. The authors focus on a mathematics unit in which students become statisticians who must understand the contextual implications of using particular mathematical tools in analyzing different data sets and reflect on what their tool choice reveals about practical situations. Through these designs, the goal is to illuminate four types of engagement: procedural, conceptual, consequential, and critical. These new opportunities to learn and to experience the consequences of decisions have the potential to change the way that students experience school. Rather than simply complying with school practices because they are important, such curricula can create opportunities for students to truly appreciate what they are doing, and why.

In our work to design curricula to support students’ engagement with key disciplinary ideas, we have found it useful to specify what knowing, as we envision it, looks like. This may seem obvious; in a world filled with published standards and content expectations, our society has become quite accomplished at defining intended outcomes. But are we? When looking
at the standards of most states, the focus is typically unspecified, with the result that meeting the standards can be accomplished through a variety of behaviors. For example, one Indiana 6th-grade math standard for data analysis reads as follows:

6.6.3: Compare the mean, median, and mode for a set of data and explain which measure is most appropriate in a given context. (Indiana Department of Education, n.d.)

Although this standard sets very clear expectations for what students have to be able to do, it is unclear what it looks like when students successfully do it. What does it look like to display an understanding of “which measure is most appropriate in a given context”? Is it enough for students to understand something procedurally, such as “if a dataset has a large outlier, don’t use the mean”? Or would we require a deeper understanding of these measures, such as: “The mean takes all data into consideration, even data that are likely to be uncommon. Sometimes, considering all of the data interferes with our understanding of what is typical. So we shouldn’t use the mean here.” Although both statements meet the expectation stated in standard 6.6.3, most educators would agree that they are not equally informative in accounting for what a student understands or does not understand about different measures of center.

Although few educators would claim that procedural forms of knowing are the ultimate gold standard of understanding, it remains, perhaps unintentionally, a significant focus of practice in classrooms (Wiggins & McTighe, 1998). This is in part because of external pressures to cover a set amount of content in a set time, which often serves to focus attention on definitional, rather than conceptual, aspects of understanding. Additionally, it is easily testable and, on the surface at least, it appears to demonstrate a form of applied competence. Much of our work with teachers, and in designing curriculum, has focused on supporting teachers and students to consider forms of engagement, not simply content acquisition. By focusing on forms of engagement, we highlight the importance and value of focusing instructional practice on students’ reasoning, rather than on simply covering content. As a framework for supporting teachers and teaching, this article presents a model for the design of tasks that create a context for teachers’ orchestration of students’ learning through whole-class discussion.

As curriculum designers, our goal is to provide teachers and researchers with resources to design the disciplinary content they are teaching so that students can appreciate the usefulness of what they are learning. Teaching so that content has meaning in particular contexts can only be accomplished when curricular tasks and the classroom norms and practices are aligned. As Squire, McKinster, Barnett, Leuhmann, and Barab (2001) stated, “Contextualizing the curriculum is ultimately a local phenomenon that arises as a result of a number of factors, including students’ needs, students’ goals, teachers’ goals, local constraints, and the teacher’s pedagogical values” (p. 483). Tasks that are designed to situate content are only useful in classrooms that allow such meanings to be explored. Likewise, classroom practices that emphasize making connections can only lead to robust learning when they are supported by tasks that create opportunities for students to grapple with the meaning and utility of content. In choosing to design educational video games, we have sought to create tasks that also influence classroom practices by creating virtual worlds that place disciplinary engagement in rich contexts. In so doing, the designed context of the video games can become another context to support whole-class discussion and deep engagement with disciplinary content.

In this article, we discuss the ways that tasks and classroom cultures can be supported through the design of these games. In particular, we focus on 4 years of data collection and design from one unit in which students become statisticians who must understand the contextual implications of using particular mathematical tools in analyzing different data sets and reflect on what their tool choice reveals about practical situations. Through these designs, our goal is to illuminate four types of engagement that we have found useful to dis-
tistinguish when designing and implementing our curricular lessons: procedural, conceptual, consequential, and critical (Gresalfi, Barab, Siyahhan, & Christensen, 2009). In the following, we outline each of these in more detail, and then walk through one design to further ground the meaning of these terms. We then discuss the potential of these tasks for framing student–teacher interactions, in particular by emphasizing the role of narrative immersion in supporting whole-class discussion.

**Forms of Content Engagement: Defining Our Theoretical Frame**

Student engagement has been defined in a variety of ways. Some definitions focus on motivation and affect, suggesting that students are engaged if they are trying hard and appear to enjoy what they are doing (Kuh, 2001; Skinner & Belmont, 1993). Another conceptualization refers to the ways students work with content, what some call cognitive engagement (Bloom & Krathwohl, 1956; Rittle-Johnson, Siegler, & Alibali, 2001). Cognitive engagement can occur in many forms. For example, whereas engaging *procedurally* to calculate the mean of a set of numbers is evident when the procedure can be used fluently, engaging *conceptually* requires being able to explain what the mean reveals about a data set. In this article, we argue that there are still other forms of engagement, that involve, for example, using one’s understanding of mean to decide whether a new medicine is working or not, and trying to determine if the mean is even the most appropriate tool to use to make a decision about a particular situation.

There are also different conceptualizations about the source of different forms of engagement. Some theorists consider engagement to be a property of an individual, believing that students either are or are not engaged as an aspect of their personalities (Helm & Gronlund, 2000; Mandinach & Corno, 1985). In contrast, others have demonstrated the extent to which engagement changes situationally, and can thus best be understood as an interactive accomplishment among students, the task they are working on, and aspects of the classroom practices (Cobb, Gresalfi, & Hodge, 2009; Gresalfi, 2009; Smagorinsky, Wright, Augustine, O’Donnell-Allen, & Konopak, 2007). Such a perspective helps make clear how and why a student can be engaged in one context, such as English class, but inattentive in another context, such as science class. Rather than simply blaming the student’s interest (he doesn’t like science), this perspective addresses how the tasks that students are working on, and the way the classroom is organized, contributes to students’ engagement (Boaler & Greeno, 2000). In our work, we assume that engagement is neither a property of the individual nor of the environment but, rather, the result of an interaction between the two. Toward this end, we distinguish four different forms of engagement that we have observed and attempt to foster: procedural, conceptual, consequential, and critical.

Procedural and conceptual engagement describe the ways students think about content. *Procedural engagement* involves using procedures accurately, but not necessarily with an understanding of why one is performing such procedures. *Conceptual engagement* involves more than plugging numbers into an equation, but additionally involves understanding why an equation works the way it does. In contrast, consequential and critical engagement concern the coordination of content, contexts, and learner decision-making. *Consequential engagement* involves recognizing the usefulness and impact of disciplinary content; being able to connect particular solutions to particular outcomes. Finally, *critical engagement* involves questioning the appropriateness of using particular disciplinary procedures for attaining desired ends. Related to consequential engagement, critical engagement captures the decision making involved in problem-solving, and involves critiquing the method itself in relation to the particular context in which it is being used.

We seek to design curricula with the goal of fostering consequential and critical engagement in order to deepen and facilitate procedural and conceptual engagement. We argue that consequential engagement is a central aspect of deep-
ening conceptual understanding, because when one uses disciplinary knowledge to examine the world, she gains richer insight into that content by seeing it through its impact on the world. A core challenge underlying our work, therefore, is how to engage students in situations that require using conceptual understandings as tools for gaining insight into, and solving, meaningful problems.

Content Engagement in Practice: The Case of Ander City

The examples in this article come from implementations of a unit in an online multiplayer video game, called Quest Atlantis. Quest Atlantis is an international learning and teaching project that uses a 3-D multiuser environment to immerse over 50,000 children, ages 9–16, in educational tasks. The unit we discuss is called Ander City, a statistics unit designed to facilitate students’ thinking about what statistical tools reveal or hide about data. As noted earlier, designs provide an opportunity, but do not guarantee particular forms of engagement—especially in terms of academic content learning. Therefore, beyond articulating our design work, we elaborate how teachers can support content engagement with our designs in a manner that illuminates the broader theoretical ideas.

Designing for Content Engagement: The Role of Tasks

Ander City is a mathematics unit about statistical data analysis that asks students to decide which mayoral candidate makes the best decisions for the children of the city. The unit requires students to use statistical tools to make decisions regarding dilemmas that the city is facing. Briefly, the storyline involves a current mayor, who is up for reelection, running under a campaign of innovation. He claims innovation will make the city a better place, and he has the data to prove it. His opponent is challenging the mayor’s agenda, and claims that traditional methods of running the city are superior. The problem is that he also claims that he has the data to prove it. The children of Ander City are confused; how can the candidates have contradictory ideas but both believe that the data supports their position? The students are asked to become statistical consultants to make sense of this muddle. The specific content that is targeted in Ander City includes learning such concepts as connecting data and their representations and making decisions and arguments grounded in data; building skills such as constructing graphs and comparing distributions of data; and understanding how representations and arguments relate to each other, as well as how real-world constraints shape the arguments one can make about data (see http://workedexamples.org/projects/stats for further elaboration; see also Cobb, 2002; Lehrer & Schauble, 2000, 2004; McClain & Cobb, 2001).

The unit seeks to support procedural, conceptual, consequential, and critical engagement. One key way this is accomplished is by referring to procedures as tools that help to solve problems. This metaphor was designed to help students think about procedures as things that work on situations, and to support the idea that more than one tool might work on the same situation, and some tools might work better than others. Conceptual engagement is supported by asking students to reason about how tools work—what does the mode suggest about a data set that is different from the median? As an example, students meet two characters, Medie and Moder, who are campaign workers for the two candidates (see Figures 1 and 2). In speaking to the characters, students engage the idea that different tools might reveal different information about the same data set. Medie talks about the importance of understanding the middle of a data set because of the need to think about balance, while Moder thinks that looking at the data point that occurs more than any other gives some insight into what’s popular. Crucially, neither explanation is sufficient for understanding what is typical about a collection of data points; these partially formed explanations serve as a resource for discussing and debating the use of, and difference between, measures of center.
Figure 1. Exchange With Medie, a Character Who Helps Students Understand What the Median Can Reveal About a Data Set.

"I think it’s about the best tool ever. It really allows us to understand what a big mess of data is telling us. It helps us to see exactly what is in the middle. With the median, we don’t get swayed by extremes, and so it’s the fairest way to think about data."

"The median shows us what’s REALLY true about data. But I’m getting ahead of myself. Let’s talk a bit more."

☑ Sounds good!

Figure 2. Exchange With Moder, a Character Who Helps Students Understand What the Mode Can Reveal About a Data Set.

"Sure. The mode is simply the data point that occurs more than any other data point. That’s why it’s so powerful—it tells you about the the most popular answer."

☑ OK, so mode is the value that occurs the most often?
We strive to create contexts that challenge students’ thinking by creating opportunities for students to connect their analyses with outcomes in the space (consequential engagement\(^2\)). In this unit, we create multiple opportunities for students to think about what particular tools can reveal (or hide) about data and support this learning by designing datasets that allow for different interpretations based on the applied tool. In one example, students are asked to determine which brand of bike is safer to offer for rental in the park—the brand that Mayor Enoch supports, or the one that his opponent, Mr. Grant, prefers. Using data they collect by running in-game trials, students are asked to determine what constitutes a safe bike—the one that stops in the shortest average distance (the one with the smaller mean) or the one that is most predictable (the one with the smallest range). As students reason about this situation, they reflect on the consequences of their analyses, and link their solutions (the range of Speedy Spokes is 24, while the range of Rollin’ Steady is 10) with their implications (“When I think of safety, I want to be able to predict when I am going to stop—so I recommend Rollin’ Steady”). An example of consequential engagement can be seen in the exchange below:

Int: According to your graph, you think Speedy Spokes?
St: Yeah.
Int: Why?
St: Well, first of all (pointing to the graph on the screen), they have really high, they stop (looks over the screen and pauses) WHOA. (2-second pause). Wait a second.
Int: What?
St: I don’t know ... actually it’s really hard, because here (turning back to screen and pointing to part of a graph), um, Speedy Spokes, they have, um, it stops sooner.
Int: Mmm hmm.
St: But it’s very hard to predict. Some because some, they go way up here (pointing to higher values on the graph), and some, they stop really um (pointing to lower values on the graph) at a different time, so I think I’d probably go with Rollin’ Steady; even though it doesn’t stop sooner, it’s about all at the same time (points to continuous part of graph), so I will know—we will know when it’s going to stop and how soon we need to do it.

In this explanation, the student is moving between her analytic outcomes (the mean and the range of the two data sets) and the implications of these measures. She notes that safety is about being able to stop quickly, but it’s also about being able to predict when a bike might stop. Thus, the context of the storyline challenges students’ thinking about what different measures reveal about the data. Suddenly, range is not just a value that is calculated by subtracting the lowest number from the highest number, but, instead, is a tool that reveals something about predictability.

This decision also involves engaging critically with the content by reflecting on which tool most effectively reveals information about the situation. This opportunity to be intentional in deciding the most appropriate tool for the situation is in marked contrast to much classroom practice where children are often told which formulas to apply for a given problem. Importantly, in such cases, when students are engaging consequentially and critically with content, they have opportunities to think about both disciplinary meanings and their impact on designed situations. Specifically, by questioning when and why different tools lead to different recommendations, students can reflect on both the tool (discipline) and its use (context). More specifically, students can exercise agency and make choices in their mathematical work, thus becoming active users (as opposed to passive consumers) of mathematics (Boaler & Greeno, 2000).

Supporting Content Engagement: The Role of the Teacher

Much has been said about the crucial role of teachers in supporting how tasks are implemented in classrooms. Classroom environments, institutional expectations, and teachers’ goals all shape how curricula are used in the classrooms (Squire et al., 2001; Stein, Smith, Henningsen, & Silver, 2000). However, the discussion of tasks and classroom cultures often imply that they are
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separate influences whose potentially competing goals can be difficult to align. In our work, we attempt to design activities with classroom cultures in mind. Our goal is to couple students’ game play with their classroom experiences intentionally, through a blending of the real and virtual. In the following, we discuss two ways that teachers can more effectively support students’ content engagement: informal questioning and whole class discussions.

Questioning in the moment. Initially, teachers can support students in completing in-game tasks by rotating around the class and monitoring student progress and choices. We have found that it is important for teachers to maintain students’ ownership and responsibility for the learning process. This helps to maintain the students’ motivation for completing the task—a motivation that is driven more by a situational rationale for engaging (engaging because of interest or personal commitment), rather than a structural rationale for engaging (engaging because of a recognition that doing so is important for a future goal, such as getting a good grade; D’Amato, 1992). An example of such immersion can be seen here, when a student asked her teacher a question, which the teacher responded to by staying consistent with the storyline:

St: Would you get in trouble if you went towards Mayor Grant?
T: Mr. Grant is who’s trying to run against the mayor. Would you get in trouble? I think it’s your opinion. You agree with what he has to say?
St: Somewhat.
T: Interesting. Well, that’s great. No, I think (2-second pause) if (3-second pause). Are you concerned about the safety of the children?
St: Yeah.
T: And you’re making your decision based on evidence about that?
St: (Nods.)
T: Then I think that’s just fine. If you’re using what you understand—your analysis, using those numbers, and you can make a good decision based on that, I think that’s OK. That’s good statistics, not politics. That’s my opinion.

This exchange accomplishes two things simultaneously: It reinforces the student’s conceptual engagement with content (using what you understand), and her consequential engagement (making a good decision based on that). The teacher responds to the student by staying within the context of the story—in fact, she makes an explicit change from answering the question herself, as the teacher “No, I think” to considering the context of the story, saying “Are you concerned with the safety of the children?” In this way, the teacher maintains the designed intention of the task of supporting students to engage consequentially by considering the relationship between particular tools and particular outcomes. She structures the task for the student by emphasizing the importance of “using … your analysis,” and making “a good decision based on that” as the intention of the assignment. Notably, although this exchange provides more information to the student about what to do, it does not limit the student in terms of how to do it. What’s more, it maintains the rationale for quality recommendations (making decisions based on an analysis) in the scenario of the game, thus maintaining a legitimate reason for high-quality engagement.

Reflection with the class. Teachers can also initiate whole-class discussions, allowing for multiple responses and viewpoints. Although challenging at times, these discussions can be led effectively by teachers who develop a set of questions before the lesson about the kinds of ideas, misconceptions, and new directions students might have. Our materials help to start these discussions with questions we have found to be effective, but it is the teachers themselves, who are more familiar with their particular students, who often guide the most compelling discussions. In these discussions, teachers are not simply trying to ensure that their class reaches the “correct” answer (because there is not a correct answer for these activities), but, rather, that they are engaged in wondering, questioning, and justifying. Time and again, we have observed that the most effective class discussions emerge when
teachers ensure that the discussion of content stays connected to the storyline of the game, rather than directing the class’ attention strictly to the content of the unit.

With respect to content discussions, the narrative can create a framework that supports teachers and students to discuss ideas in ways that require reasoning beyond procedural knowledge. As an example, the materials that accompany our units often include discussion prompts that highlight the story and disciplinary tensions of students’ engagement, as seen in Figure 3. Along with those prompts, we include suggested questions whose goal is to focus on all four forms of engagement, such as the following:

- How does your method of analysis support the argument you are making?
- Does the way the graph is organized make it easier to see what the person is talking about?
- Why do you think Mayor Enoch thinks that his bike is better?
- What makes Mr. Grant claim that his bike is safer?

As teachers discuss these different solutions with their students, they are able to ground their discussion in the story, which supports consequential and, at times, critical engagement. At the same time, however, teachers and students can also continue to engage procedurally and conceptually, as they think about how tools work and how they were used. An example of this interplay can be seen in the following discussion, which took place after students had submitted their first recommendation about which brand of bike was safer. The class had just reviewed the explanations in Figure 3.

T: So, I want you guys to think about the candidates—Mr. Grant and Mayor Enoch. Are either of them lying? Or do they both have just reasons to support the bike of their choice? Will, what are your thoughts on that? Is one of the candidates lying? (pause) Kay, is one person lying?

Kay: No.

T: No—what is happening?

Kay: They both have different ways of looking at the data.

T: Yeah, they both are looking at the data in two different ways. What they’ve done is taken the same data and looked at it from different viewpoints, and used it in different ways. OK? Can you see how you can make a just argument both ways?

T: Sooo. Remind me. Who can tell me how I find this range, which is what this person looked at here. Lily?

Lily: It’s the highest number, when you put it from least to greatest, and subtract the lowest number.

T: So, you’re looking for the range, the difference between the lowest number and the highest number. So, for Speedy Spokes, we looked at the difference between 27 and 54, and for Rollin’ Steady, we looked at the difference between 43 and 55. OK? So, that’s the range, and that’s what this person did.

In this exchange, the teacher and students engage critically with content by considering how and why the candidates might argue different positions using the same data. At the same time, they engage procedurally by ensuring that they know how to use tools accurately. In this way, the storyline serves as a resource for both the teacher and the students as they talk together about the task. In particular, the narrative can serve as a launching point for both mathematical understandings, and to connections with worlds outside of the video game. As students come to understand how tools work, and when and how they can intentionally use those tools in order to support particular arguments, then they can be said to be engaging fully and productively with statistics. As these exchanges illuminate, interpreting the data in different ways has consequences, which creates a rationale for students’ consequential and critical engagement. It helps them to link their analyses with the claims they are able to make. Thus, the purpose of the assignment is not simply to “make a decision,” but to persuade someone else that your decision is correct, a standard that requires much deeper understanding of content.
Conclusion

We have outlined a framework of content engagement that acknowledges the importance of conceptual, consequential, and critical engagement. Even though these forms of engagement can be fostered in many ways, we have found the technologies and methodologies of video games particularly useful for creating learning situations in which students can experience consequential engagement. This is because, unlike in the real world, in video games we can manipulate situations so that they are maximally useful for learning. Video games can provide a situation that is fundamentally different than the real world and this is both personally and conceptually quite powerful. In a video game, players do not simply practice a concept; they have a chance to play with ideas and take on new roles. They are no longer simply students, but instead are historians, reporters, scientists, or statisticians (Barab, Gresalfi, Dodge, & Ingram-Goble, 2010).

Importantly, these designs do not teach themselves. The teacher plays a significant role in ensuring deep content engagement, learned in such a way that students can think about it in the context of other situations as well. This involves teachers providing opportunities for students to appreciate how the academic concepts applied in the particular narrative relate to other situations—what is commonly referred to as transfer. More than the concepts, we also have observed teachers reinforcing the roles students played in the game, referring to students as excellent scientists, mathematicians, historians, and so forth (Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007).

These new opportunities to learn and to experience the consequences of decisions have the potential to change the way that students experience school. Rather than simply complying with school practices because they are important (or, more specifically, because an adult says it is important), such curricula can create opportunities for students to truly appreciate what they are doing (D’Amato, 1992). Thus, we argue that the technologies available today allow educators to look beyond print-based textbook into a new form of curriculum, one that is narratively rich, personally motivating, conceptually rich, and situationally consequential. What’s more, these technologies provide important supports for teachers in their attempts to support students’ engagement with content in ways that go beyond mere mastery of tools. By using immersive and
interactive narratives that help students think differently with and about content, teachers can support students in being engaged with content procedurally, conceptually, consequentially, and critically. These four forms of content engagement are likely to occur not simply because they are assigned, but because the game world has been designed such that successful realization of the narrative goals requires this form of engagement.

Notes

1. The design of these activities has been heavily influenced by curricular tasks designed by Paul Cobb and his research team, and Rich Lehrer and Leona Schauble and their research team.

2. Because of space constraints and the reader’s likely familiarity with such forms of mathematical engagement, we do not discuss procedural engagement here, but move directly to discuss how the three other forms of engagement were supported in this unit.

References


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