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Big Ideas 11/30/2017

Overview

This document is intended to aid the process of designing an educational intervention, particularly for future Zach in case he needs a reminder of the core principles of EGIA. Each big idea includes a definition, a short statement on why it's important, and ways to implement it. All of the ideas are important and interconnected, but are listed in rough order of priority. Overall, the ideas lay out what learning means, how to motivate learners, ways to ensure that knowledge in the classroom will transfer to other contexts, and important ideas to consider when evaluating the effectiveness of instructional methods.

Big Idea 1: Constructing Models of Reality

What it is

Learning requires more than receiving input and absorbing knowledge. Educational interventions should help students *construct* appropriate mental models of reality.[1]

Why it's important

If we want students to engage in deep learning, they need to grapple with ideas and make sense of them. Thinking of the mind as simple storage bin encourages bulimic learners, who will likely forget knowledge from the class and fail to transfer conceptual, procedural, and dispositional skills to other contexts (see Big Idea 3).

How to implement it

1.1—Connect students' prior knowledge to what you want them to learn

Students do not enter the classroom as blank slates; they come with a rich set of ideas and models of the world.[2] Though these models may have worked for them in the past, students may hold certain misconceptions that hinder the learning process. High schoolers in an introductory physics class, for instance, may refuse to believe that a wall could exert a force when someone leans on it. An instructor could use the bridging technique to help students understand how this is possible: start with the students' accurate prior knowledge that a spring can exert a force when pushed, and then analogize that reasoning to a foam mattress, then to a pliable piece of wood, and finally a wall.[3] This is an example of the undoing principle at work.[4]

The social, political, and economical contexts surrounding a student's upbringing have a profound effect on his or her models of the reality. For example, kindergarteners from lower-income families may have less experience with explicitly mathematical tasks (like playing certain board games), and thus are likely to have a logarithmic representation of how integers are placed on a number line rather than a linear one.[5] When designing instruction to help correct misconceptions, students must encounter situations in which their faulty mental models do not work.[6] In the case of the Siegler paper, kindergarteners played board games that required them to practice counting on a board with evenly-spaced numbers.

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[1] Bain, K., 2004, p26
[2] Ambrose, S.A. et al., 2010, p12
[3] Ambrose, S.A. et al., 2010, p26
[4] Schwartz, D.L., et al., 2016, location 4768 (Undoing)
[5] Siegler, R.S., 2009
[6] Bain, K., 2004, p27

1.2—Provide a structure for helping students organize knowledge

In any domain, constructing an appropriate model of reality is inherently linked to organizing knowledge the way an expert would. While a novice may only have sparse knowledge organizations with superficial links between concepts, an expert will have rich structures with meaningful connections among facts, skills, and dispositions.[7] It may be difficult for students to organize knowledge like an expert, and the way they naturally arrange information can vary widely depending on their culture.[8] Two techniques can be particularly useful for helping students construct appropriate knowledge structures. First, scaffolding can provide a temporary structure for students to help them organize information in their minds even if they cannot see the big picture yet.[9] Second, timely feedback can be used as a "GPS" to help students understand their current knowledge framework (where they are) and how to alter it to align with that of an expert (where they need to go).[10] Together, these techniques form a roadmap that helps students make the transition from sparse, superficial knowledge organizations to rich, meaningful ones.

1.3—Engage students, but avoid cognitive overload

Constructing a model of reality is an active process, but asking students to engage in too many tasks can cause lack of motivation, bulimic learning, and/or loss of sleep. When designing instructional assignments, aim for an appropriate amount of generative processing while minimizing extraneous processing. While students do need to engage in behavioral activity that can be observed and assessed, try to only include activities that require psychological engagement.[11] A good strategy to reach this balance is to think of ways to make instruction "thought-driven" rather than "stimulus-driven" (e.g., thinking about solutions to a mystery movie instead of just watching an action movie).[12] However, be careful not to make an activity more complicated than it needs to be; choose the right kind of instruction for the right kind of goal. For example, memorizing facts is important in certain contexts. In this case, an intervention that encourages elaboration may be sufficient.[13] Avoiding cognitive overload will also help students get enough sleep, which is essential for consolidating knowledge and staying alert during instruction.[14]

Big Idea 2: Communal Motivation

What it is

Learners in a class may come from a variety of contexts, but, when handled the right way, this diversity can be harnessed to motivate learning rather than hinder individual students.

Why it's important

Even if you understand that students need to construct models of reality to learn, you'll get nowhere if students do not want to engage in this slow, complex process. It's easy to inadvertently alienate certain students based on stereotypes and preconceived notions.

[7] Ambrose, S.A. et al., 2010, p49
[8] Ambrose, S.A. et al., 2010, p47
[9] Schwartz, D.L., et al., 2016, location 3671 (Participation)
[10] Ambrose, S.A. et al., 2010, p139
[11] Clark, R. & Mayer, R., 2016, ch2
[12] Schwartz, D.L., et al., 2016, location 2053 (Imaginative Play)
[13] Schwartz, D.L., et al., 2016, location 1039 (Elaboration)
[14] Schwartz, D.L., et al., 2016, location 6149 (Zzzzzz)

How to implement it

2.1—Help students reframe negative beliefs about their place in a community

Due to stereotypes, low self-efficacy, or other contextual influences, a student may lack the motivation to engage in an instructional activity. In *What the Best College Teachers* Do, Bain exemplifies a situation in which students might not listen to a teacher's genuine advice because they feel as if it is grounded in stereotypes. Each member of the class was asked to turn in an essay with a picture of themselves attached. After receiving feedback that simply stated what was wrong with the essays, African American students were less likely to make revisions than white students were. This is a rational response, as prior experiences in similar contexts often affect expectations.[15] However, when the critiques were framed in a way that made it clear the instructor actually believed in the students' abilities to improve (by stating that the essays could be accepted in a journal with high standards if a few changes were made), a larger percentage of the black students applied the advice.[16]

2.2—Take students' contextual norms into account when designing instruction and assessing performance

Some students are extroverts and some are introverts. Different cultures may value one over the other, but the classroom should provide opportunities for all personality types to show their strengths. If a particular student tends to keep quite during full-class discussions, do not assume that he or she has nothing to contribute. He or she may be more comfortable sharing ideas in small groups or in journal entries.[17] Avoid discriminating against certain dialects when evaluating something like language ability and be sensitive to the idea that a "normal" amount of arousal can be overwhelming to someone with anxiety.[18]

2.3—Create a culture where it's safe to fail

It's tough for an individual to try and fail in front of a crowd. Insecurity or the potential for embarrassment might be strong enough to prevent a student from experimenting or attempting something new. An instructor can remedy this by establishing norms that "reduce the risk associated with suboptimal performance."[19] By modelling inclusive behavior and attitudes, you can encourage students to take risks when they are uncertain about a response, and foster understanding when individuals mess up.[20]

Big Idea 3: Deep and Sustainable Learning

What it is

Students should have a thorough understanding of the material and remember what they learned after leaving the classroom. For a given domain, deep understanding refers to the "full range of competence" expected at a learner's level, which includes metacognitive knowledge and skills, as well as dispositions.[21]

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[15] Ambrose, S.A. et al., 2010, p77
[16] Bain, K., 2004, p72
[17] Carver, S.M, 2017, Lecture 8/29/17
[18] Schwartz, D.L., et al., 2016, location 5378 (Norms)
[19] Schwartz, D.L., et al., 2016, location 2451 (Knowledge)
[20] Ambrose, S.A. et al., 2010, p182
[21] Carver, S.M., 2006, p206

Why it's important

It's great if a student is motivated enough to construct a new model of reality, but students can only truly benefit from a classroom experience if they can apply the knowledge in other contexts. We want to discourage bulimic learners who will forget the bulk of the material once they no longer "need" it for the class. A deep, expert-level knowledge organization (or as expert-level as possible given the learners' prior knowledge and developmental level) enables students to employ what they learn and continue to grow.

How to implement it

3.1—Encourage students to grapple with ideas rather than simply memorize them

In contrast to the "information acquisition" model of learning, students need to struggle with a concept a bit in order to gain a deep understanding of it.[22] A particularly useful strategy is just-in-time telling, where students experience problems *before* they receive ideal solutions and explanations.[23] As some students may feel uncomfortable with this task, creating an environment where it's safe to fail (see Big Idea 2.3) necessarily applies here.[24] The process of failing without worry and then constructing a more accurate model of reality fosters a growth mindset by demonstrating to the students themselves that they can learn new things even if they have difficulty at first.

Students should not stop grappling with ideas after the initial challenge; rather, "good learning environments provide a trajectory for continued learning and deeper involvement" by keeping them within the Zone of Proximal development.[25] Faded worked examples, where the learner receives less and less scaffolding as he or she improves, can help keep an activity at a level that is too difficult to complete independently, but is feasible with help.[26]

3.2—Employ formative assessments that drive students to deepen their understanding

Good formative assessments push students to make their knowledge organizations more precise while enabling instructors to measure the learners' competency. In domains where spatial representation is feasible, visualization tasks are an excellent choice because of their relational determinacy.[27] Asking a student to draw a diagram of the solar system requires her to think about the relative distance of the planets from the sun, rather than simply knowing the number of planets and the fact that some are further away than others. From the diagram, an instructor can quickly assess her understanding of some basic principles (Are the rocky planets much closer than the gas giants? Are the orbits circular and in the same plane?).

In other domains, having students teach their peers offers a good opportunity for learners to enhance their own knowledge while providing the instructor more evidence of the depth of their understanding. Due to the protégé effect, which states that people tend to put in greater efforts to learn on behalf of others, a student will likely endeavor to reflect on his own model of reality when asked to teach.[28] By

[22] Clark, R.C. & Mayer, R.E., 2016, p21

[23] Schwartz, D.L., et al., 2016, location 2111 (Just-in-Time Telling)

[24] Schwartz, D.L., et al., 2016, location 2255 (Just-in-Time Telling)

[25] Schwartz, D.L., et al., 2016, location 3614 (Participation)

[26] Schwartz, D.L., et al., 2016, location 5528 (Worked Examples)

[27] Schwartz, D.L., et al., 2016, location 5122 (Visualization)

[28] Schwartz, D.L., et al., 2016, location 4589 (Teaching)

observing the student-teacher's lesson plan, the actual instructor can check the student's degree of comprehension and provide feedback as necessary.

See Big Idea 4 for more detail on creating and using assessments.

3.3—Promote transfer with techniques that solidify the underlying structure of models of reality

The ability to apply knowledge to other domains usually depends on understanding the deep structure of that knowledge. Two complementing techniques that facilitate deep learning are analogy and contrasting cases. Analogies are particularly helpful for preparing for far transfer, where the tasks differ on the surface, but have fundamental similarities in their underlying structure.[29] They can be used during instruction (explain a novel idea by making an analogy to a familiar one) as well as assessment (provide students with two examples and ask them to identify the essential similarities).[30] On the other hand, contrasting cases work well in situations where the goal is to discern key features by differentiating apparently-similar examples.[31]

In any case, giving students ample opportunities to apply newfound skills in diverse contexts is essential to making sure they can do it outside of class.[32] Even simply holding discussions about the conditions of applicability can improve likelihood of transfer.[33] While it may not always be feasible to track students after they leave the course to see if they are applying their learning to other domains, there are ways to assess how well a student is able to transfer. For example, the instructor could "specify a context and ask students to identify relevant skills or knowledge."[34]

3.4—Explicitly teach metacognitive skills to help students become self-directed learners

Metacognitive skills involve being a good judge of your own knowledge and self-monitoring your own dispositions. Developing them is critical to becoming a self-directed learner[35] and can be of great help when applying knowledge to new situations. Asking students to reflect on their own work and offering plenty of opportunities to revise assignments are good strategies for teaching metacognition. In particular, the process of self-explanation encourages learners to continually test themselves and monitor their own progress.[36]

Big Idea 4: Authentic Assessments

What it is

Good assessments provide deep, genuine insight into the students' level of understanding and mastery of learning goals.

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[29] Schwartz, D.L., et al., 2016, location 158 (Analogy)
[30] Schwartz, D.L., et al., 2016, location 165 (Analogy)
[31] Schwartz, D.L., et al., 2016, location 662 (Contrasting Cases)
[32] Ambrose, S.A. et al., 2010, p117
[33] Ambrose, S.A. et al., 2010, p116
[34] Ambrose, S.A. et al., 2010, p118
[35] Ambrose, S.A. et al., 2010, p190
[36] Schwartz, D.L., et al., 2016, location 4340 (Self-Explanation)

Why it's important

We cannot directly look at students' brains to determine if they have met our goals. Mere instructional design, even if done carefully and thoroughly with respect to educational principles, cannot lead us to conclude that learning took place in the course. We need authentic assessments that are properly aligned with all types of learning goals. This necessitates creating tasks beyond traditional tests and quizzes, which usually only focus on superficial course content (like basic facts and procedures).[37] In addition to providing the instructor with evidence of the students' level of mastery, good assessments can provide valuable feedback to learners to help them monitor their own progress.

How to implement it

4.1—Scale the complexity of assessments with the intellectual depth of the learning goal

Note that there is a continuum of assessment types from informal checks for understanding to performance tasks.[38] Learning goals that target deep levels of understanding require more complex assessments than those that focus on simpler facts and procedures do.[39] "Performance tasks," which involve "complex challenges that mirror the issues and problems faced by adults," provide particularly helpful evidence of mastery of primary learning goals.[40] In striving to create assessments that cover all of the learning goals for a course, keep in mind that traditional tests and quizzes can offer sufficient data for evaluating students' knowledge of simpler facts and skills.[41] You do not need to avoid traditional assessments like the plague; you only need to recognize their limitations.

4.2—Keep assessments practical by considering the context surrounding the learning environment

If we had unlimited time, money, and energy, we could always gain more and more insight into our students' level of understanding by expanding the scope of our assessment activities. Obviously, abundance of educational resources is a pipe dream, especially for most K-12 schools. Still, good assessment design enables instructors to gauge learning effectively. As I cannot express it better, here is a quote from page 206 of Sharon Carver's *Assessing for Deep Understanding* (emphasis mine):

> *"The key is to explicitly focus on assessing aspects of students' learning that are directly related to the specified deep understanding, together with critical features of the teaching/learning process, in order to* ***maximize the usefulness of the assessment within the constraints of time and resources****."*

Considering context constraints is especially important for informal learning environments, such as museums. In a setting where the learners show up sporadically and are only present for a few hours at a time, student-focused assessment activities need to measure learning over shorter time intervals. Some examples include surveys, interviews with parents, and observations by staff members.[42]

4.3—Refer to the assessment triangle and strive to meet the standards for each point on it

Introduced by the National Research Council in 2001, the assessment triangle provides a useful framework for developing tasks that allow instructors to evaluate students' knowledge. Sharon Carver

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[37] Carver, S.M., 2006, p205
[38] Wiggins, G. & McTighe, J., 2005, Fig 7.4
[39] Wiggins, G. & McTighe, J., 2005, Fig 7.11
[40] Wiggins, G. & McTighe, J., 2005, Fig 7.5
[41] Wiggins, G. & McTighe, J., 2005, Fig 7.5
[42] Field trip to Children's Museum of Pittsburgh, 11/17/17

elaborated on the idea in *Assessing for Deep Understanding* and suggested standards for each point. Referring to these ideas will help you design assessments that meet the 3 S's (sound, sensitive, and systematic).

Point 1: Cognition

- The cognitive and metacognitive knowledge, skills, and dispositions you want to measure
- Standard: Sufficiency
- Ask yourself:
    - Do the assessments cover the range of learning goals?
    - Do the assessments genuinely align with their respective learning goals?

Point 2: Observation

- What the students actually need to do and what evidence of learning you can acquire from the tasks
- Standard: Reliability
- Ask yourself:
    - Are student performances repeatable (i.e., test-retest reliability)?
    - Are scorers consistent with each other (i.e., inter-rater reliability)?

Point 3: Interpretation

- The use of scoring results to report and give feedback on learning
- Standard: Validity
- Ask yourself:
    - Does the assessment interpretation actually reflect the truth of who learned and the degree to which they learned?
    - Are the measures actually tapping their target (internal validity)?
    - Is the evidence generalizable (external validity)?

Big Idea 5: Experiments Where Everybody Wins

What it is

It's necessary to vary targeted aspects of the instruction to test its effectiveness. Make sure the students in the control group also benefit from the (hypothesized to be) better form of instruction.

Why it's important

This big idea provides a way to balance the benefits of gathering empirical evidence to support a method with the potential costs of using a group of students as controls. As a matter of fairness, we shouldn't let half of a class miss out on higher-quality instruction.

How to implement it

5.1—Vary a targeted aspect of the instruction, but don't blind yourself to alternative explanations

Instead of arbitrarily choosing an aspect of the instructional intervention to vary in the experiment, consider which features make up the "active ingredients" of the course. These features are hypothesized to lead to the largest learning gains for students.[43] For example, in 2009, Siegler examined

[43] Carver, S.M., 2017, Lecture 11/16/17

whether experience with board games that involve mathematical skills help young children develop a linear representation of integers (instead of a logarithmic one).[44]

However, don't be too quick to cast aside other possible explanations for the learning gains. Taking a bigger-picture view of the research program, it can be useful for initial studies to cover secondary and tertiary prospects in addition to the main hypothesis. You can subsequently narrow the focus in tiers as you gain insights from further analyses and research.[45]

5.2—Use experimental methods that are rigorous enough for researchers and principled enough for practitioners

In the classroom, experimental manipulations can be robust and valid without providing an unfair advantage to one set of students. The "Now and Later" design offers a good way to achieve this when interventions need to be tested as a whole. In this procedure, one group initially receives the treatment while the other does not. Partway through the course, the groups are flipped. This allows the researcher to observe (i) the improvement of a treatment group compared to a control and (ii) the maintenance of learning gains when the treatment ends. If the intervention does not need to be tested as a whole, you can also use split class design, where everyone experiences all features of the instruction except for one (hypothesized) key aspect.[46]

The idea of employing rigorous, but fair, methods also applies to smaller-scale experiments. The bulletin at the Children's School at CMU had an excellent example that I can refer to for inspiration. The study was examining whether exposure to children's books depicting atypical gender roles could reduce gender stereotyping. In one group, students read the books with atypical roles. In the other, students read an unrelated book. To ensure that both groups received the benefit of instruction in gender roles, each group read the other book after the critical part of the experiment.

It is also worth noting that a researcher can strike a balance between rigor and principle when assigning students to groups. By using stratified random sampling while giving instructors "veto power" about certain student combinations, the experiment can achieve validity while avoiding "potentially explosive" situations.[47]

Conclusion

There are a lot of ideas here and it may seem hopelessly complex at times to design good educational interventions. Remember that this challenge is precisely why you got into the field. The struggle is real, but also a positive indication that you are striving to help a population of learners that vary widely in their prior knowledge, cultural experiences, values, and goals.

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[44] Siegler, R.S., 2009
[45] Carver, S.M., 2006, p217-218
[46] Carver, S.M., 2006, p211-212
[47] Carver, S.M., 2006, p212-213

References

Note

The ABCs of Learning book (Schwartz, D.L., et al., 2016) is Kindle version that does not include page numbers, only locations. Thus, I have also included chapter name in parentheses whenever this source is referenced.

Full references that do not appear in the syllabus

Clark, R.C. & Mayer, R.E. (2016) *e-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning, Fourth, Edition*. Hoboken, NJ: Wiley.

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