The Deconstructed Campus: A Reply to Critics

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In *The Deconstructed Campus* (Mazoué, 2012) I contrast two divergent models of educational practice: monolithic instruction and precision education. The former embodies legacy practices that hinder effective learning whereas the latter is characterized by transformative changes to institutionalized education. Monolithic instruction refers to practices that combine batch-processed student learning with folk pedagogical approaches to teaching. The institutionalization of monolithic education in schools, largely through classroom instruction, has produced a regressive system of education that is based on the mass standardization of learning. In contrast to intuitive approaches to teaching, precision education applies evidence-based principles and practices to create conditions that best enable each student to learn. Precision-based education applies research drawn from the burgeoning science of learning to educational practice with the goal of creating the optimal conditions for individual learning. One of the most significant implications of a shift from monolithic instruction to precision-based learning is that it has the potential to undermine the dominant role that land-based educational institutions have had as exclusive providers of knowledge and credentialing.

In their rebuttal to *The Deconstructed Campus*, Shrock (2012), Ross and Morrison (2012) and Armellini and Hawkridge (2012) advance a number of criticisms against precision education. Although I will be unable to respond to every objection point-for-point, this paper addresses some of those that seem to me to be the most salient in terms of evaluating the case for precision education. Their most important criticisms are that the argument for precision education:

1. Lacks empirical support.
2. Confounds instructional methods with media.
3. Disparages the role of teachers.
4. Serves commercial market-driven interests.
5. Is a whimsical adulation of futuristic ideas.

Common misunderstandings

I would like to begin by clarifying several generic misunderstandings before commenting on the authors' specific criticisms. Much of the criticism from Ross and Morrison (2012), Shrock (2012), and Armellini and Hawkridge (2012) is predicated on the notion that I am advocating that computer-based tutoring systems should completely replace human involvement in the learning process. Nothing could be further from the truth. Not only do I state that this implication does not follow from precision education (Mazoué, 2012, p. 87) but I expressly allow for the continued reliance on face-to-face instruction in those academic disciplines in which it is necessary. I allow for the fact that not all forms of learning may be well-suited online (Mazoué, p. 88). My stated position, therefore, is that the extent to which place-based learning can be digitally rendered into an effective online alternative is an open question. Whether innovations emerge that replace human-guided instruction with technology-mediated forms of learning is an empirical issue. Not giving mollifying assurances that location-bound learning is in all cases necessary, however, does not imply that it is totally unnecessary. Nor is it a vilification of teachers to suggest that there may be alternatives to classroom-based instruction that afford students improved opportunities to learn.

Some of the commentators also misstate my position in saying that I predict the "elimination" of colleges and universities (Shrock, p. 105). They seem to believe that my paper is a manifesto dedicated to dismantling land-based post-secondary institutions and a triumphal declaration that precision education is a fait accompli. In fact, my advocacy of precision education throughout the paper is much more moderate and qualified than they allege. I do not claim that we have reached the point at which we can immediately "shutter" brick-and-mortar institutions (Ross and Morrison, p. 124). As I clearly point out, we are in the initial stages of an ongoing process of research and development and that "none of us can say with certainty where they will ultimately lead" (Mazoué, p. 91). At this point, precision education should be viewed as more of an aspirational ideal informing research efforts rather than a competing model of educational practice. My paper simply calls attention to a number of well-known trends, some of which have been occurring over decades, that raise questions about the effectiveness of face-to-face instruction and, by implication, the future viability of land-based institutions as exclusive providers of learning. The persistence of land-based educational providers will depend on whether the process of institutionalizing precision education succeeds. What my paper does is raise, as a speculative possibility, a question about the extent to which location-independent learning (pending rigorous empirical research) might feasibly replace location-bound instruction. It does not presume to prophesy the demise of land-based institutions as a foregone conclusion.

Another unfounded claim repeated in several of the commentaries is that I underestimate the magnitude of the task required to implement precision education. At no time do I suggest that precision education is "nearly ready to be implemented" (Ross and Morrison, p. 124). As leading researchers in the learning sciences note, the process of developing and continually improving cognitive courseware will be a long and laborious task. "Addressing the chasm between learning science and educational practice," they point out, "will require massive efforts from many constituencies, . . ." (Koedinger et al., 2010, p. 1). The deployment of an extensive research and development infrastructure will therefore be necessary to produce course exemplars and sustain their continuous improvement. When judged by the amount of effort and expense invested thus far, there can be no other conclusion but that the implementation of precision-built curricula on a scale that rivals land-based options will be an enormous undertaking.

It is worth noting in this regard that the commentators fail to acknowledge the flip side of this argument: The fact that the amount of effort and expense required in maintaining the wasteful inefficiencies and questionable effectiveness associated with classroom-based instruction is no less daunting. A dependence on handcrafted models of instruction that rely on folk pedagogy arguably requires an even greater investment of time and resources, not to mention the opportunity costs incurred by foregoing more effective alternatives. The question that should be addressed therefore is not just the magnitude of the effort involved but whether the switch to precision education will be worth the effort in the long run in terms of providing improved learning outcomes and greater efficiency.

Another source of misunderstanding is the claim that precision education is a "technology solution" and nothing more than computer-based instruction (Ross and Morrison, p. 119). In fact, my definition of precision education as "the application of research-based principles to inform and guide the ways in which we teach and assist students with their learning" (Mazoué, p. 78) does not even refer to technology. Precision education is primarily concerned with implementing the conditions that best enable learning. For reasons that I explain below, the comparison between analog forms of batch-processed instruction in classrooms versus digitally-enabled learning environments is ultimately a choice between conditions that best enable students to learn.

Reply to Ross and Morrison

As Ross and Morrison point out, however, there are a number of areas on which we agree. Foremost among them is that there is a need to improve higher education. The status quo is simply not good enough. As data on retention, graduation rates, and academic outcomes indicate (Arum and Roksa, 2011; Aud et al., 2012; Knapp et al., 2011; Radford et al., 2010), current practice falls short in terms of consistently realizing the conditions that enable successful learning. We also agree that we should approach learning as a process that is amenable to improvement through scientific understanding. Educational practice needs grounding in the best available research on how students learn. What is less clear, however, is how thoroughgoing Ross and Morrison think the scientific rendering of education should go. Although they agree that "the increased sophistication of contemporary science in understanding human learning and cognition" is a desirable development that "will enable the establishment and exploitation of 'user-centered, network-mediated environments'" (Ross and Morrison, p. 120) they seem to think that this goal should be accommodated within current educational practice. Although we find common ground therefore in acknowledging that there is a problem, we disagree on the solution. We disagree on whether the improvements needed require the kind of fundamental reform represented by precision education.

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Precision education does not lack empirical support

In addition to rejecting my arguments against monolithic instruction Ross and Morrison find those *for* precision education fraught with problems. One of their principal objections is that the evidence for precision education is scant and that the research conducted thus far is at best tentative and inconclusive. When judged on its own merits, they argue, precision education is found to lack "credible evidence of effectiveness" (Ross and Morrison, p. 119). Precision education, in their view, is based on unproven instructional strategies that lack sufficient evidence to be taken seriously as an alternative to prevailing practices. Their overall assessment, then, seems to be that, despite its worthy aspirations, precision education is too far removed from current educational reality to merit serious consideration.

Instructional approaches should not be adopted that require us to take a leap of faith regarding their effectiveness. It is certainly reasonable, then, to demand that there be credible evidence demonstrating the benefits of precision education. Admittedly, we are in the very early stages of understanding how to apply the learning sciences to educational practice. I would not disagree in the least therefore with the characterization of the evidence in support of precision education thus far as provisional and promissory. Even so, Ross and Morrison's conclusions about both the quality of current research and the future prospects for developing effective precision-based courseware are unduly pessimistic. Their charge that precision education lacks a credible basis in the research literature is overstated. Although they cite one study, for example, that casts doubt on the effectiveness of intelligent tutoring systems (Ross and Morrison , p. 124), they omit other reports that find that they have positive effects or potentially positive effects on learning (What Works Clearinghouse, 2009a; 2009b; 2009c; 2012a; 2012b; Barrow, 2009; Carnegie Learning, 2010; Ritter, 2011; VanLehn, 2011).

Granted, the research portfolio demonstrating the effectiveness of newly emerging digital learning platforms is small but growing. Prototypes of course exemplars with robust learning analytics capabilities are only beginning to be implemented with the expectation that they will have increasing impact as they mature (Bacow, 2012). It is one thing to say, then, that more evidence of the efficacy of a precision-based model of learning is needed. It is another to say that the incipient state of such evidence is proof of its improbability. Innovation, in its early stages, rarely emerges on the scene with full-blown advantages over established practices. As with the initial stages of any process of scientific inquiry, the accumulation of evidence is an ongoing process of discovery. It would be surprising, however, if it turned out that the application of the scientific method to our understanding of how learning can be improved were to yield null results. In fact, the evidence thus far demonstrates just the opposite.

A demand for evidence, therefore, can be used to forestall as well as justify the incubation of promising lines of new research. While a demand for proof is reasonable, it should not be used as a peremptory tactic to argue that a lack of conclusive evidence disqualifies an innovative model as impractical or impossible. Indeed, our conclusions about the conditions that best enable learning, no matter how well-documented, should always be viewed as provisional and open to revision. It is worth noting in this regard that Clark himself considers his claim (discussed in the next section) that instructional methods, and not media, account for learning is a *hypothesis* and not a conclusion (Clark 1994, p. 24). The nascent state of applied research in the learning sciences should not, therefore, be taken as a justification for committing ideational infanticide. A thoughtful weighing of the potential for new ideas to germinate is no less prudent than relying on the weight of those that have grown to maturity.

Precision education does not confound instructional methods with media

Citing Clark's medium-method distinction, Ross and Morrison charge that my claim that precision education is a more effective model of learning than face-to-face instruction confounds delivery modes with instructional methods. Learning effectiveness according to Ross and Morrison, "all depends upon *instructional design*—the effectiveness of the embedded instructional strategies used for the particular context and learning goal at hand" (Ross and Morrison, p. 121). Because it attributes learning effectiveness to media and not just the application of instructional methods, the claim that precision education has inherent learning advantages over place-based instruction, they argue, is based on a confusion.

If one accepts Clark's claim that there are no learning benefits from media, then they are correct. The problem with their reasoning, however, is that my argument for precision education is not based on Clark's analysis but rather on Kozma's alternative interpretation that media attributes *do* make a difference to learning outcomes. Far from being out of the mainstream, the notion that media attributes "constrain" and "enable" methods and make the application of methods possible is a position that, according to Reiser, has an "overwhelming" amount of research support (Kozma, 1991; Reiser 1994, p. 47).

Although conceding that digitally enabled learning may have some inherent advantages, Ross and Morrison counter that face-to-face instruction also has its own unique advantages as well. As a mode of instructional delivery each has its own area of applicability and neither, they argue, can be said to have a carte blanche advantage over the other as an instructional medium. Sweeping comparative judgments regarding the effectiveness of face-to-face or digitally-enabled learning, they claim, cannot be made independently of particular instructional contexts. They conclude that, at most, there is a relative parity between the effectiveness of human-assisted and computer-aided instruction and that it would be a serious error to think that one form of instruction is inherently superior to the other. To each its own, we might say. Are we left then with a standoff?

That different types of media have different affordances with respect to enabling the effective application of instructional methods entails more, however, than a stalemate between the advantages of instructor versus machine-based learning that Ross and Morrison suggest. Digital learning environments are not simply inert vehicles that 'deliver' instructional methods. Indeed, the metaphor of transportation misrepresents the learning process by suggesting that knowledge is a commodity to be 'delivered.' As others have noted, *instructionism* badly distorts the fact that learning is a *process* and not the transfer of a pre-packaged deliverable (Papert, 1990; Jonassen et al., 1994). We should therefore avoid the language of 'delivering instruction' because it reinforces the simplistic notion that the acquisition of knowledge is essentially a transfer between a *giver* and *receiver*, rather than viewing learning as a complex cognitive *process* occurring in each learner mediated by enabling conditions.

The crucial test of Clark's medium-method distinction is not whether we can find a counterexample to his claim that "absolutely any necessary teaching method can be delivered to students by many media or a variety of mixtures of media attributes—with similar learning results" (Clark 1994, p. 27). The relevant issue is not whether different media can support similar instructional strategies; in those cases where they do, we can expect similar results. Rather it is those cases where *the same method cannot be applied as effectively depending on the medium* in which it is rendered. Even if there is nothing unique about digital media in the sense that the same or similar instructional methods could also be applied in an analog medium, it does not follow that digital media are *no more* effective. The justification for generally preferring digitally-based platforms over face-to-face instruction therefore lies in the claim that digital media are able to do a better job operationalizing the conditions that enable learning. Because this claim is central to the argument for precision education, we need to examine it more thoroughly.

It would seem odd to claim that the properties of different media are irrelevant to the performance of a task and that the only difference that matters in one's choice of media are their "efficiency characteristics" (Clark 1994, p. 26). That is to say, that the only difference, for example, between using a marshmallow and a steel hammer to drive a nail into a wooden board is that it will take a while longer using a marshmallow. The properties of a marshmallow and a metal hammer relate to more than just their efficiency in performing a task. Using a marshmallow to pound a nail is not simply a *less efficient* method than using a metal hammer; it is entirely *inadequate* to the successful execution of the task. In this case the choice of a medium is a condition that determines the successful execution of one's method of construction. If our goal, then, is the effective execution of a method, such as driving a nail into a wooden board, then media and their properties are not incidental to the successful application of that method. The utter inappropriateness of some types of media for a task entails that they are not simply less efficient than other media but that they lack the very properties necessary for the successful execution of the task itself. Simply put, Clark "fails to acknowledge the fact that certain media attributes make certain methods possible"(Reiser, 1994, p. 45).

Perhaps, though, I have misconstrued Ross and Morrison's concept of *method* by interpreting it more narrowly than they. All along I have assumed that Clark's distinction between medium and method would lead us to conclude that hammers and marshmallows are different *media*, and not constituent properties of different methods. Should we then construe the molecular structure of steel hammers and marshmallows as defining properties of one's *method* rather than compositional properties of different media? On this account, *hammering a nail* would be a different method than *marshmallowing a nail* rather than their being two instances of the same method using different media. On the interpretation that each is a different method, then, some methods are more effective than others. Hammering a nail and marshmallowing a nail would simply be two different methods of which one is more effective because it is better suited to the task of driving nails into wooden boards.

To say that driving a nail with a hammer is a better method of construction than marshmallowing a nail begs the question, however, why some methods are better suited than others for this task. To say that "when the instructional methods remain essentially the same, so does the learning regardless of the medium used to 'deliver' instruction" is like saying that "using objects that apply sufficient force are equally effective in driving a metal nail into a wooden board." So, for example, using bricks, hammers, stones, compressed-air nail guns are all "essentially the same" as construction methods for driving nails into wooden boards. They all satisfy Clark's "replaceability test" (Clark 1994, p. 22). But what is it that determines their adequacy as methods? What is it*,* one might ask, that makes these methods better, i.e., more conducive to the successful execution of the task at hand than others? What explains why, e.g., hammering a nail is a more effective method of driving a nail into a wooden board than marshmallowing a nail, if not *the properties of the different media* being used?

If the adequacy of one's method in this case is defined in terms of a common property, namely, 'having sufficient force to drive a nail into a wooden board,' and this property cannot be defined independently of properties of the media being used, then media are not irrelevant to identifying those methods that are successful in executing one's task. One cannot say that a medium is *just a mode of delivery* and then distinguish between the effectiveness of different methods by referring to their medium-differentiating properties, i.e., 'hammering-a-nail-into-a-wooden-board-using-a-*steel-hammer'* as opposed to the less effective method of 'marshmallowing-a-nail-into-a-wooden-board-using-a-*marshmallow.'* One cannot therefore explain what makes something an effective method without referring to the task-enabling properties of the medium used to perform the task. The very notion of what constitutes an 'appropriate method' depends on the *task-enabling attributes of a medium*.

Here, then, is the dilemma: On Clark's analysis media do not possess learning-enabling properties, only embedded instructional methods. Whether an instructional method is effective, however, depends on the learning-enabling properties of the *medium* in which it is embedded. If what determines the application-adequacy of a method depends on media attributes, then, contrary to Clark's hypothesis, media attributes are not irrelevant to what it is that makes one's method an effective method. In fact, they are more than just relevant. The necessity of including a reference to media attributes as a defining property of an instructional method *qua appropriate* renders the claim that methods – not media – are the only properties that influence learning inconsistent.

This argument shows that it is not erroneous to hold the view that different media can have different capabilities for enabling learning. In fact, it is Clark's view that is problematic. Contra Clark, the difference between digital and analog learning environments is not simply reducible to a superficial difference in "delivery mode." Rather, the crucial distinction between them lies in their different learning-enabling capabilities. And if it can be shown that technology-enabled learning implements instructional strategies more effectively than non-technology-enabled environments, then digital environments have an inherent advantage. The basis for preferring digital learning conditions over face-to-face settings would lie precisely in the former's greater learning-enabling capabilities. What reasons are there, then, for thinking that digital learning conditions are more effective than analog learning environments?

Ross and Morrison hold that certain types of well-designed face-to-face instruction in classroom settings are better suited for learning than digital alternatives. A good way to test their claim is by asking whether classroom-based instruction is better suited than precision education with respect to enabling research-based principles of learning. If face-to-face group instruction provides the optimal environment for the application of learning principles, then we should agree with Ross and Morrison that precision education is unnecessary as an alternative educational model. If, on the other hand, face-to-face methods of group instruction generally do not support the effective application of learning principles even under instructionally well-designed conditions, then they can be justifiably viewed as deficient and candidates for replacement by more effective alternatives. The criterion we use should not simply be the fact that conditions are such that principles of learning *can* be applied, but whether those conditions enable their *most effective* application.

Let us assume then that face-to-face instruction embodies all the best practices to which Ross and Morrison refer: teachers review prerequisites, promote an interest in the material, motivate, activate prior knowledge, present content, ask and respond to questions, pace content based on class progress, preview and review (Ross and Morrison, p. 122). Now, under conditions of group instruction occurring in a typical classroom let us ask about the extent to which each of these best practices can be effectively implemented for each individual student. Under classroom conditions, how much of each student's prior knowledge is assessed in terms of its appropriateness and accuracy? What techniques are used in the classroom to activate each student's relevant prior knowledge in ways that create meaningful relationships to new material? To what extent is lecture material presented in a developmentally appropriate way that builds on and extends each student's current level of understanding? And to what extent does the presentation of material engage each student's attention in ways that are relevant to their understanding? How effective is group instruction in answering questions that specifically relate to each student's comprehension of the material? What strategies monitor and identify gaps and errors in students' understanding? And what strategies are used to ensure that effective follow-up is given to rectify those errors by providing individualized attention and immediate corrective feedback? How, then, during a live class, is all of this information gathered and effectively managed in a way that systematically improves each student's learning? At best, only some of these practices can be effectively implemented via classroom instruction, and then sporadically and only for a few students who, typically, are not the ones who are most in need of help (Brophy et al., 1970).

As a further test of the comparative effectiveness of digital and analog learning environments, let us consider how well each of the two following instructional methods would be implemented as an analog or digital process: concept mapping and adaptive learning. Consistent with Clark's replaceability test, one could certainly render a concept map in analog form. One could type or print text and draw diagrams with lines indicating conceptual relationships on paper or a whiteboard. But are analog media easier to use and more effective than digital concept mapping applications? Given that mind maps can grow to hundreds or many thousands of nodes, the physical limitations of creating and revising analog versions of complex representations are obvious. The principal advantage of digital concept maps, however, lies in their functional capacity to embed, tag, and link information in ways that allow for the creation of an extensive nesting of interlaced representations and interactive content. The capacity of digital media to enable the learner to create, manipulate, and share intricately layered representations in ways that are not possible using analog media is an inherent advantage.

Similarly, classrooms serve as a medium for conducting assessments. Instructors can, for example, answer questions and give corrective feedback, identify misunderstandings, and provide in-class clarifications. But is the classroom the most effective venue in which to monitor and assess how each student is learning? How would one implement adaptive assessment techniques in a classroom of 40 students in a way that would come close to providing each student with an individualized assessment of their learning? How would a classroom teacher effectively monitor and respond to each student's individual responses to different questions and provide immediate, learner-specific feedback? Even its most ardent supporters would have to admit that classroom-based group instruction is ill-suited for collecting actionable data about the state of each student's understanding and using it to improve their performance. Within the group instruction model, effectively tailoring in-depth instruction to each individual learner is simply not feasible.

Do face-to-face and digital learning environments, then, produce similar outcomes? According to Strader and Thille (2012) there are five well-documented limitations of traditional classroom-based instruction that have a negative impact on the quality of student learning:

1. Many instructors teach to only a certain percentile of the class.
2. Students do not receive the immediate feedback they need to learn.
3. Students' knowledge states are a 'black box' to the instructor.
4. Seat-time is favored over the demonstration of competency.
5. The process of creating instruction is inefficient.

These inherent limitations of traditional classroom instruction are impediments to learning that largely outweigh the benefits that Ross and Morrison cite in its favor. "In the traditional classroom," Thille points out, "faculty operate with little data about the current knowledge state of their students and the richness of the faculty expertise is often wasted" (2012, p.11). Again, the point is not that students cannot learn in classrooms but that, in general, classrooms are ill suited for the application of those conditions that optimize learning. Unlike classroom instruction, the data mining capabilities of digital learning environments are able to gather multivariate data about student performance, analyze it, and use it to provide individualized feedback. Digital learning platforms have the potential therefore to serve as "Educational Positioning Systems" (EPS) that precisely navigate each student through their curriculum along individually guided "pathways and routes to maximize student success" (Baer and Campbell, 2012, p. 63). Initial reports indicate that courseware explicitly designed in accordance with effective practices drawn from the learning sciences and enhanced with learning analytics to function as Educational Positioning Systems are having a positive impact on student performance (Evans et al., 2008; Lovett et al., 2008; Schunn et al., 2008).

It is easy, then, to conflate two separate questions: 1) "What is the best way for students to learn *in classrooms*?" and 2) What is the best way for students *to learn*?" Some may assume that the answer to the second question is the same as the answer to the first. We do not need to speculate, however, about what the conditions are that produce the most effective learning.

Thanks to Bloom's pioneering research we already know that the answer to the second question is not the same as the answer to the first. Based on the work of Bloom and his colleagues comparing the relative effectiveness of three conditions, 1) tutoring, 2) mastery learning, and 3) conventional classroom instruction, the least effective learning condition, they found, was the traditional classroom model of group instruction (Bloom, 1984). The most effective form of learning is a combination of one-to-one tutoring with mastery learning. Bloom's estimate is that about 90 percent of students receiving tutoring and corrective feedback can perform at two standard deviations above the average student taught by conventional group instruction (Bloom, 1984). Subsequent research has found that, although the effect size Bloom claims for human tutoring may be too high, it confirms the general conclusion that intelligent tutoring systems, unlike conventional classrooms, have the potential to approximate Bloom's Two Sigma effect by customizing context-specific feedback and targeted guidance to the individual learning needs of each student (Van Lehn, 2011). As Clark and Mayer recently noted, "Other than one-on-one tutoring with human mentors—an expensive option that often yields inconsistent results—no other delivery environment offers the customization options available in asynchronous e-learning" (Clark and Mayer 2011, p. 16).

Precision education does not disparage the role of teachers

Ross and Morrison also claim that precision education fails to acknowledge the important role that teachers play in educating students. My critique of lecturing and classroom-based teaching, they charge, is a "strident criticism and dismissal of the contributions of human teachers to student development via coaching, modeling, and selected uses of didactic instruction" (Ross and Morrison, 2012, p. 119). Giving technology a more prominent role in those areas in which it better enables learning does not, however, discredit the contributions of teachers. The criterion for judging the suitability of human guided or machine-aided instruction should be their effectiveness in producing optimal learning outcomes. In those areas in which instructional coaching and guidance from teachers best enable learning, they should be the preferred methods of instruction. In those areas in which machine-guided learning is found to be more effective it should be used in place of less effective practices that rely on teachers. There should not be a bias in favor of one or against the other. Whatever conditions best enable students to learn should be preferred.

It would be mistaken, then, to think that precision education is opposed in principle to human-guided instruction. The role of technology is not to replace but combine with human intervention in those areas in which they will have the greatest impact on learning (Beichner et al., 2011). Precision education would in fact likely bring to bear *even more* forms of instructional support from learning specialists in areas that are presently neglected. Precision education may very well result therefore in students having even more personal contact than typically occurs via the current model of batch-processed group instruction. Rather than showing disrespect for teachers, those cases where improved learning results from replacing what humans do with machine intelligence will allow both teachers and students to interact with each other in even more meaningful and creative ways. I am therefore in agreement with Ross and Morrison in holding that the contributions of both human and machine guided learning should be viewed as complementary and not mutually exclusive.

What precision education *does* require, however, is a shift in our thinking away from the notion that what a teacher does is of singular importance in bringing about optimal learning outcomes. Helping students transition from a novice's superficial level of understanding to knowledge mastery requires more than having them observe how experts organize *their* knowledge. Unfortunately, however, many educators are still wedded to the notion that learning is a product of what *they* do, and not primarily about what *learners* do; that it is all about how teachers render and convey content for student consumption. This teacher-centric focus is particularly evident among those who extol the virtues of teaching as performance art (Jenkins, 2011). Although there is nothing wrong about being inspired or motivated by smart people exhibiting an infectious enthusiasm towards their areas of expertise, there is a difference between being enthralled by someone's smartness and having it function as a causal factor that enables others to become smart.

The notion that good teaching is a performance appears to be based on the idea that being exposed to those who are learned produces quality learning. Such a view, however, reflects a skewed understanding of *whose* performance effectively enables learning; what is relevant to learning is not the *teacher's* performance (understood as simply imparting knowledge or demonstrating one's mastery of a subject) but each *student's* performance as part of a process leading to mastery of the material being learned. It is worth recalling Wiggins' advice that "it's not teaching that causes successful, eventual learning – i.e. accomplishment. It's the attempts and adjustments by the learner to perform that cause accomplishment" (Wiggins, 2010). Blurring the distinction between those conditions that are causal factors in learning with showmanship simply reinforces the mistaken notion that good teaching is about the stagecraft and theatrics associated with the packaging and delivery of a product and not about careful attention to creating the conditions necessary for learning. A fascination with what we might call the 'TEDification' of education at startups like the Floating University and the Minerva Project further reinforces the erroneous idea that simply exposing students to elite faculty produces effective learning.

Taking a naïve dispositional approach to teaching and learning, i.e., attributing successful teaching and learning to the traits of teachers and students, ignores the structural causes of learning. We should not, however, confuse the *phenomenology* of learning, the surface-level features associated with the *experience* of learning, with the causal factors that explain the *process* of learning. The confusion of experiential with causal factors, for example, appears to account for the subjective over-valuation of the effects of interpersonal immediacy on learning (Hess & Smythe, 2001; Witt et al., 2007; King & Witt, 2009) and teaching (Bacow et al., 2012, p. 20, footnote 19). As Bloom's research shows, however, those variables that have the greatest effect on improving student learning outcomes are not associated with the presentation of content but with what the learner does and the feedback-corrective process (Bloom, 1984).

Being well-intentioned and conscientious do not in themselves make one an effective practitioner. While we should applaud and support the hard work and dedication of teachers, we can and should be critical of the effectiveness of the process that defines how their efforts are being structured and deployed. Teaching without an understanding of how to apply the learning sciences is like blindly practicing medicine without an understanding of the basic sciences. That physicians practiced medicine before its advent as a science does not detract from their dedication; they were not presumably any less devoted to their profession or to their patients' well-being than those who now practice with the benefit of a more scientifically grounded medical education. Nevertheless, it is also true that the latter are better able, in virtue of the transformation of medicine into a scientific endeavor, to treat their patients. The same is true of education with respect to the use of enabling technologies to make better student learning possible.

Precision education is not driven by commercial interests

Ross and Morrison raise the specter of commercialization by implying that precision education would "blindly welcome in the latest flavors of technology solutions marketed for campus use" (Ross and Morrison, p. 128). Their suggestion is that precision education is prone to being driven by commercial interests rather than a desire to improve student learning. This oft-repeated recrimination against the use of educational technologies is typically invoked in a desperate attempt to discredit innovation. It feeds into a generalized paranoia that resists attempts to improve the status quo by mischaracterizing them as being motivated by a mercenary interest in corporatizing academe. Those who are skeptical about the motivations of those who are driving the development of digital learning environments and precision-built courseware will be relieved to know, however, that those who are in the forefront of the research are fellow educators seeking to improve the quality of student learning. Major research universities, non-profit educational organizations, philanthropic foundations, and government agencies – not for-profit corporations – are the ones leading the way in creating open source/open access courseware. Through projects like the Open Learning Initiative, the Next Generation Learning Challenges Grants, the Multi-institutional Cognitive Coursewares Design initiative, and edX, it is the not-for-profit sector that is engaged in collaborative design initiatives that are driving the development of early prototypes of precision education.

Undoubtedly, there are profiteers operating in the educational marketplace with mercenary motives who view non-traditional forms of education as an opportunity to exploit students. That some may have ulterior motives, however, does not disqualify every innovation that challenges educational orthodoxy as the work of the invisible hand of corporate profiteering. Although the accusation of commercial exploitation will appeal to some who imagine a corporate conspiracy lurking behind every educational application of technology, the facts simply do not support the allegation. Rather than exploit students, the development of freely accessible, learning-optimized courseware would serve to democratize education and promote individual empowerment. Indeed, the charge of commercialization is ironic given that it is the institutionalization of monolithic practices by colleges and universities that has created and sustained our current industrial model of standardized education.

Finally, being affiliated with a non-profit college does not sanctify one's motives. The presumption that, unlike corporations, colleges and universities operate with high-minded sensitivity towards those whom they teach or employ is itself not immune to criticism. Quite apart from the questionable treatment of undergraduate students (Thornton, 2012), we can also ask how well our current system is working to nurture and support graduate students and contingent faculty, many of whom would agree with the proposition that "the edifice of higher education is increasingly being maintained on the backs of an academic underclass" (Berrett, 2012). And those who are enthralled by notions of how well higher education is treating its newly minted Ph.D.s who, if they are 'fortunate,' are increasingly joining the ranks of contingent faculty, should read recent Chronicle articles that present a less than flattering view (Patton, 2012). The commoditization of education and exploitation of faculty and students is not a reproach to which technology-enabled learning is uniquely liable.

Precision education is not a whimsical adulation of 'futuristic' ideas

Finally, Ross and Morrison portray precision education as outside the mainstream. It is, in their view, a speculative proposal that indulges in the whimsical "adulation of futuristic ideas" (2012, p. 120.) Far from being a fringe notion, however, the aims of precision education are congruent with recent national policy statements on educational reform in the United States, Canada, and the European Union (Premier's Technology Council, 2010; Redecker et al., 2011; U. S. Department of Education, Office of Educational Technology, 2010). Something very much like precision education is cited by the authors of the National Education Technology Plan as a 'grand challenge problem' worthy of ambitious research and development efforts (U.S. Department of Education, p. x). One of their key recommendations is a call to "Design and validate an integrated system that provides real-time access to learning experiences tuned to the levels of difficulty and assistance that optimizes learning for all learners and that incorporates self-improving features that enable it to become increasingly effective through interaction with learners" (p. xv). In place of a go-it-alone approach to teaching they endorse a model of "connected teaching" in which "teams of connected educators replace solo practitioners" by serving as "facilitators and collaborators in their students' increasingly self-directed learning" (p. viii). And as an alternative to classrooms, they recommend the increased use of digital learning platforms because "technology provides access to more learning resources than are available in classrooms and connections to a wider set of 'educators,' including teachers, parents, experts, and mentors outside the classroom" (p. vi). Rather than reflect an outlier mentality, precision education in fact echoes the recommendations made by some of the nation's leading educators.

The Europeans also view an educational system built on the learning sciences as integral to their future. The 2011 European Commission's Joint Research Centre Report endorses a model "shaped by the ubiquity of Information and Communication Technologies (ICT)" as its "central learning paradigm" (Redecker et al., 2011, p. 10). The future direction of learning, as they see it, is one in which "Assessment will, on the one hand, become embedded in the learning process and pedagogy will rely increasingly on interaction, including the interaction with rich technological environments, which will be responsive to learners' progress and needs." In their view, "assessment will continue to move towards technologically-supported automation, while peer production will remain marginal. On the other hand, however, content, teaching and accreditation will become disaggregated" (p. 30). Their view of the future sounds very much like a description of precision education. Again, time will tell whether precision education is whimsical or an innovation that will largely supplant the status quo. Even in the absence of fully-formed institutional models of precision education, however, it is fair to say that it is a seminal idea that is being taken seriously by educational policy makers in the forefront of national and international reform.

Reply to Shrock

Like Ross and Morrison, Shrock defends the traditional paradigm of classroom-based instruction and endorses the individual-practitioner model of teaching on which it is based. In her reply, she spends a considerable amount of time detailing why, in her view, precision education would be disastrous as an alternative to place-based instruction. She goes to great lengths to show what is *wrong* with precision education, but has little to say about what it is that makes the model she defends, place-based group instruction, *right*. Concerned with driving home the point that precision education *fails*, she does not explain how or why conventional forms of face-to-face instruction *succeed*. The presumption that they do seems to be taken as a self-evident truth without need of explanation. Are colleges and universities ideally structured as learning-enabling institutions? One would think, from reading Shrock's comments that, except perhaps for a few minor adjustments, the answer is a resounding 'yes.' Don't tamper, she counsels, with our citadels of learning. The fundamentals are sound!

The problem, however, is that the fundamentals are not sound. Measures of student success reveal chronic deficiencies in retention and graduation rates and in the quality of learning outcomes (Arum and Roksa, 2011; Aud et al., 2012; Knapp et al. 2011; Kutner et al., 2006; Radford et al., 2010). These indicators of systemic dysfunction are largely attributable to the enduring legacy of standardized practices that define teaching and learning at most colleges and universities. What the data indicate is that, by ignoring for the most part how individual students learn, institutionalized batch-processed instruction has not only inhibited the ability of some students to learn, but it has systemically limited their prospects for future academic and career success. As Arum & Roksa point out, the creation of an institutionally enabled capabilities gap has had the effect of producing a two-tiered educational system: One for well-prepared students who become successfully employed graduates, and another for those who are not prepared and who struggle to find a job even if they do graduate (Arum and Roksa, 2012). Precision education would correct these systemic weaknesses by replacing the legacy practices of group instruction with adaptive programs that individualize learning.

The notion of a non-traditional university education, however, strikes Shrock as an oxymoron. Indeed, she views non-place-based forms of education as an "assault" on the status of universities as havens for learning and research and, by implication, an existential threat to civilization itself. She avers that only place-based institutions can conduct research and properly instruct and credential students. Non-traditional forms of education lack legitimacy in her view and serve only to adulterate both the process of learning and the products that result from them. The problem, unfortunately, with her account is that she does not give any evidence in support of her claims except for issuing a series of doomsday predictions of what she believes would happen if we were to adopt an educational model that takes a more scientifically grounded approach toward how people learn. Absent corroboration from other sources we are left to rely simply on Shrock's ex cathedra pronouncements.

Shrock's 'alternative vision' of the deconstructed campus paints a dystopian picture of precision education (Shrock, 2012, p. 113). It is a world in which the quality of learning does not matter, there is rampant online cheating, little or no meaningful interaction occurs between instructors and students, those responsible for supporting student learning are overworked and disinterested, assessment of student work is either lax or invalid, graduate education and faculty research wither and atrophy, undergraduate education degenerates into indoctrination, and the free expression of ideas ceases under a regime that imposes rigid forms of thought control. In other words, imagine the worst possible degradations that could befall education and offer them as my proposal for precision education. Shrock even gives a name to her dystopian fantasy: the "Electronic Dark Ages" (2012, p. 117). The triptych of disaster she envisions portrays technology-enabled learning as a "scam" perpetrated on unwitting or uncaring students by unscrupulous profiteers. Unfortunately for Shrock and those who are inclined to subscribe to her wildly exaggerated characterization, this unflattering caricature bears no resemblance to what I am actually proposing nor is it a credible account of the events that would likely follow from my views.

Although impending catastrophe no doubt accurately describes what Shrock fears will result from adopting a system of education that treats learning as a science, it is a grotesque distortion rather than an accurate portrayal of the implications of institutionalized precision education. For example, as course exemplars replace handcrafted courses and define optimal forms of learning, they will, she argues, reduce the number of courses to only a few mega-courses with huge enrollments. This, Shrock contends, will entail less contact with instructors thereby resulting in an inferior quality of learning: "Each of these courses will enroll hundreds of thousands of students, so there will be no meaningful human interaction with individual students" (2012, p. 114). Well, that conclusion might follow, but only if we were to assume (contrary to what I am proposing) that instruction would continue to be batch-processed and modeled on current practices, not fundamentally transformed by the learning sciences.

The dire consequences predicted by Shrock's slippery slope argument are based on a number of faulty assumptions. First, as noted earlier, precision education entails that there will likely be more not less contact with learning support specialists. Second, from the perspective of each student, the learning experience will more closely approximate Bloom's ideal of one-to-one tutoring with mastery learning. Learning will therefore be more individualized and effective in comparison to batch-processed group instruction in a classroom; it will certainly not be experienced by the learner as if he or she were in a classroom with hundreds of thousands of students. When supplemented with social media and other forms of highly interactive technology-mediated communication, it strains credulity to think that optimized online learning environments would isolate students and restrict, rather than expand, their opportunities for robust academic and social interaction.

I share the concern that, as course exemplars create greater curricular coherence and convergence as they map and formalize knowledge domains, we guard against the regimentation of ideas. Incorporating multiple perspectives into course exemplars, however, is not antithetical to the goal of optimizing learning nor is it an insurmountable task. Indeed, we can ask to what extent handcrafted courses routinely expose students to diverse perspectives, especially given the fact that, in the design of individually crafted courses, the diversity of points of view is often a matter of instructor prerogative. To how many different perspectives and interpretations are students typically exposed in a handcrafted class? A concern about narrow and biased perspectives does not, therefore, exclusively pertain to course exemplars. It would be groundless, then, to object that the requisite number of balanced perspectives on any given topic could not be included as part of an exemplary designed curriculum.

Concerns about designing an inclusive curriculum representing a diversity of perspectives should also be balanced against the proliferation of unnecessary duplication. To what extent should a curriculum lend itself to endless variation (Thille and Strader, 2012)? What, for example, should students of elementary statistics or colonial American history know? For most curricula it should not be impossible for subject matter experts to agree on a set of core learning objectives, assessments, and a common set of course and discipline-specific learning protocols. Exploring the potential for instructional “aggregation by disciplinary affinity” (Wulf, 2003, p. 20) is a worthy goal that would improve learning if it were systematically implemented. A continuation of the wasteful and expensive duplication of effort resulting from a go-it-alone approach to instructional design and teaching is not only unnecessary but guarantees that the quality of student learning will continue to vary widely (Berrett, 2012).

As noted earlier, the challenges facing the development of optimally designed courseware are indeed painstaking and not without considerable investment. But why would one think that face-to-face instruction is any less challenging or more effective in virtue of taking a largely go-it-alone approach to instructional design and teaching? Why would one think that providing an optimal learning experience would be any less daunting and more readily achievable when using handcrafted methods instead relying on a large-scale research effort? It would indeed be surprising if each occurrence of a uniquely handcrafted course unfailingly ensured that the most important material always gets taught in a way that maximizes each student’s learning. This last point relates directly to Shrock’s assertion that “The more idiosyncratic the design, the greater the reliance on assessment, and the more problematic the consequences if the assessment is invalid” (2012, p. 109). This is intended to be a criticism of precision education but it is, in fact, a good example of what is wrong with the handcrafted model of teaching. What could be more idiosyncratic than a handcrafted approach to the design of each course? If it is an impossible task for precision education to enable learning mastery through frequent, accurate assessment of student work, it would be all the more so under conditions that make it even more difficult to capture, analyze, and effectively assess information about student learning.

Apart from a consideration of the pedagogical advantages of precision education in enabling better student learning, it is also important to address Shrock’s concern about its possible impact on research. “If universities are abandoned,” she worries, “what happens to research?” (2012, p. 111). What could possibly replace universities as creators and conservators of knowledge? I too am concerned about tampering with a system that nurtures free-ranging intellectual curiosity. In an ideal world, support for the unlimited pursuit of knowledge for its own sake would exceed even current levels of institutional support. I am skeptical, however, of the claim that either research or learning would be irreparably harmed if they were no longer physically and operationally conjoined on the same land-based campus.

The alternative that Shrock and others do not appear to take seriously is that the deinstitutionalization and relocation of expertise would not entail its demise. Universities are trusted as authoritative repositories of knowledge because of the experts who are affiliated with them. Their expertise goes where they go, which is to say *just about everywhere* thanks to the ubiquity of communication technologies. University affiliation may be a convenient way to locally harness expertise and identify individuals who possess it, but it is not the only way in which expertise can be developed, organized, accessed, and shared. The claim that land-based universities are the only effective firewall standing between the preservation of knowledge and forces dedicated to its destruction presents therefore a false alternative. Again, the connection between *what research centers do* and *where they are located* is contingent and not ordained by necessity; with the increasing virtualization of research, scholarly communication and productivity no longer require that scholars work in physical proximity. Despite romantic notions to the contrary, the learning, research, and socialization that occur on college campuses can occur in other venues apart from ivy covered buildings.

Whether publically or privately funded, research will arguably continue unabated in those areas in which it is regarded to have value. Issues over *what kinds* of academic research will be supported and *how much* remain to be seen and are open to conjecture, as they sometimes are now. Professional schools and graduate research and training, at least in STEM areas, would seem to be largely unaffected by precision education. But what about its impact on scholarship in the arts and humanities? In answering this question, we also need to consider: How much locally concentrated expertise is needed to sustain academic vitality in a particular field? What provisions are currently in place to ensure that the optimal number of scholars practicing in a discipline is maintained? How many people with terminal degrees does an academic discipline need to prevent intellectual atrophy? Who decides, for example, how many Ph.D.s in medieval history are needed to maintain the preservation of intellectual vitality in that field? The answers to these and other questions about how much and what kinds of intellectual productivity our system of higher education should accommodate and maintain appear to be largely arbitrary and, in some cases, disconnected from not only the needs of learners but from the research needs within certain areas of study as well. Given that the handcrafted model of teaching is often the institutional enabler that sustains faculty scholarship, it seems reasonable to conclude that a shift to precision education would likely have an impact on the volume of scholarly research that is currently produced in certain academic areas.

The Deconstructed Campus: A Reply to Critics

Replacing the handcrafted model of instruction with precision education will undoubtedly therefore initiate a reinvention of educators' roles. As applied research produces optimally designed curricula, it will reduce the need for highly credentialed scholars to design their own individually crafted courses. Less demand for content experts creating their own individually designed courses will be offset, however, by an increased demand for others working directly with students to improve their learning. As with other instances of occupational disintermediation, the transformation of the traditional role of faculty can serve as a catalyst for innovation by leading to the formation of new areas of professional expertise that support student learning and scholarly research. Some faculty will no doubt welcome the opportunity to pursue a career track that allows them to concentrate solely on their research while others will embrace the equally important task of assisting students with their learning. Others will view their Ph.D.s as preparation for alternative careers outside academe (Cassuto, 2012). And perhaps an additional benefit for everyone would be the ushering in of a broader conception of expertise, one in which even more individuals would participate in research thereby enhancing the reach and sustainability of intellectual inquiry as a social value. Along with the wikification of knowledge, precision-based curricula would therefore help to promote the dissemination and vetting of scholarship as a broadly-based activity instead of treating it as a domain reserved for only a few.

Legitimate questions remain about what impact precision education would have on the incubation of scholarship and creativity given the historical role colleges and universities have played in nurturing both. The positive effect that it would have on student learning, however, is less problematic. Rather than serve as an enabling host for the corrosive abuses Shrock envisions, precision education would actually do a better job protecting against the very evils about which she cautions. The very opposite of what Shrock portends is likely to occur under precision education: it will offer greater openness and access to the very best quality education for every learner, at an affordable cost, enabled by a professional staff of specialists dedicated to each student's success. This hardly sounds like a recipe for disaster.

An Educational Reformation

My contention is that a precision-based model is *in general* a more effective medium in which to learn than classrooms because it is better able to realize the conditions that enable learning. Instead of physically grouping students into a classroom as the unit of instructional interaction, precision education takes as its focus the creation of conditions that optimize learning for each student. Any suggestion of de-bricking the college campus tends to be viewed, however, as the defiling of sacred ground and is typically greeted with hostility. For many, then, the very idea of a de-located curriculum is a taboo that evokes strong emotional reactions (Lang, 2012). Criticisms of school-based learning, however, are nothing new. Although the thought of challenging the notion of traditional classroom-based instruction as the optimal learning environment may strike some as heresy, it has a long and distinguished history going back at least as far as John Dewey (1900). What *is* new, however, is the rationale for challenging the primacy of classroom instruction: the recognition that digital learning environments based on the learning sciences can be used to create conditions that are more effective in enabling learning than traditional analog forms of instruction.

Criticism of the quality and effectiveness of precision education is typical of the skepticism that accompanies disruptive innovation when it is first introduced (Christensen et al., 2008). The first reaction of those defending a mainstream practice is to compare the worst features of innovation against the best features of the current practice. As applied to learning-optimized digital environments the typical criticism is that they either cannot be as good as face-to-face instruction or that they are subject to a set of disqualifying objections to which traditional forms of learning are exempt. In either case, the rejectionist tendency is to treat digitally-based learning dismissively as inferior to the status quo. Although this may be the case in the near-term, it is not a reliable predictor of the trajectory of future innovation. If there is one lesson from the history of disruptive innovation, it is that we are often wrong in assuming that an existing practice defines enduring standards of optimal quality.

Calling into question long-held beliefs and practices may strike some as unthinkable. Because the traditionalist model of education is deeply engrained in institutional practices at all levels of formal education there is a tendency to assume that the way we educate is not only pedagogically sound but optimal; that it embodies the most effective conditions for student learning. Despite the best of intentions, however, the data show otherwise. We need to be mindful therefore of what Tagg calls the “status quo bias” (2012, p. 10), a sense of complacency based on an unwarranted confidence in the correctness of our assumptions). Occasionally questioning the soundness of our assumptions serves as a corrective against paradigm paralysis and a misplaced confidence in the benefit of maintaining the status quo. It is therefore important that we challenge our imaginations by considering alternatives that question the seeming inevitability of conventional assumptions about how we educate.

Although the notion of precision education expands the range of our imaginative possibilities, it is more than just a speculative exercise. The deconstruction of colleges and universities as the principal locus of post-secondary education is based on a reasonable inference from trends that have been occurring for quite some time. Three factors in particular are driving change toward precision education and away from campus-based institutions:

1) The predictive power of the theory of disruptive innovation.
2) The emergence of the learning sciences.
3) The growing movement toward a competency-based model of education.

The first provides the conceptual framework within which to understand how digital disintermediation causes institutional decentralization and deconstruction (Christensen 2009; Christensen et al 2011). Colleges and universities are no more exempt from being disrupted by innovation than other institutions that have undergone fundamental change. The radical implications of the second are just beginning to be understood and have yet to be fully realized. Once the application of the learning sciences lead to widespread improvements in the quality of digitally enabled learning, however, they will precipitate a disruption in the core services currently provided by colleges and universities. It will no longer be plausible to argue that you need to go somewhere to learn. The third driver of change, the movement away from a time-based to a competency based educational model, will serve to further unbundle the acquisition of knowledge from the certification of its possession. It will also shift the balance of power from institutions to individual students by giving them greater choice in determining how to certify their credentials. As predictive indicators, all three factors appear to point to the inevitable unbundling of teaching and learning from place-based educational institutions.

Since the publication of *The Deconstructed Campus* a number of events have occurred that signal that transformational changes to the traditional model of land-based learning are underway: the emergence of the Massive Open Online Course (MOOC) model as an alternative to location-bound, proprietary forms of learning; the participation of elite institutions in the development of free and openly accessible courses offered through portals like edX, Coursera, and Udacity, all of which undermine the model of individually crafted courses and the "college credit monopoly" (Carey, 2012); the acceptance of transfer credit for MOOCs by accredited institutions, such as Colorado State University's Global Campus and Antioch University; Gates Foundation grants to develop MOOCs for "high enrollment, low-success" introductory courses; the partnership between the Saylor Foundation and Excelsior College and StraigherLine opening up a path to credit for free and low-cost courses; the ongoing development of learning optimized courseware through the expansion of the Open Learning Initiative and CCLI; the APLU/OLI Multi-institutional Cognitive Coursewares Design project; contributions to the literature on academic disruption (*Game Changers*, the ITHIKA Reports); the movement from seat-time to competency-based learning pioneered by Western Governors University and enjoined by the recently announced University of Wisconsin Flexible Degree program, the first publicly-funded competency-based degree program scheduled to start in fall 2013; and examples of institutional redefinition and innovation at Western Governors University, Southern New Hampshire University's College for America, the University of Minnesota-Rochester, Charter Oak State College (CT) and Ocean County College(NJ). All of these developments can be construed as precursors of a digital shift toward institutionalized forms of precision education. Gauging the rate at which this shift occurs will depend on the progression of the following indicators of transformational change:

- The application of the learning sciences to course design.
- The use of technology to individualize learning.
- The development of digitally-enabled course architectures that optimize learning.
- The replacement of intuitive approaches to teaching with practices based on the learning sciences.
- The movement away from classrooms as the principal locus of learning.
- The creation of online degree programs based on precision-built course exemplars.

Finally, although some of my critics label me as a 'technicist' (Armellini and Hawkridge, 2012, p. 132), I think it would be more accurate to use the term 'moralist' in describing my views. *How* we educate students has a deeply moral dimension. Beyond jousting over competing models of education we should not lose sight of their implications on the quality of students' lives. In particular, we need to be wary of a blindness to those features of our educational system that harm students by failing to provide the conditions that best enable them to learn and succeed in achieving their educational goals. Rather than optimize learning, traditional educational practices have served to impede student progress by functioning as a "societal sorting mechanism" (Menand, 2011). Can we honestly say, then, that the way our educational system currently treats students does not violate one of the most fundamental tenets of morality: First, do no harm? If not, then we should find it deeply troubling to remain complicit in defending a system that harms those entrusted to our care by perpetuating practices that guarantee worse outcomes. On the other hand, it is hard to understand what could be viewed as harmful about the fundamental premise on which precision education is based: that we owe it to each student to optimize the conditions that will enable him or her to learn and progress toward the successful completion of their educational goals. No apologies need be given, therefore, in defense of precision education by holding student learning as a priority no matter how fanciful and utopian that notion may seem.

One thing on which we can all agree is that higher education is undergoing an unprecedented period of transformation. Long-standing assumptions about the role of colleges and universities are being questioned and established orthodoxies surrounding our notions of teaching and learning are being challenged by innovations that may supplant them. If what we are experiencing are the early stages of a paradigm shift toward precision education, it would not be an exaggeration to characterize this transitional period as an Educational Reformation. It would mark a fundamental shift in our thinking about the nature of education from its being largely governed by the intuitions of individual practitioners to its becoming a scientific enterprise. At issue is whether colleges and universities can adapt and evolve but remain essentially unaffected in the way they operate or whether they will be rendered increasingly obsolete by a precision-based model. On this issue my critics and I are aligned on opposing sides of the debate: on one side are those who see change leading to radically different and improved alternatives to the traditional model of education and, on the other, those who believe that innovation should occur within the framework of the conventional practices that define current institutional orthodoxy. To prevent this difference of opinion from becoming an entrenched ideological divide it is important that we differentiate between sound and specious arguments and agree to embrace the former and eschew the latter. Hopefully the exchange of views in this paper and the commentaries to which it responds will serve to delineate and clarify the issues that are relevant to understanding the impact of disruptive innovation on the future of brick and mortar institutions.

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