

# Teaching and Learning as Interdisciplinary Communication

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## *Abstract*

*This article defines learning as the gap between current and required knowledge and teaching as the process of designing and implementing interventions to reduce that gap. It then lists principles for good learning to occur. These principles require that interventions be designed with multiple disciplines in mind so that the student is able, capable, and willing to learn the intended subject matter. It then lists the constraints to applying these principles in the lecture, online, and blended modalities. It concludes by defining a rigorous teaching process as one that follows the principles of continual improvement as defined by Deming's PDSA cycle.*

## **1. Introduction**

Substantial literature exists about teaching and learning. Most of us are associated with institutions of higher learning and hence may consider ourselves experts on the topic. However, during 2020 the global COVID-19 pandemic which impacted over 1.2 billion students in 186 countries (Suprenant, 2020), teaching had to be reinvented from a teacher-student interface to a student-technology interface. Emerging research indicates that the impact on learning was, in some cases, counter intuitive. Whereas it was expected that student engagement and learning would be negatively impacted, the opposite was true in some cases. This may be attributed to the ongoing advances in hardware, software, telecommunications systems, instructional systems, instructional design models, curricular systems, and academic management systems that have and are profoundly affecting education (Saba & Shearer, 2016).

The pandemic gave teachers and students no choice but to implement remote learning. The knowledge and experience gained with various modalities of remote learning are assets that could be deepened and deployed in the future, creating blended modalities of teaching and learning, also in service of a greater personalization of education, and to extend learning time and learning opportunities for all students. It will be important that the lessons learned from this real-life experience are systematically collected and evaluated, and that education systems and schools investigate ways through which innovative teaching and learning environments can be more fully integrated into schooling (Reimers et al., 2020).

For the reinvention of teaching from a teacher-student interface to a student-technology interface to be successful, teachers must abandon their traditional role of being the provider of information to a class and must assume the role of a learning facilitator to students. Students have, among other things, different backgrounds, different socio-economic status, and different learning styles and the teacher's job is to assure that all students learn. To make this happen, teachers must have knowledge of many disciplines which must be integrated to fully engage students with their learning environment. The objective of this paper is to posit teaching and learning as interdisciplinary communication and to examine how such a learning environment can be forged into a rigorous teaching process.

To achieve this objective, an operational definition of teaching and learning will be provided. A description of learning principles pertinent to the COVID-19 era and beyond will be developed. These principles cross disciplinary lines and their application requires interdisciplinary integration of knowledge that creates the physical and emotional ability together with the motivation for the student to learn the disciplinary material. The constraints of applying these principles in the more prevalent educational modalities (lecture, online, and blended) will be presented. The paper will conclude by defining rigor in teaching and learning.

## 2. Teaching ≠ Learning

While these two terms are inseparable, they are NOT the same. Learning consists of closing the gap between current knowledge and desired (or, required) learning outcome. Teaching is a deliberate *process* designed to close the learning gap. The teacher is responsible for managing the teaching process. Figure 1, adapted from Kaufman and Guerra (2013), depicts these relationships. Note that a Learning Need is a *noun*. It states in measurable terms where we are, knowledge wise, and where we want to be. It is not a verb, which would imply action. It is the end that we want to achieve through the teaching process, managed by a teacher.

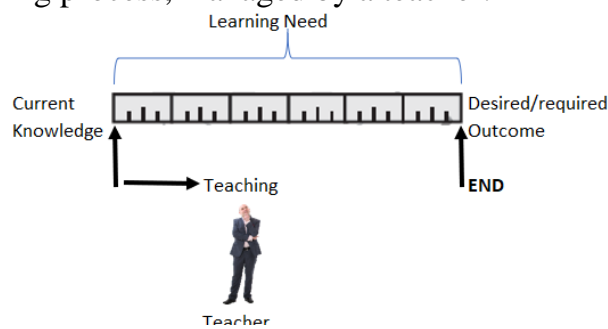


Figure 1: Relationship between teaching, learning, and teacher

Several authors (Swart, 2017; Smith, 2018; Buus, 2020) have defined teaching as a process. Figure 1 leads to defining teaching as the continual process of *identifying* people’s current knowledge and incorporating their needs, experiences and feelings to *create and implement interventions* to close the learning gap and thus help them to achieve their desired end. The process is illustrated in figure 2.

This definition of teaching places the teacher in a role akin to a physician. As a physician must diagnose a patient’s barriers to good health and prescribe a cure, so must a teacher identify the barriers that a student is encountering to being fully engaged with their learning environment and prescribe interventions that will overcome those barriers.

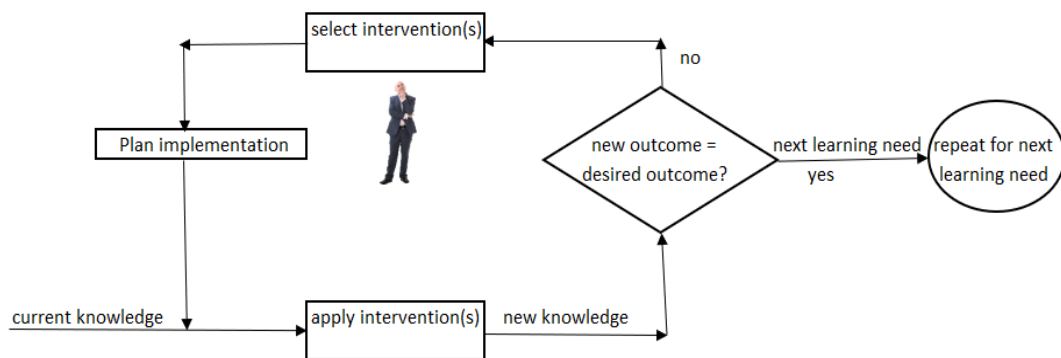


Figure 2: The teaching process

### 3. Creating Interventions Through Multidisciplinary Communication

The COVID-19 pandemic awakened the enormous potential for innovation which has lain dormant in educational systems. It has made it apparent that there are clear benefits to students in expanding their learning time and learning opportunities beyond the walls of the school through distance and blended learning. Access to technology can eliminate distance as a barrier. Online and blended learning will help to adapt learning to individual needs which will facilitate them to acquire essential 21st century competencies such as collaboration, communication, independent research, and higher order cognitive skills. The momentum created by the strategies of education continuity during the pandemic should be sustained and advanced so education will continue to be relevant to the needs of the 21st century (Reimers et al., 2020).

The above emphasizes means – e.g. the use of technology – but it does not address the ends, which are achieving the learning of 21<sup>st</sup> century competencies. The OECD, through its Innovative Learning Environments Project (Dummont et al., 2012) has explored the nature of learning through the perspectives of multiple disciplines including cognition, emotion, and

biology. The research resulted in “The 7 principles of learning.” These included:

1. Learners at the center: Encourage *active engagement* with their learning environment.
2. Learning is social in nature: Encourage *collaboration* because they push learners of all abilities.
3. Emotions are integral to learning: Use emotions to create *motivation* to learn effectively.
4. Recognizing individual difference: Adapt interventions to the *personal learning* characteristics of the individual.
5. Stretching students: Use *scaffolding* and recognize that high-achieving students can help lower achieving students.
6. Assessment of learning: There must be clarity in expectations. Assessment strategies must be consistent with expectations. There should be a strong emphasis on *formative assessment*.
7. Building horizontal connections: It is important for learners to see the connections between formal learning and the wider environment and society. This may be achieved by *developing higher order cognitive skills* through a complex, meaningful project that requires sustained engagement, collaboration, research, management of resources, and the development of an ambitious product

All these principles plus disciplinary knowledge must be blended in a learning environment and are non-substitutable. If one of them is absent, it cannot be substituted by a greater emphasis on the one of the others. They are all needed. Thus, the challenge of the teacher is to integrate multiple disciplines to develop interventions that will close the learning gap

Smith (2018) encapsulated many of the above principles in his discussion of teaching as a process. However, he recognized the importance of recognizing and cultivating teachable moments. When the timing is right, the ability to learn a particular task will be possible. Unless the timing is right, learning will not occur. This principle was referred to as Just-in-Time Learning by Bolton (1999) and was successfully used in flipped learning by Swart (2017).

The ultimate purpose of any intervention is the learning of disciplinary subject matter. But what appears to count most is how this is conveyed. Sometimes, subject matter expertise can get in the way by emphasizing the gap in knowledge between the student and teacher (how many time have we not heard a student say “I am sure so and so is brilliant, but they can’t teach?”). Figure 3 indicates the conceptual importance between *what* is said (disciplinary knowledge) and *how* it is said (multi-disciplinary knowledge). While teaching is interdisciplinary communication, the more advanced the studies, the more important disciplinary knowledge becomes.

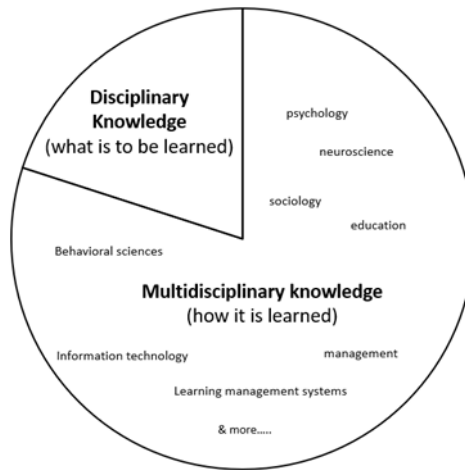


Figure 3: Disciplinary vs multi-disciplinary communication for effective learning

#### 4. Constrained Intervention

The job of the teacher is to create and implement interventions that employ the principles of learning to close the learning gap. However, implementing such interventions are constrained by educational modality: On-Campus, online, or hybrid. In this section we will examine each modality in terms of the constraints it imposes on the implementation of the principles of learning.

##### 4.1 On-Campus Lecture Courses

This educational modality is most often associated with the popular conception of teaching and has endured over the centuries. Figure 4 shows a painting of a university lecture class in the year 1233. Lectures were a necessary vehicle for conveying information due to the cost and time to produce a book and the inability to copy books, except manually. Thus, individuals who possessed a book would read (e.g. lecture) the book to an audience. As depicted in the encircled areas, not the entire audience was engaged with what was happening at the lectern.

After the invention of the printing press in the mid 1400's, books became more common place and by the mid 1700's were so common that Dr. Samuel Johnson (1709 – 1784) remarked "People have now-a-days got a strange opinion that everything should be taught by lectures. Now, I cannot see that lectures can do so much as reading the books from which the lectures are taken. I know nothing that can be best taught by lectures, except where experiments are to be shewn."

Despite Dr. Johnson's remark, lectures continued to be the educational modality of choice for universities until today, as shown in Figure 5 with little change in student engagement.



Henry of Germany delivering a lecture to the University of Bologna, 1233.

Figure 4: A university lecture in 1233



Figure 5: A contemporary lecture

Friesen (2014) provides a modern perspective on Dr. Johnson's remark. The lecture transforms the artefact of the text into an event – an event in which the text is brought into conversational relationship with the audience and with the present. Given ongoing developments in multimedia technologies, the future bodes well for the illusion that we know of as the lecture. The dynamic and multimedial mix provided by the Web presents many possibilities for the lecture that can confirm its current – and longstanding – function of creating a living present for conversation. It does so not only by capturing the lecturer as performer and animator in audio and video, but also by providing new and varied ways of inserting this performance into a living present.

Capturing the lecturer in audio and video and watching it when the knowledge it contains is required (or desired) is a vastly different proposition than watching a live lecture in a scheduled class where attendance may be required as was reported in an article in BBC NEWS (Pickles, 2016) asking “Shouldn’t lectures be obsolete by now?” They confirmed what Figures 4 and 5 show, namely attention deficit. Research showed that students remember as little as 10% of their lecture just days afterward. They also indicated that a Harvard study in 2014 found that, on average, attendance at lectures falls from 79% at the start of the term to 43% at the end.

If we examine how the 8 Learning Principles (Just-in Time Learning included) apply to on-campus lecture courses, we see that lectures are simply not designed for applying the principles. Everyone comes to class, hears the same lecture, regardless of familiarity with the material and, at best, asks a question or two. The material may not be needed until an assignment is due or until a quiz or exam. Hence, the likelihood is that learning will not take place until lecture notes are reviewed and or the text is read close to the due date. Active learning and collaboration are antonyms to listen to a lecture – they just do not happen during a lecture, although a group project may have been assigned. Since everyone is in class listening to the same material, creating just-in time learning moments for individuals is not feasible. Accounting for individual differences cannot be considered. Scaffolding, or stretch learning can take place, but only by the class and not the individuals. What is a stretch to learn for some is easy for others. However, a good lecturer can motivate students in a class.

## **4.2 Purely Online Courses**

Purely online courses can be lecture courses that are transmitted in real time to remote sites via the internet using conferencing technologies such as Zoom or WebEx. They can also be courses that consist entirely of online elements that facilitate the three critical student interactions: with content, with the instructor, and with other students (Sener, 2015).

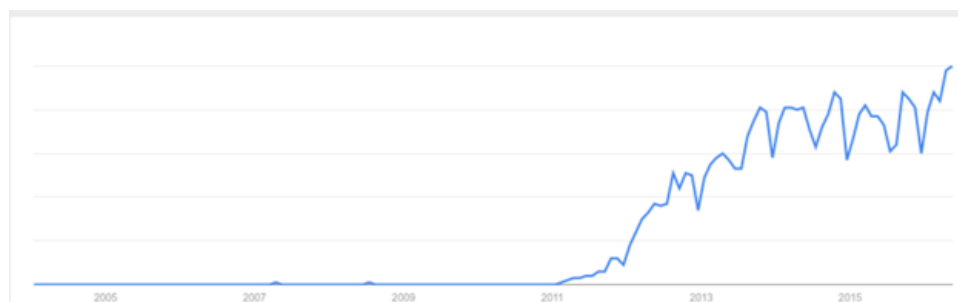
In the former, the lecture is communicated to a remote location and communication with the instructor or other students takes place virtually. The class is focused on the information the instructor provides and, very much like a live lecture, opportunities for active learning, collaboration and Just-in-Time learning are limited. Accounting for individual differences in learner backgrounds, when providing the lecture, is difficult, if not impossible.

For entirely online courses that consist of elements that facilitate student interactions with content, instructor, and other students, the instructor has flexibility on designing interventions that address the principles of learning.

This flexibility is much greater in online courses than in lecture courses. Lectures can be recorded and, together with reading assignments, placed on the web for students to access at *their* convenience. Classes can be organized in teams so students can collaborate virtually as they experience problem-based learning. Students can help each other to reach stretch goals as the scaffold their learning, and the instructor can be available to provide coaching and consulting and uncover “teachable moments” to implement Just-in-Time learning. Swart and MacLeod (2020) present details on how to implement these concepts in online courses and show that student outcomes for such classes are superior to those achieved in lecture classes Swart & Wuensch (2017).

### 4.3 Blended (Flipped) Courses

Blended courses require some activity online as well as some in a classroom. There are many interpretations and variations of this modality. This section focuses on the flipped classroom (or “Flipped Learning”). It is a particular form of blended learning that is receiving increased interest as judged by the number of headlines containing “Flipped Learning” in their title (Figure 6) as well as by the explosive market capitalization of companies providing services, hardware, and software to serve the flipped classroom market (Figure 7). In a flipped class, lectures are placed on the web and are assigned for viewing, together with any reading assignments, as homework *before* class. During class, students engage in interactive group learning through the collaborative solution of a problem that requires knowledge of the lecture and reading materials. Thus, the role of homework and lectures are flipped. The role of the instructor becomes that of a learning coach and consultant. During class, students can give or receive help from their team. The instructor can coach the team or consult with individual team members to provide motivation and/or Just-in-Time learning that will help them to successfully complete their problem. Achievement of learning objectives can be assessed at the end of each class or series of classes. Problems at the end of class can build on each other so that students can learn to develop their higher-level cognitive skills through scaffolding.



**Figure 6.** Growth of Interest in flipped learning  
(<http://flglobal.org.research>)



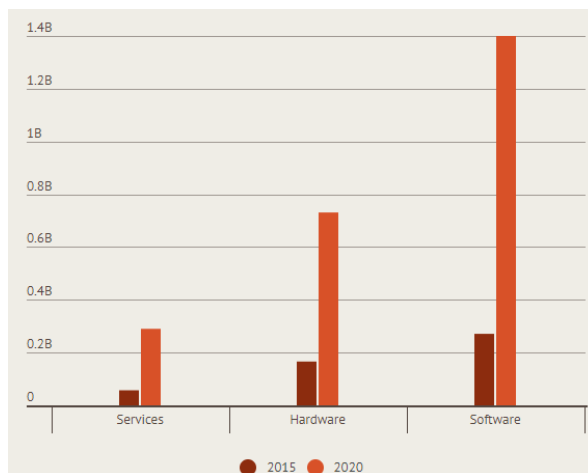


Figure 7: Flipped learning Market Valuation (USD) 2015-2020 (<http://flglobal.org.research>)

The flipped classroom, as well as online, consist entirely of online elements that facilitate the three critical student interactions: with content, with the instructor, and with other students. This provides the teacher with opportunities to use their interdisciplinary knowledge to design interventions that will implement the learning principles in their classes with the caveat that the instructional modality will place constraints that limit the extent to which the principles can be implemented. This process is shown in Figure 8.

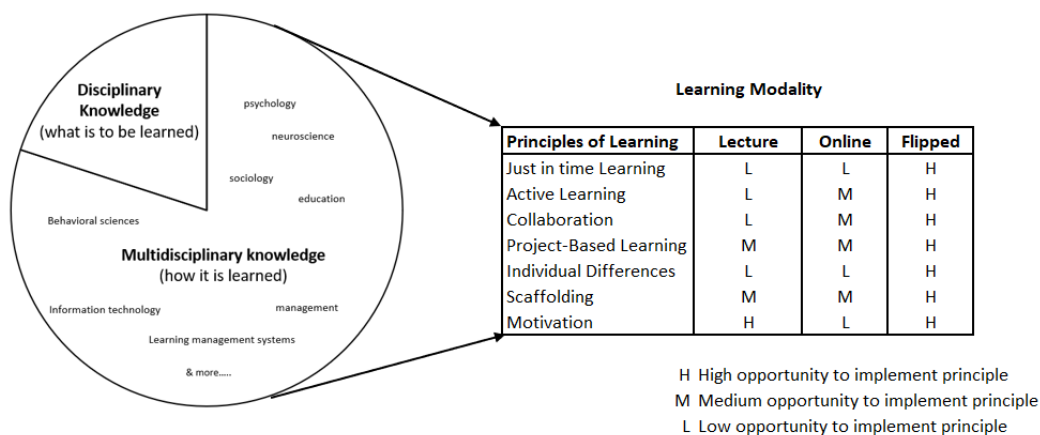


Figure 8: Harnessing knowledge to implement learning principles teaching

## 5. Rigor in Inter-Disciplinary Communication: Teaching and Learning

Teaching was illustrated in Figure 2 as a process of selecting interventions to reduce the learning gap. The interventions consisted of the instructor incorporating knowledge from multiple fields including cognition, emotion, and biology to eliminate barriers to student full engagement with their learning environment and hence facilitate their learning of the course

subject material. Doing this term after term is a process that will consistently produce similar results. However, as custodians of higher education, it is our responsibility to provide the best classes we can, not only once, but continually. To achieve this, a rigorous system of continual improvement must be built into the teaching process.

A rigorous teaching process will follow Deming's PDSA cycle (Bounds et al., 1994). This cycle applied to the teaching process is shown in Figure 9. It consists of four steps:

- **Plan** (develop the syllabus).
- **Do** (teach the course according to the syllabus).
- **Study** (obtain and study the results).
- **Act** (identify, based on the results of the Study step, what changes you are going to make to the syllabus).

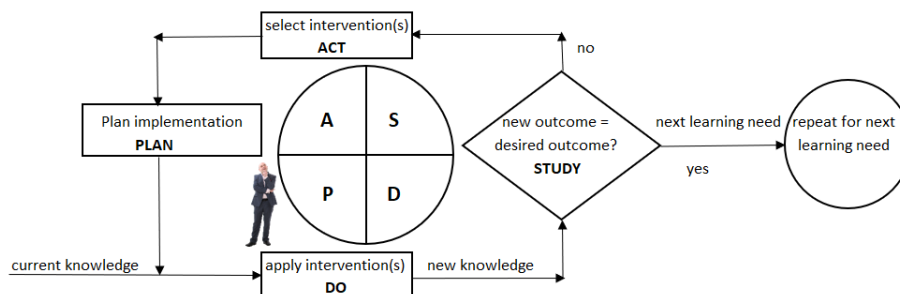


Figure 9: A rigorous teaching process

A key element in the application of the PDSA cycle is that a process cannot be improved unless it can be measured. Measurement takes place in the STUDY part of the PDSA cycle. Perhaps the most important and, perhaps controversial, aspect in education is what to measure.

Many might argue, as do accrediting agencies such as AACSB and ABET, that technical quality – what service has been provided – should be measured. Technical quality is referred to as Assurance of Learning (AoL) and it consists of measuring grades that students achieve. While this is undeniably important, from a process improvement point of view it is important to measure *how* the results were achieved. Only by changing the “hows” will outcomes change (i.e. Insanity is doing the same thing over and over and expecting different results).

The teacher achieved results not by merely communicating the required disciplinary knowledge, but also by using interdisciplinary knowledge to eliminate barriers that students encounter that prevents them from being fully engaged with their learning environment. These barriers can be thought of as distances, not in physical terms, but in transactional terms. The Theory of Transactional Distance was first developed by Michael G.

Moore (1993) and operationalized by Zhang (2003) who defined Transactional distance as the cognitive, psychological, social, cultural, behavioral and/or physical distance between learners and the other elements of their learning environment. She (Zhang) developed the Scale of Transactional Distance to measure it. The scale consisted of four dimensions, the transactional distance between: student and student (TDSS), student and content (TDSC), student and teacher (TDST) and student and instructional technology (TDSTECH). This scale was subsequently updated by Paul et al. (2015) and is referred to as the Revised Scale of Transactional Distance (RSTD).

A key property of the scales of transactional distance mentioned above is that the transactional distances are highly correlated with student satisfaction and learning. Thus, in the PDSA process, the teacher can diagnose the source of a barrier to learning to a specific element in one of the transactional distance constructs (**Study**), then apply interdisciplinary knowledge to prescribe an intervention that will alleviate that barrier (**Act**), implement that intervention (**Plan**), teach the course (**Do**), and then measure the resulting impact on student satisfaction and learning (start of the next PDSA cycle). A detailed example of this process for a flipped class is given by Swart (2017) and for an online class by Swart and MacLeod (2020).

## 6. Discussion

This research has looked at teaching and learning with particular emphasis on the COVID-19 era and beyond. The education world was totally unprepared for the disruption caused by the pandemic and had no choice but to do what many students and educators vowed they would never do – namely teach and learn at a distance.

While many cling to the romanticized version of the good old days when teachers were teachers and students were students, research does not support this notion as an ideal model for student learning. Students retain a fraction the information that is disseminated in a lecture and given the opportunity, many choose to not go to class unless compelled to do so under threat of grade reduction or worse. Nevertheless, the non-scholarly literature seems to be perpetuating this notion and the longing for a return to the old normal. Why? Perhaps the answer lies in the higher education reward system that signals to new faculty that their future depends on research productivity. Good student evaluations of teaching are important and the best way to get them is to teach like everyone else and acquiesce to demands for extra credit from students who are not succeeding by the end of the semester (Hall et al., 2012).

This paper has focused on effective learning, not on whether students are learning what is necessary for success in the 21<sup>st</sup> century. While many countries are shifting to a knowledge-based economy in which new knowledge is generated at an exponential rate, university curricula are mired in bureaucracy. A program change typically takes three years to navigate through an approval cycle. Faculty resources are not redeployable – music professors can not be transformed into engineering professors and vice-versa. Hence, while university strategic plans often cite that their objective is to create leaders and/or that they will serve as engines for economic development of the state or region, it is virtually impossible to align those goals with their curricula. This is further complicated by educational systems being organized during the industrial age. In the United States as in Germany (Scholl, 2020) curricular standards stem from the industrial age and specify how many resources and how much time must be spent on creating a product – e.g. how many hours of teaching, exercises, and support are required for producing a university graduate. Funding in most state universities is determined by the number of students that are enrolled in each of its programs. This formula-based approach ignores that students, unlike hard goods, have individual abilities, capabilities, and motivations and can learn best when learning interventions are tailored to their learning styles.

## 7. Conclusions

This paper is focused on learning and on the role of the teacher as a designer of interventions to close the learner gap. These interventions go beyond conveying disciplinary information to students. They involve accounting for individual student ability, capability, and motivation to learn the disciplinary material. Thus, to be effective, the teacher must be able to integrate and synthesize material from multiple disciplines to be effective and efficient in accomplishing the disciplinary learning goals of the course. To be continually effective, teachers must engage in a rigorous teaching process that systematically measures and improves their ability to find interventions to close the learning gap.

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