CHALLENGES TO IMPLEMENTING SCIENTIFIC TEACHING IN SOUTH KOREA

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ABSTRACT

The idea that giving lectures is not the best mode of teaching has been an established premise for over twenty years in STEM education in the US. With this understanding in hand, American STEM education has undergone a profound shift in emphasis away from traditional lecture formats to more hands-on approaches that strive to maximize feedback for students while simultaneously emphasizing skill development. Scientific teaching and active learning have been two of the most successful platforms to emerge in this effort. Despite having important advantages that have been demonstrated empirically in contemporary education research literature, the adoption of scientific teaching and active learning on a wider scale has been slow, even in the US, where the National Academy of Sciences and the Howard Hughes Medical Institute (HHMI) have been very active in promoting their use. This article reviews the advantages of the two systems as well as some of the challenges to their implementation on an institutional scale. Some of the known solutions to these challenges are discussed, culminating in a review of recent literature on South Korean classroom culture. With this review as a base, we offer a short commentary on what might need to be done to nurture a greater dissemination of scientific teaching and active learning in South Korea.

Keywords: STEM education, South Korea, education policy, scientific teaching, active learning.

SCIENTIFIC TEACHING

The idea that giving lectures is not the best mode of teaching has been an established premise for over twenty years in STEM education. Donald Bligh's work in the 1980s and 1990s is often credited with having established this fact (Bligh, 1998; Bligh, 1985). Not surprisingly, these early findings were greeted by some with skepticism (Wilson and Korn, 2007; Matheson, 2008). Subsequent work by a number of other research groups has nevertheless confirmed the fact (Armbruster, Patel, Johnson, & Weiss, 2009; McCarthy & Anderson, 2000; Niemi, 2002). This lack of effectiveness has been demonstrated in both knowledge learning (Powell, 2003; Laws, 1991; Sivan, Leung, Woon, & Kember, 2000) and, more importantly, in skill learning (Hake, 2001; Handelsman, Houser & Kriegel, 1997; Pukkila, 2004). For STEM training, the latter result becomes especially important because lab and science process competence are usually the two most desired educational outcomes in university programs (Roth & Roychoudhury, 2003; Harlen, 1999; Padilla, 1990).

With this understanding in hand, STEM education in the US, particularly at the university level, has undergone a profound shift in emphasis away from traditional lecture formats to more hands-on approaches that strive to maximize feedback for students while simultaneously emphasizing skill development (Alfieri, Brooks, Aldrich & Tenenbaum, 2011; Hofstein & Lunetta, 2004). The centerpiece of these efforts has been the idea of scientific teaching, a concept coined in the 2004 *Science* paper by Jo Handelsman and colleagues (Handelsman et al, 2004). This work essentially defined the concept of scientific teaching as the process in which learning is treated like a scientific subject: examined using carefully designed experiments that give quantifiable and statistically significant data about student outcomes (Miller, Pfund, Pribbenow & Handelsman, 2008).

Since 2004, scientific teaching has been applied to examine a wide array of educational considerations (Ebert-May & Hodder, 2008; Pfund, 2009). The effectiveness of inquiry-based learning has been a particularly successful avenue of development (Quitadamo, Faiola, Johnson, & Kurtz, 2008; Reynolds & Caperton, 2011), as has the uncovering of the advantages of learning through group discussion (Osborne, 2010; Millis, 2010; Ferreri & O'Connor, 2013). The use of technology in the classroom, particularly as concerns personal feedback systems (Hoffman & Goodwin, 2006; Gauci, Dantas, Williams, & Kemm, 2009; Pierce & Fox, 2012) and the development of better techniques for teaching primary literature (Hoskins, Lopatto, & Stevens, 2011; Kozeracki, Carey, Colicelli, & Levis-Fitzgerald, 2006) have been some of many important advances in STEM education. In recent years, the lessons from these works have been applied in combination to achieve a number of very significant improvements in learning gains and student outcome (Freeman et al, 2004; Labov, Reid, & Yamamoto, 2010; Udovic et al, 2002).

ACTIVE LEARNING

As the many discoveries through scientific teaching have been combined into new strategies and curricula, a particularly powerful approach for STEM education has emerged, an approach called active learning (Petress, 2008; Machemer & Crawford, 2007). At its base, active learning is a system that attempts to maximize feedback and students interactions with both student peers and instructors (Bot, Gossiaux, Rauch, & Tabiou, 2005). To achieve this goal, active learning involves a fundamental redesign of the activities that occur in and out of the classroom (Ebert-May, Brewer, & Allred, 1997; Taraban et al, 2007). The bulk of this is accomplished by "reverse design" or "flipping the classroom" (Jensen, Kummer, & Godoy, 2015; Stone, 2012; Bishop, & Verleger, 2013).

Traditional, lecture-oriented STEM education takes place with in-class activities dominated by lectures and out-of-class activities dominated by problems sets. These problem sets usually ask students to apply the things they learn in lecture. The main issue with this format is that the average retention of lecture material by students is quite low, with very few remembering more than five to ten percent of what they are exposed to (Bligh, 1998; Armbruster, Patel, Johnson, & Weiss, 2009; Bligh, 1985). Not only does this severally impair the effectiveness and efficiency of learning, it also imposes immense pressure on students to make up for their lack of understanding by studying outside of class with little guidance from instructors. In STEM fields, this pressure is compounded by the problem sets, which force students to learn the required base knowledge and problem solving strategies on their own (Milman, 2012; Roehl, Reddy, & Shannon, 2013).

In active learning, reverse design and flipped classrooms invert the orientation of traditional lecture classes so knowledge delivery now occurs outside of class time through readings or online lectures while problem-solving becomes the main in-class activity (Abeysekera & Dawson, 2015; Tune, Sturek, & Basile, 2013). This format offers many important advantages uncovered by research conducted through scientific teaching. The first advantage is the fact that in-class problem-solving allows for much more cooperative learning and enhanced feedback for students, both from instructors and student peers, increasing the range and efficiency with which the students learn (Auster & Wylie, 2006; Armbruster et al, 2009). Another important advantage is the reoriented focus of the class on skill development. Since the ability to apply and utilize science knowledge is often the ultimate goal of STEM education, this reorientation is a natural refocus that brings greater instructor supervision over more important learning outcomes.

The adoption of active learning has been shown to result in wide-spread improvements in student outcome across STEM fields. The most impressive improvements have been observed in learning gains (Haak, HilleRisLambers, Pitre, & Freeman, 2011; Freeman et al, 2011) and student grades (Yoder, & Hochevar, 2005; Armbruster et al, 2009). Higher student retention in STEM majors (Braxton, Jones, Hirschy, & Hartley, 2008; Crosling, Thomas, & Heagney, 2008) and increased interest in STEM subjects (Smith et al, 2009; Martyn, 2007) are also two very important advantages of active learning. Since active learning usually takes the form of problem solving activities with other students, the level of engagement is significantly better than a lecture (Petress, 2008; Machemer & Crawford, 2007).

CHALLENGES TO IMPLEMENTATION

Although the advantages of both scientific teaching and active learning have been well demonstrated in empirical terms, the adoption of these methods on a wider scale has been slow, even in the US (Anderson et al, 2011). Awareness has been the first significant barrier (Niemi, 2002). In the US, the National Academy of Sciences and the Howard Hughes Medical Institute (HHMI) have been the two most prominent institutions pushing for the adoption of these new systems. HHMI has spent hundreds of millions of dollars in the last two decades to spread awareness, train instructors, and develop educational programs founded on the principles of scientific teaching and active learning. The most ambitious, and perhaps most successful, of these has been the establishment of the “Summer Institutes on Scientific Teaching”, an annual circuit of regional conferences designed to train university faculty on the principles and application of scientific teaching and active learning (Pfund et al, 2009).

Another significant barrier has been skepticism. For the vast majority of STEM faculty, lectures have been the mainstay of their own teaching and learning experiences. Most of these faculty have seldom been exposed to the possibility of alternative teaching methods, resulting in a deeply embedded reluctance and suspicion of non-lecture techniques. Since active learning and scientific teaching systems tend to require more work to set up than a series of lectures, this added effort also can function as a deterrent. It has been observed in a variety of contexts that younger instructors, such as postdoctoral fellows or graduate students, are less reluctant to try new teaching methods than older peers but the targeting of these younger individuals for systematic reform has generally required training and support on an institutional level since the preparation and implementation of properly designed scientific teaching and active learning systems does require significant guidance and feedback (Wieman, 2007). Despite the large investments by HHMI, the truth remains that the majority of STEM instructors in the US, higher education and otherwise, are still unaware of the important advantages of scientific teaching and active learning.

The issue of reluctance in adopting new teaching methods is exacerbated at research universities because of the way new faculty are recruited. By and large, new faculty at research universities are recruited and compensated based on research achievements. This trend often leaves pedagogical skill and experience as a secondary consideration in the hiring process (Bush et al, 2006). This is despite the fact that the majority of faculty salaries are still paid through money derived from student tuition, money which students pay for teaching. Even after being hired, the majority of promotions and monetary rewards that faculty receive derive from research accomplishments. Cognizant of this issue, HHMI has targeted a large number of resources to incentivize education reform through the adoption of scientific teaching and active learning systems (Prince, Felder, & Brent, 2007), efforts which remain ongoing.

One of the angles that HHMI has targeted with great success in promoting education reform has been graduate student and postdoctoral training (Boyle & Boice, 1998; Nerad, 2004). Both of these training processes have traditionally focused entirely on research outcome, with the goal being the publication of high impact articles in SCI journals. A typical PhD program does, of course, have teaching requirements for graduate students but these requirements are seldom implemented with a curriculum or organized effort to indoctrinate specific teaching techniques. It is in this space that HHMI and other institutions have begun implementing training infrastructure for disseminating scientific teaching and active learning principles. In many respects, this is a “roots up” culture-change approach that aims to expose future faculty to the importance of alternative teaching methods (Austin & McDaniels, 2006).

Another successful angle for implementing more scientific teaching and active learning has arisen through the establishment of teaching faculty rosters. The University of Minnesota, Twin Cities, has been one of the institutions at the forefront of this effort, creating a roster of teaching professors trained specifically in empirically verified methods (Teaching Assistant Professor: Biology Teaching and Learning, n.d.). These faculty are tasked with designing and implementing courses, usually at the introductory level, to spur wider culture change at the institutional level by exposing students early to more enjoyable and more effective learning environments. Through these implementations, it is hoped the students themselves will apply pressure through heightened expectations for more education reform in upper level courses. This approach showcases the importance of student feedback and involvement in driving institutional reform (Bowles & Gintis, 2011).

Through HHMI funding, the University of Minnesota, Twin Cities, has established training programs for postdoctoral associates to participate in the introductory courses run by teaching professors. Under the guidance of the teaching professors, postdoctoral associates receive training in scientific teaching theory and active learning design, allowing them to experience a more hands-on approach to the adoption of alternative teaching methods. In many respects, this hands-on experience directly mirrors one of the important goals of active learning: to provide more practice in applying concepts and skills (Labov, 2004). At Fudan University, our BIOS program (BIOS program, n.d.) also implements similar training for graduate students, who work alongside peers and faculty already trained in the use and proper application of scientific teaching and active learning systems. These class environments, therefore, not only function as learning centers for students but also training centers for instructors.

THE KOREAN CONTEXT

Considering the global education landscape, the lack of awareness of scientific teaching and active learning is even more pronounced outside of the US. In Europe, no centralized authority we are aware of has yet joined the cause as an agent of change like HHMI. This absence results in a general lack of support and funding, perpetuating the lack of awareness. Although some basic concepts about active learning, such as flipped classrooms and personal response systems, have begun appearing in some European countries, the vast majority of education research literature remains predominantly of US origin, leaving much opportunity for improvement.

The Asian context is nearly identical to the European one. Although many East Asian countries such as China, Japan, and South Korea tend to share a strongly favorable reputation for competence in science, these countries also exhibit very little awareness of scientific teaching and active learning. Much like in Europe, some basic awareness of reverse design and personal response systems exists and even appears sporadically in education reform literature. However, the major issue with the implementation of these concepts in Asia has been a near total lack of understanding of how these implementations work and a lack of appreciation for the sophistication involved in their proper application. This lack of understanding usually originates from a fundamental misunderstanding of the basic principles of scientific teaching and active learning.

In the specific case of South Korea, the overall absence of a centralized authority supporting and advocating for scientific teaching and active learning training is exacerbated by certain aspects of Korean classroom culture. In many ways, the structure of modern Korean education, particularly higher education, is decidedly western in its design (Sung & Lee, 2017). The interactions that take place in the classroom, however, are decidedly Confucian (Shin, 2012). At base, these interactions are characterized by two main considerations: high levels of instructor authority and high levels of student obedience. Nonverbal immediacy is one of the characteristics that can be used to quantify these aspects of interaction, with Korean instructors known to exhibit significantly lower levels than US peers (Park, Lee, Yun, & Kim, 2009). Despite the fact that higher levels of nonverbal immediacy have been shown to correlate with higher student satisfaction in a variety of different contexts (Pogue & AhYun, 2006; Zhang, 2006; Jaasma & Koper, 1999), the powerful expectations of Confucian class culture pervade even today, raising the question of whether such prevalence needs to be addressed.

Recent work has suggested that foreign faculty residing in Korea tend not to adopt the local Confucian classroom culture, even when teaching in Korea for extensive periods of time (Ghazarian & Youhne, 2015). Important differences between Confucian and western classroom culture can be reaffirmed in a very recent study examining the mannerisms of Korean and Dutch teachers (van de Grift, Chun, Maulana, Lee, & Helms-Lorenz, 2017). This work concluded that Dutch instructors were better at “creating safe and stimulating” learning environments while Korean instructors were better at “teaching learning strategies”. This latter conclusion is consistent with the idea that Korean instructors not only teach content but also dictate the methods with which students are expected to learn (Shin, 2012), reaffirming instructor authority.

Despite their high levels of authority, Korean instructors have recently been shown to suffer from “protective vulnerability” (Song, 2016). This vulnerability is defined by the expectation that any teacher must be a master of their subject. This expectation creates a strong cultural pressure that can shame the instructor for not knowing something in their area of expertise. Recent work has shown how this pressure can sometimes generate classroom environments where student questions and creativity are discouraged because they could challenge the limitations of instructor knowledge, potentially prompting embarrassment and shame (Song, 2016). The discouraging of student questions and creativity appears to take place in one of two modes. In the active mode, instructors have been observed directly admonishing students for challenging class content they delivered. In the passive mode, an unspoken cultural understanding pervades that makes it impolite for students to challenge what the instructor might be saying, indirectly protecting the instructor's weaknesses (Song, 2016).

From the perspective of disseminating better teaching methods such as scientific teaching and active learning, high levels of instructor authority and high levels of protective vulnerability work against motions for reform. If instructors are accustomed to "always being right" and afraid of admitting there might be other, better teaching techniques they don't know, the Confucian pressures are seriously counterproductive in bringing about better educational outcomes. In fact, we have directly experienced the consequences of these pressures in our own efforts to inform other teachers and faculty about the advantages of scientific teaching and active learning. In these interactions, we have witnessed a range of responses from reluctance to outrage that someone would question the effectiveness of their established teaching techniques, which remain almost entirely lecture-oriented. Therefore, in our estimation, the expanded adoption of active learning and scientific teaching in South Korea will likely require two things: 1) the establishment of some institutional authority to both inform and train and 2) a simultaneous movement to loosen the power of instructor authority so that reform can take place. Only when this power loosens and the voice of students can be heard will more student-centered learning approaches like active learning begin to gain wider acceptance.

CONCLUSIONS

It is interesting to observe how decisive empirical evidence of superior teaching outcomes does not necessarily precipitate adoption of better teaching methods. In fact, the literature we have reviewed would suggest this empirical step is only the first in a long, arduous process of reform. Despite the many challenges mentioned here, we remain optimistic that East Asia is a prime locale for implementing scientific teaching and active learning. Not only does East Asian culture hold education in high regard as a common virtue, the need for countries like South Korea to embrace improvements in STEM education outcome necessitates such reform. As mentioned above, we believe this effort requires an overall change in education culture such that the emphasis of reform becomes student-centered, with the desires and needs of students taking precedent over the cultural authority of instructors. Although this article focuses specifically on the classroom culture of South Korea, we believe many of the trends likely also apply to other countries in the region such as China and Japan.

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