

**Educational (dis)continuities:  
coordinating physics instruction in pre-college and university**

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This paper examines the structural and ideological challenges of coordinating high school and university physics instruction. I present the results of an experimental study to offer a university level physics class in a local high school. The following paper documents student success and how student achievement is bound to a broader framework -- the coordination among different institutional partners, and reconciliation of their differing cultural norms.

## **Introduction:**

In the United States over the past century, both the need for a college degree and access to institutions that provide them have increased dramatically. However, while the education system has expanded significantly, it is not clear that we best access this potential for educating students. In fact, my experiences of teaching physics both at the university and in high school suggest that the discontinuities between these educational systems serve to filter out students from higher education generally and from the sciences in particular. The situation appears to be yet worse for those students from under-represented populations.

A recently study from the Stanford University Bridge Project details the problem of educational discontinuity between high school and higher education [1]. An overwhelming proportion (88%) of eighth grade students expect to attend some form of higher education. Indeed, 70% of students who graduate high school make it to some form of college within two years of graduating. Despite this promising statistic, students are not adequately prepared for college success. In particular, 40% of students in 4-year institutions and 63% of students in 2-year institutions enroll in remedial courses. While almost half of first year college students attend community college, half of these students do not continue. Over 40% of all students who take more than 10 college credits do not graduate with a two or four year degree. For students of color, the situation is worse. African American students are only half as likely to receive a college degree as their Anglo counterparts, while Latinos are one-third as likely [1].

While most students graduate high school,<sup>1</sup> they generally do not graduate from college. There is an educational gap between high school preparation and college success. The authors of the Bridge Project make several policy recommendations to address this gap [1]. They advocate, "[1] senior-year courses ... linked to postsecondary general education courses [and, 2] expanding successful dual or concurrent enrollment programs between high schools and colleges so that they include all students." Simultaneously, the California Master Plan for Education cites the importance of a bridge between high school and university [2]. In particular, the community college (or two-year college) system plays a critical role by providing "opportunities for high school seniors to enroll concurrently to further strengthen their readiness for college or university enrollment and to accelerate their progress toward earning collegiate certificates or degrees."

What might be learned from attempts to bridge the worlds of high school and college? Here, I present the results of an experiment to study the effects of offering a university level physics class in a high school. While the creation of a successful program includes many different facets, what turned out to be easiest, and most rewarding was improving student mastery of the domain, introductory physics. The following paper examines student success and how student achievement is bound to a broader framework -- the coordination among different institutional partners, and reconciliation of their differing cultural norms. Ultimately, what appears to be significant student achievement is substantively diminished by the surrounding institutional structures and differing expectations of what it means to learn physics. A variety of emergent themes are

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<sup>1</sup> Approximately 90% of students in school graduate from high school [1].

discussed, from structural discontinuity to normative differences in institutional epistemology.

### **The Study:**

The experimental high school course was designed to mimic the University of California's introductory algebra-based physics sequence while simultaneously offering students one semester of community college credit. The class was a three-way partnership between the university (where I was housed), the high school (where the class was taught) and a local community college (which would provide credit and other future courses for the students). Each of the participating institutions had substantive reasons to support the activity. Most notably, the University of California has a guaranteed transfer agreement with the community college system. Students who obtain 60 credit-hours of approved coursework and perform at a high enough level (B or better) are automatically granted admission to the U.C. In many circles this is seen as a mechanism for addressing the anti-affirmative action movement in California. In other circles, transferring is seen to address the California Master Plan for higher education. From the high school perspective, such a class instills a culture of college-going attitude, provides a bridge to the university, and potentially provides a cost-saving educational strategy. The community college benefits from an added population of students and builds on one of its main goals, the transfer of students to the university system.

The class was held at a public charter school located in a large California city. One of the main reasons I ended up at a charter school was that it was one of the few places I would be allowed to teach.<sup>2</sup> The high school itself was diverse in the dictionary sense, a mix of European-American, Hispanic, African-American, and Asian-American students. Students were admitted by lottery after a pre-screening application. The application selected for students who wanted to attend. The school explicitly stated that it was looking for motivated, rather than high performing or prepared students. The school is progressive, project-based, relatively new, and small (approximately 400 students).

The class met three days per week and was comprised of three lectures and one recitation section. We followed a traditional text, and used a hybrid of lecture notes and activities from UC Physics 1 and University of Maryland Physics 121. The recitation sections were largely based on *Tutorials in Physics* [3]. The class began with 38 students (mostly seniors) and ended with 31. Student background varied from those who had taken no physics and had mastered limited amounts of trigonometry to students who had taken an advanced placement physics course and were concurrently enrolled in a college level calculus class.

My explicit goals for the students were far broader than to teach them the basic formulas and procedures. The class was designed to develop student mastery of the traditional content domain (both conceptual and analytic approaches), their epistemological commitments (what it means to know physics), their abilities to reflect on their own

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<sup>2</sup> Ironically, I teach current and future high school teachers, yet I am not certified to teach high school students.

knowledge, and their attitudes about the domain. As such the class emphasized student involvement and started from the basics.

### **Data and Themes:**

Two forms of data were collected: qualitative field-notes and pre-and post-test survey of student mastery of the domain. Within 24 hours of teaching each class, I wrote an account of the day's activities. In the description below, I present a few excerpts from these notes to document this activity and some of the relevant themes that emerge. While these data may be considered subjective, they serve to interpret the meaning of the "more objective" measures of pre- and post- test scores on validated instruments. The notes also capture the norms and surrounding practices that help us interpret why and how this course evolves as it does. While several themes arise through the course this experiment, I highlight a few that shaped my experience and leave us with challenges as we continue to develop educational environments for the future.

First, it became clear to me that my students could learn advanced level material. Since the class paralleled two university courses, I could compare student achievement in this course with students enrolled in the university counterpart. Most notably, for the second of the two course mid-terms, the high school students were issued the same mid-term that the University Maryland course offered the prior year. In addition to using identical exams, the University of Maryland scoring rubric and scales were used. The high school course average on the exam was 68%; the Maryland students averaged 62%. On the pre- and post- survey of student conceptual mastery of the domain, students posted gains of 44% on the Force Concept Inventory [4]. These assessments were corroborated by a myriad of examples from my daily field-notes. On the one hand, students came into the course with the traditional challenges of not knowing the domain, or being ill-prepared mathematically. For example, following our first quiz I note:

Day 8: The quiz poses lots of challenges to the class... I announce that it [will last] 15 minutes and it probably goes on for 25. [On] the first question ...a variety of classic problems showed up for the students. In plotting the position versus time for two different trains (one at constant speed another slowing down), some students take position to be the same as velocity, others interpret  $v=x/t$  instead of  $dx/dt$ . Some people don't know how to express speeding up or slowing down

On the other hand, throughout the class, there were ample opportunities to observe student mastery of the domain:

Day 17: From the outset [of recitation] Marty goes to the board. He is teaching 3 students (Abel and a couple of others) how to solve the [last] problem. They spent 45 mins at the board. By the end, it was covered with diagrams and math. They were very proud of it. He did a great job walking [other] students through his analysis. I stop in at one point to point out that all these equations showed up from one:  $a = -g...$

Day 43: As I was grading the homework I came across a delightful response from one of my students, Larry M. [For] a standard, but complicated problem using Bernoulli's equation, Larry spent a page and half working from the basic equations that I had provided in class. In the end, he gets the right answer,  $v = \sqrt{2gh}$  and recognizes this is the same for free fall. He writes, "OKAY! I now realize this is the same as  $v = \sqrt{2gh}$ . The book says as with Torricelli [a theorem I had not mentioned in class] That if  $P_3 = P_1$  then  $v = \sqrt{2gh}$  and this is really what I [crossing out we] just derived."

In the course, the students and I developed a culture of engagement, responsibility, and inquiry. Efforts such as asking students to vote on of class material to be covered, beginning class with music which simultaneously related to their lives and to the physics we were studying, and working side-by-side with students on physics problems all contributed to the creation of our educational culture.

One may also consider other forms of success within this experiment. University graduate students in physics and education participated in the class and were given the opportunity to learn, observe and teach in a real high school environment. Regular meetings of representatives from the high school, community college, and university began to pave the way for longer-term forms of coordination. Additionally, as originally intended with this experiment, students were given the opportunity to receive college credit for their work.

However, despite coordinating the course outline and syllabus with each of the partnering institutions, students were required to take a challenge exam at the community college if they wanted to receive college credit for their efforts. The exam was created for the students by the faculty of the community college. If students opted to take the challenge exam, they would receive a college course transcript with whatever grade they received on the exam (including D or F). At the end of my course, 19 of the high school students opted to take the exam. The vast majority of these were the top-performing (A and B) students in my class. 15 of the 19 students received grades of C, D, or F on the exam and hence their college transcript. Only one student marked an A.

Three key themes begin to detail why so many students failed, and why it is such a challenge to create sustainable and scalable forms of inter-institutional collaboration.

#### Structural discontinuity:

While considered a success within the confines of the classroom walls, this micro-culture sits within broader, existing worlds to which it was structurally bound. Whether the availability of text books, how many times our class could meet, or aligning university and high school schedules, the surrounding institutional structures framed how this micro-culture could be created. Each partner institution had its own structure that constrained how the class could operate. At times, the differing institutional structures were at odds. Most notably the arrangement of institutional structures required that the high school students had to take a high-stakes exam in order to receive college credit.

### Norms and practices:

These surrounding institutional structures are instantiated in differing norms and practices. For instance, university instructors generally act autonomously, and cover a curriculum of their choosing (bound by history, a text, and loose curriculum guidelines). While high school instructors might be seen in similar fashion, curriculum standards, external assessments and certification constrain the scope of instruction and approach. In a high school environment it is often mandated that external examiners evaluate a class. In the university setting, it is unheard of. Thus, from differing perspectives the high stakes examine may seem appropriate or not.

### Ideology / epistemology:

Least obvious, perhaps, is the critical norm (or epistemological commitment) of what it means to learn physics. However, if the high school, community college, and university were aligned in terms of what it meant to learn physics, many of the structural and normative differences would have disappeared. As evidenced by traditional practices in the high school and community college system, mastery of physics was more closely aligned with mastering procedures, and short, analytical problems that emphasized the manipulation of formulae. As described, the experimental course strived to include a broader framework for such procedural and problem solving strategies, which included synthesis, estimation, reflection, articulation, sense-making, and conceptual mastery. The students' ultimate failure on the community college exam may have reflected this misalignment.

### **Conclusions:**

While it is necessary to couple better secondary and post-secondary education in the United States, fundamental discontinuities that are rooted in the structures, norms, and practices of these institutions must be addressed to improve coordination within the educational system. While high school students are able to achieve high levels of success in a university-level physics course, fundamental discontinuities in participating agencies mute the achievement of the students and seriously hamper efforts to create sustainable and scalable forms of educational collaboration. In the long run, sustained educational reform simultaneously requires restructuring -- both top-down (institutional structures and norms) and bottom-up (educational practices/ cultures).

### **References:**

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