

Using the resources of the student at the urban, comprehensive university to develop an effective instructional environment

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Abstract. Physics Education Researchers have provided instructors with (1) tools to assess student learning, (2) details on the state of student knowledge, and (3) instructional materials and learning environments that have proven to be effective in promoting understanding. Unfortunately, the vast majority of this work has centered on students and instruction at the traditional research university. As instructors begin to implement innovative instructional materials, and as researchers begin to investigate student learning with diverse populations, complex differences emerge. The use of traditional PER tools in non-traditional environments, such as the urban, comprehensive university, often leads to a very narrow picture of student development. Often, this limited view highlights deficiencies in learning and fails to reveal the strengths and resources of this population. In this paper we highlight issues we face with some of the traditional research tools and provide evidence for the resources we have found with our population of students.

Keywords: collaboration, scientific community, student resources, group work, inquiry, Physics Education Research.

PACS: 01.40.Fk, 01.40.G-

INTRODUCTION

Members of the Physics Program at Chicago State University (CSU) have been involved in reforming the introductory physics course to better serve the needs of the student at the urban, comprehensive university. The project takes an integrated approach to curriculum reform that involves research into student learning, implementation of model instructional materials, strong collaboration between the faculty and students in physics at CSU, and strong collaborations with colleagues at diverse institutions throughout the United States. In this paper, we describe and provide evidence for the particular student resources we have identified as a result of this project.

Although the bulk of the work has been focused on the physics courses at CSU, we are now beginning to work with area community colleges. This project has helped create a learning community that builds on ideas from the faculty, the undergraduate researchers who focus on student learning, and the students enrolled in our classes. We discuss and provide evidence for three specific resources we have found in our students. Specifically, (1) a receptiveness to the inquiry style of instruction, (2) a willingness to be part of a scientific community (3) a robust content

understanding that is often hidden and challenging to assess.

We believe that the presence of these resources may be a function of our student population. CSU is a public, comprehensive, urban institution located on the far south side of Chicago. Demographically, 85% of the undergraduate students identify as Black, 7% Hispanic, 3% White, and 5% other.

The research methods we use to identify these resources include diagnostic tests and open-ended questions, one-on-one interviews with students and videotaping of classroom interactions. Because we have found evidence for the resources, described above, with students at many stages in our program we do not provide detail regarding the context in which the questions were asked.

RECEPTIVENESS TOWARD THE INQUIRY STYLE OF INSTRUCTION

Students at our university generally accept the tools and methods of reform-based physics instruction. Students engage in peer discussion very easily and often welcome questions from the instructor and typically offer little resistance to this instructional approach. In addition, students appreciate the instructional approach of elicit, confront, resolve and

feel that this approach aids them in understanding the material. These resources align extremely well with much of the reformed instruction, making the urban, comprehensive classroom a fertile environment for implementing these reform efforts.

Evidence for student receptiveness in this type of learning environment comes from observations in the classroom and also from interviews conducted with students. The following quote illustrates what we believe many of our students feel about the use of questions in the physics course.

I think [the questioning used in the class] did a good job ... it wasn't easy ... but it was good in the end. ... I was so frustrated. ... I didn't like that every time we had questions it seemed like you would not answer them ... just give me the answer - is what I'm doing wrong or right? Because that's how you're used to it working. ... It took me a couple of ... labs to get used to that. ... It was still frustrating but it was good - because I had to do it and I knew I had to do it. If you had given a little bit ... I probably wouldn't be able to think through some of the things I think through now. ... It's still hard. ... How do you start? How do you prompt yourself? ... I know it when you [the instructor] are around. How do I know it when you are around and I don't know it? But I had to think - Okay, just as easily as he's coming over - and you kinda know what he is going to say - you can ask yourself the same question - and start the process yourself. ... It was good that you were doing it - but in a way I was depending on you. ... It was a little crutch. ... But it caught on.

Although this student states that the questioning method was frustrating, she recognizes that this approach was important in helping her learn the material. This student also states that she was able to develop more independence as a result of this instructional approach. This issue of confidence and independence came up often in the classroom and during the interviews. Another student commented on how this style of instruction builds confidence.

“... When we'd get stuck ... he [the instructor] would keep on asking questions ... until he notices a facial change. ... He'll be like, well, what about this? ... He knows when the light bulb goes on and then he'll walk away. He'll like just vanish or something. ... It helped me not become dependent on him. ... It helped me think about things in another way. So, did you think about it this way? Did you think about it this way? I'm not going to lie - ... Physics as a whole - I was just ... scared of it completely. ... I thought I was going to always need help. ... When I got to your [the instructor's] class, I was like,

this can be done. This can be done. ... It built confidence and appreciation.”

Although having quotes like this are an important start in viewing how our students view guided-inquiry in the classroom, they only provide evidence from a small sample of the population. In order to get a general sense of the classes' views we developed a short diagnostic and administered the diagnostic to students in the calc-based introductory physics class at CSU in addition to students at a local high school [1].

The survey asks students to read through two scenarios in which one student is aiding another student in determining the relative directions of the velocity and acceleration for an object that is slowing down. In the 1st scenario, one student asks the other student questions to help them construct an understanding while in the 2nd scenario the student explains the concept without the use of questions. Results on the survey showed that 54% of the CSU students (N=13) favored scenario 1, 23% favored scenario 2, and 23% said they were equally good. Results at the local high school (N=55) showed 40% choosing scenario 1 and 60% choosing scenario 2.

These results suggest that the majority of CSU students share the view that the guided inquiry approach is an effective method of instruction.

WILLINGNESS TO BE PART OF A SCIENTIFIC COMMUNITY

This receptiveness in participating in the inquiry-based classroom stems from student willingness to be part of a scientific community in which knowledge is built through resolving how predictions fit or don't fit with observations and peer discourse. Also important is the student commitment to community knowledge, rather than individual knowledge.

Students in our courses seem to be comfortable being incorrect and we often see students valuing recognizing and resolving inconsistencies. Although others have commented that the practice of eliciting student ideas can be frustrating and damaging, the students we work with seem to accept this as an important component toward fostering conceptual change. A number of students have clearly articulated the importance of tools such as pretests in aiding their understanding.

One student stated, “the more that you test yourself the better ... you get. ... When we are learning the concept after the pretest you realize that you got an answer wrong on the pretest so maybe you'll remember that more.. ... When I got it wrong - well I guess its good that the lab showed me that I got it wrong as far as I realized it. ... But I think that it helped me remember the answer to that particular

question or maybe a similar question.”

This acceptance of the pretest was also present in the work with our pilot cite, Olive Harvey Community College (OHCC). OHCC serves a similar student population. After many of the laboratories, we interviewed the students in the class as a group. In one case, the interviewer asked the students at OHCC to comment on the pretests. One student, stated that “By giving the pretest - I do better.” A second student went on the say that “... a lot of the times you don't get the right answer but it helps ... put you [in] the mindset so when you do the lab - you can figure out where you went wrong.”

This value on the incorrect answer comes up again as a CSU student described the “Aha” moment. She stated that “... when you are totally just so off about something and then you get it - and because its like a radical change in what you were thinking that you remember that - you just remember - its like - Oh - okay now I got it”

It is fairly uncommon that students see value in incorrect responses. During group work students placed great value on the input of their peers - whether their peers were incorrect or correct. This is a fairly sophisticated view of group work that often develops much later in a student’s academic career. One student stated: “... it was helpful working in groups and talking with other people. ... That was one of the more helpful things - only because ... in the middle of the class - and you said discuss it with people. Even if people had wrong answers - or right answers - doesn't matter - just the fact that you are getting other ways of looking at things - was really helpful.”

This learning community extends beyond the classroom, into the program as a whole. By involving undergraduate students in education research projects, the entire physics community at CSU becomes part of the support structure for those in the classes. Last year, six students were involved in research projects regarding assessing student learning of physics: Stephanie A. Barr, Geraldine L. Cochran, Virginia L. Hayes, Sean Gallardo, Crystalann Jones, and Erica P. Watkins. We believe this large scale involvement is due to the fact that our students are invested in the program and see themselves as integral parts of the learning environment at CSU. Their roles are crucial to the success of the project and they are able to clearly articulate why their opinion is important to the success of the project. One student stated,

... I haven't had a class with as much intense critical thinking as physics so I think that that helps a lot and... going over the student pretests and exams - ... I like the idea that if I can find some type of trend ... as far as the students aren't doing well in it - and it can actually be changed based on some observations that the teacher wouldn't be able

to notice from their views - I think that helps a lot. I like that because I feel like I am helping the students in a sense. ... There are a lot of teachers who view your thought process ... so you really don't understand ... why we are not understanding this concept. But to the students ... it's really very simple ... why we don't get the concepts. So I think that is pretty cool.

This role that the undergraduate students play is essential because, as this student stated, they are able to observe student issues that the faculty members do not see and will be able to provide a perspective that is unique. Elmesky and Tobin discuss, in detail, how high school students have been involved in education research at the urban high school [2].

ROBUST (BUT HIDDEN) CONTENT KNOWLEDGE

The physics program at CSU has been implementing the Force Concept Inventory (FCI) for over ten years. Before implementing our instructional reform efforts, gains in the calculus-based physics course were roughly 20%. After our changes we began to see gains in the 30% range. Despite continued revisions to our classes and our instructional approach we still see gains at only the 30% level. In this section we provide evidence that these results give a very incomplete view about content understanding of the students in our courses.

Instructors at CSU have anecdotal evidence that the reformed physics class is improving conceptual understanding and are often quite pleased with what they observe in the classroom. In this environment students are actively constructing knowledge and are involved in sense-making activities. Instructors provide some level of scaffolding by asking students guided questions and tailoring these questions to where the students are in their understanding. We find that in the classroom environment students are able to recall their formal physics knowledge and apply it to challenging tasks. We have also seen this in one-on-one interviews. We have previously described a study in which students were given seven questions from the Force Motion Concept Evaluation (FMCE), concerning a sled on a frictionless surface [3, 4]. The students we interviewed responded quite quickly to these questions and performed poorly. During the interview, the interviewer asked the students to explain their reasoning. Through the process of explaining, students began to trigger their formal knowledge of Newton’s Laws and were able to go back and correct many of their previous answers. These results suggest that our students possess:

(1) intuitive ideas and tend to answer certain

questions using these intuitive ideas. Often these ideas conflict with formal physics knowledge.

- (2) correct formal knowledge that is often not triggered in tasks like the one above. Students need extra prompting to activate this knowledge but once activated they can apply this formal knowledge correctly.

These two statements highlight the fact that students have developed correct content knowledge but they go into certain modes, in specific environments, which prevent them from accessing and using this knowledge.

There are a number of instances where we have seen that students possess correct formal knowledge of physics concepts that they can apply to challenging tasks. Unfortunately this formal knowledge can be fairly well hidden. In addition, students are often uncomfortable giving responses that are less familiar to them, despite robust content understanding. In the following example, a student responds to a kinematics question. Despite a strong understanding of the topic the student resists drawing the correct v vs. t graph because it does not feel comfortable to her.

The question involves an object moving in front of a motion sensor, slowing down. The student is given a graph showing a constant, positive acceleration for the object. Because the object is slowing down, a correct response would involve the student noting that the velocity must be negative and that the slope of the velocity graph must be positive. The question was asked on an exam in the algebra-based course and in an interview after the exam. We present results from the exam and the interview from the same student. Figure 1 shows the student's response on the exam.

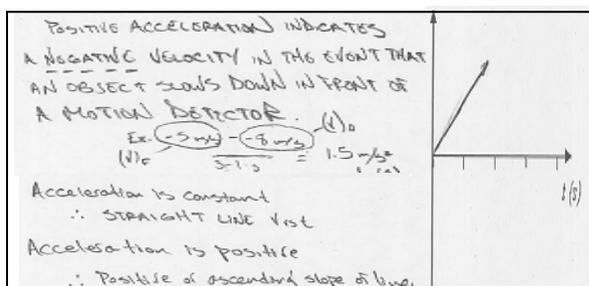


FIGURE 1: Student exam response.

In this example we see that the student clearly understands that the velocity must be negative and shows this using both a qualitative argument as well as sample numbers. She also clearly states that the velocity graph must be straight and that the slope must be positive. But when she draws the graph she decides to abandon her statement regarding the sign of the velocity. During the interview the student states “if I

go with this one ... the upward sloping velocity - above the x axis - which means it's positive - but I still think my answer is wrong ... I can't prove it. ... it proves my positive acceleration - but it doesn't give me my slowing down motion ... okay ... I am still sticking with my positive upward sloping velocity even though I feel it's wrong - ... I like it better than the other two but I still feel it is wrong.”

This exam and interview response shows strong content knowledge but provides evidence that there are issues that hamper student performance and go well beyond content understanding.

CONCLUSIONS

Although preliminary, this paper provides evidence suggesting that students at the inner-city, comprehensive university possess a number of resources we often do not find in more traditional student populations. Rather than focus on deficiencies, we have chosen to highlight strengths that we believe the physics education community can build upon. The particular resources we have identified and described support the goals PER-based instructional materials. Future work needs to explicitly describe how these resources can be used to foster content understanding that is more readily accessible by our students.

ACKNOWLEDGMENTS

This work was supported by the NSF Course, Curriculum, and Laboratory Improvement Program under grant DUE 0632563. Much of the work presented here is a result of undergraduates involved in education research projects at CSU.

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