Factors that Impact International Students’ Learning of Introductory Physics at Georgia State University

Eric Kweku Appiah
Factors That Impact International Students’ Learning of Introductory Physics at Georgia State University.

(A Physics Education Research Project)

By

Eric Kweku Appiah

Thesis Submitted in Partial Fulfillment of Georgia State University

Advance Research Honors

Georgia State University Honors Program

2011
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(A Physics Education Research Project)

By

Eric Kweku Appiah

Under the Direction of Dr. Cherilynn Morrow

Abstract

This study focuses on the most salient factors that affect international students’ learning of introductory physics in Georgia State University. The factors considered were, students’ previous study of mathematics, previous study of physics, language issues, pedagogical difference (i.e. style of teaching, Classroom culture & environment) between GSU and students’ country of origin. For international students who are proficient in English, classroom environment and culture (pedagogy) seem to be the most important factor. For International students who are not very proficient in English, language remains the most important factor. The effect of language barrier on international students’ learning of physics turned out to be more complex than originally thought of. Some students understood instructors differently depending on what country the students come from and on what country the instructor comes from. Instructor offices hours and student advisement emerged as other key factor that helps some international students to succeed in their study of physics at GSU.
Extended Abstract

This study uses a combination of quantitative and qualitative enquiry to focus on determining the most salient factors that affect international students’ learning of introductory physics in Georgia State University. For purposes of the study, “international students” were defined as those who attended high school in a country other than the US. These students comprise a significant portion of the physics courses at Georgia State, and this study was motivated by the desire to support their success. The study involved a collaboration with the newly emerging Physics and Astronomy Education Research Group who has recently begun the routine collection of student learning data in all of its introductory physics courses. The factors considered in the research design were informed by the literature on student learning for all students while including the possibility of new factors emerging in interviews with international students. Factors probed included students’ previous study of mathematics, previous study of physics, language issues, pedagogical differences (i.e., style of teaching, classroom culture & environment) between GSU and the student’s country of origin. For international students who are proficient in English, classroom environment and culture (pedagogy) emerged as the most important factor. For international students who are not very proficient in English, language remains the most important factor. The effect of language issues on international students’ learning of physics turned out to be more complex than originally considered. Some students understood instructors differently depending on what country the students come from and on what country the instructor comes from. Instructor office hours and general accessibility for addressing questions emerged as especially important options for international students who felt uncomfortable asking questions in front of the whole class. An unanticipated outcome of the study was to discover how the vast differences in the structure of high school mathematics education in non-US countries has serious implications for the way we advise and query international students in physics vis-à-vis their academic background before entering Georgia State. Moreover, the study revealed that students who had taken a high school physics course generally scored no better than those who had not taken a high school course on a pre-test of conceptual knowledge in physics. However, students who had taken a physics class in high school had dramatically higher learning gains when given a post-test near the end of the Georgia State physics course. This phenomenon suggests that more consideration should be given to prior course-work in combination with a diagnostic pre-test to advise students about which math and physics courses to take when they arrive at Georgia State.
Factors That Impact International Students’ Learning of Introductory Physics at Georgia State University.

(A Physics Education Research Project)

By

Eric Kweku Appiah

Honors Thesis Supervisor (Dr. Cherilynn Morrow)

Honors Program Director

Thesis Submitted in Partial Fulfillment of Georgia State University Advance Research Honors

Georgia State University Honors Program

2011
Acknowledgement

I thank God for the wisdom and strength He gave me to undertake this project.

Special thanks to Dr. Cherilynn Morrow for her unwavering support and leadership. This thesis would not have come to completion without her support.

I want to thank Dr. Brian Thoms whose guidance and supervision on the quantitative aspect of this project proved invaluable every step of the way.

Lastly, I want to thank John Aiken and Christopher Oakley and the Georgia State University Physics and Astronomy Education Research Group for all their support in this project.
Dedication:

Ms. Regina Dede Djangmaki Appiah

My mother whose presence is always with me
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Introduction

The research question for this study is: What are the most salient factors that affect international students’ learning of introductory physics in Georgia State University?

1-1 Operational Definition of International Students

Georgia State University defines international students as “nonresident alien students who are citizens of another country and have been granted some sort of U.S. visa.” (ISSS Report, 2009 p.2). However, for the purpose of this study, the operational definition of an “International Student” is one who attended high school outside of the United States. I adopted this broader definition to include permanent residents and U.S citizens who might have attended high school in another country and who thus have similar challenges to international students with visas. Georgia State’s definition could leave out some students whose experiences might be valuable for this research. Students who do not fall under the operational definition of this study will be referred to as local students.

1-2 Motivation for Study

I (student researcher) take particular interest in understanding the factors that influence international students’ learning of physics because of my own experiences as an international student from Ghana who is majoring in applied physics at Georgia State. I had all my education up to the equivalent of a US junior college in Ghana before continuing my studies at GSU. In Ghana, I experienced a very different pedagogy and culture of teaching and learning compared to what I encountered here at Georgia State. At Georgia State, I have enjoyed the excitement of learning in an environment where one has better access to instructors and all the needed tools to succeed in school, and yet I had the occasional feeling of alienation as result of cultural
differences and language-related challenges. My motivation for conducting this study is to understand more about the learning experience of students from other countries who are taking physics courses at Georgia State, and to identify factors that promote their success. I strive to present a fair and an academically rigorous research design, but I acknowledge that my own experiences as an international student could both benefit and bias my interpretations.

1-3 Statement of the Problem

There are many studies on factors that affect the success of all students in introductory physics, and there are studies that show different test scores for women and minorities. The problem is that little attention has been given particularly to international students as a separate unit of study, even though they can make up a significant portion of the student body.

International students enrolled in introductory physics courses come with unique challenges that might not necessarily be experienced by fellow students who are native to the United States. Other countries can have entirely different educational systems, with different emphases related to teaching and pedagogical strategies. Students come in with different levels of preparation in mathematics and physics, and in some cases, they have languages of instruction other than English in their countries of origin.

1-4 International Students at Georgia State University

The location of Georgia State University at the heart of downtown Atlanta, a city that is often characterized by its diverse population, is reflected in the university’s student population. Appendix E shows the various countries from which international students in GSU come from according to year of enrollment. This diversity is very likely reflected in the demographics of students who register to take physics courses on GSU campus.
To verify my impression that international students make up a significant portion of the students in introductory physics, I undertook a preliminary study to compare the percentage of international students at Georgia State with the percentage of international students taking introductory physics.

In the 2009 edition of Georgia State University’s International Student & Scholar Services (ISSS) Report, GSU defined International Students as “non-resident alien students who are citizens of another country and have been granted some sort of U.S. visa.” (p.2). According to this report, these visas include but are not limited to F visas, J visas, and H visas. In Fall 2009, the total student population at GSU was 30,263. In the same year (2009), GSU’s ISSS reported a total of 1408 students (4.65%) enrolled as non-resident alien students.

As noted earlier on, for the purpose of this study, the operational definition of an “International Student” is one who attended high school outside of the United States. I had asked the Physics Education Research Group to modify the information form that is completed by every student in all introductory physics classes to capture whether or not a student did high school in a country other than the US (see Appendix C). I then performed a hand count of the number of international students. By this definition, 70 students out of 815 students (8.59%) who registered to take the introductory physics classes in Fall 2010, self-identified as international students.

The pie charts in Figures 1a and 1b compare the percentage (8.59%) of international students (high school in another country) in introductory physics classes in Fall 2010 to the percentage (4.65%) of international students by GSU’s definition (non-resident aliens with visas) in the GSU student body. It is interesting to note that use of GSU’s definition of “international student” as a means to estimate the percentage of international students in introductory physics
would have resulted in a substantial underestimate. However, if one adds to the mix of GSU students, the resident aliens with visas, (in addition to non-resident aliens) then the percentage of students jumps to $\frac{3575}{30,263} = 11.8\%$.

![Resident/ non residents aliens](image1.jpg)  
![International Students](image2.jpg)

**Figure 1 (a).** Percentage of GSU students who are International Students (non-resident aliens with visas). Fall 2009.  
**Figure 1 (b).** Percentage of students who took an introductory level physics class in Fall 2010 who are International Students (went to high school outside the US).

According to data provided for the Fall 2010 semester, international students in introductory physics speak over 32 different languages combined. These languages include: Amharic, Arabic, Bulgarian, Bangla, Cantonese, Chinese, English, Farsi, French, German, Gujarati, Hebrew, Hindi, Korean, Malayalam, Norwegian, Persian, Russian, Somali, Spanish, Tamil, Telugu, Urdu Vietnamese and Vulcan. The instructors in these physics classes tend to be just as diverse as the students.

The often highly diverse educational and cultural background of international students enrolled in college physics courses, combined with their high numbers at an institution like Georgia State, warrants that a more critical attention be given to their performance vis-à-vis their prior educational, pedagogical and cultural experiences. Knowledge of the factors that most affect their success will allow instructors to make introductory physics courses more responsive to their unique backgrounds and challenges. The concern that international students get the most
out of their physics classes in particular, and their overall college experience in general defines the motivation for undertaking this study.

1-5 Purpose of Study

The objective of this study is to begin to discern the salient factors that have the most impact on international students learning of physics. I hope to identify empirically verifiable factors that have the greatest impact on international students learning of physics especially here at GSU, which could help the physics department improve on instruction and classroom environment to better serve international students.

2 Background and Literature Review

Some studies focused on how factors such as prior (high school) preparation in science and math affect students’ success in college physics (e.g. Sadler, P., Tai, R., 2001, Savinainen, A., & Scott, P. 2002, Pollock, S. J., 2009). Others studies compare student performance in different pedagogies like integrated lecture and laboratory versus the traditional separate lecture and laboratory. (e.g. Beichner, R. J. et al., 2007; Hake, R. 1998; Hammer, D. 2000; (Sokoloff & Thornton, 1997). A major part of the efforts by these groups has been focused on trying to identify factors that help students in general to understand the concepts being taught (e.g Hegarty-Hazel & Prosser, 1991; Maloney, O’Kuma, Hieggelke, & Van Heuvelen, 2001; Wilhelm, Thacker, & Wilhelm, 2007; McDermott & Shaffer, 2001). In the literature, there seem to be very few studies that focus mainly on international students learning of physics. One study along these lines was done in a Canadian University with a student population as diverse as that in GSU. In this study, Completion of high school physics showed a positive correlation with
students understanding of physics in college (Antimirova, Naoack & Milner-Bolotin 2009). In this study, it was noted that students’ demographic characteristics such as mother tongues and country of origin did not seem to play any significant role in determining the level of students’ understanding of physics (Antimirova, Naoack & Milner-Bolotin 2009). However, a masters’ thesis study in GSU seem to show that demographic characteristics such ethnicity has a significant effect on students’ performance in the introductory physics courses. It was suggested in this study that language issues could account for that trend (Upton 2010). Both studies used the same conceptual diagnostic instrument in their studies. There seem to be a conflict in the findings concerning student demographics and their conceptual learning at least in these two studies. No conclusive judgments can be made only from these two studies. These results only reveal the need for more of such studies that aims at finding a more scientific, empirical, and statistically relevant information on this issue. This study will be a step toward contributing to the knowledge base in this emerging field.

3 Research Methods and Design

3-1 Hypothesis

Based on the literature research above, the hypothesis of this study is that, the most salient factors that impact international students’ performance (for better or for worse) in introductory physics classes at Georgia State University will include, but not be limited to:

1) Previous study of mathematics; 2) previous study of physics; 3) language issues; 4) pedagogical difference (style of teaching, Classroom culture & environment) between GSU and students country of origin. Based on my personal observation and experiences, I predict that language issues, and the differences in the pedagogical strategies and classroom culture have
more of an impact on students’ understanding of physics than factors like prior preparation in mathematics and physics.

3-2 Nature of Data to be collected

In order to test this hypothesis, the design of this study entails both quantitative and qualitative modes of enquiry. As a measure of student performance, I use the results of a nationally used instrument to measure conceptual understanding of Newtonian physics that is called the Force Concept Inventory (FCI) (described in more detail below). As a mean to discriminate between pedagogies, I use information about whether labs are integrated with or separate from the lecture portion of the course (pedagogies are also described in more detail below). As a means to learn about students’ native language and background in high school math in physics, I use de-identified data obtained from the Information Survey (see Appendix C) routinely collected and archived by the Physics Education Research group before administering the FCI at the beginning of all introductory physics courses, including both calculus-based and algebra-based courses. I chose to focus my study on the introductory mechanics courses (Phys 1111 – algebra-based; and Phys 2211 – calculus based) since for these courses the FCI is routinely administered as both a pre- and post-test, and thus it is possible to compute normalized gains as a measure of student conceptual learning in the courses. Such a pre-post diagnostic test is not yet routinely administered in the second semester introductory physics course. An aggregated data was requested from the GSU PER group (See Appendix D) for students FCE scores.

Qualitative inquiry involved more in-depth interviews with six international students who volunteered from these introductory mechanics classes. Appendix A provides the IRB-approved Informed Consent form, and Appendix B provides the IRB-approved Interview Protocol, which
poses questions related to all of the factors considered in this study while remaining open to the possibility of unanticipated factors that might arise. In particular, students were asked to compare the nature of their classroom environments in high school (in a country outside the US) with the nature of the classroom environment in their physics course (or courses) at Georgia State, and to talk a bit more about whether and how English being a non-native language can be an impairing issue for them.

Interviews were conducted for volunteer students who met three recruitment criteria as articulated on the Recruitment Flyer (see Appendix G):

1. The participant student must have attended high school outside the United States
2. The student must have taken physics in high school.
3. This student must be enrolled in an introductory physics course (Phys 1111, Phys 1112, Phys 2211, or Phys 2212) in the Spring of 2011

3.3 The Force Concept Inventory

The Force Concept Inventory (FCI) is a multiple choice introductory physics test that is primarily designed to measure students’ conceptual understanding of Newtonian physics (Hestenes, D., Wells, M., Swackhamer, G., 1992). This diagnostic tool is a nationally recognized and a widely used instrument in many physics education research projects due to its validity, reliability and the fact that it is readily available and easily accessible (Savinainen, A., & Scott, P., 2002.) The FCI has 30 multiple-choice questions taken from six main categories in Newtonian Physics. These categories are Kinematics, Newton’s three laws of motion, the superposition principle and the kinds or types of forces (Helstenes, D., et al 1992.)

This instrument does not test the students’ conceptual understanding of every aspect of physics. As noted earlier, the FCI specifically assesses students’ conceptual understanding of
Newtonian physics and kinematics alone. Many people have some common sense assumptions about how Newtonian mechanics works. Due to this assumption, the authors of the FCI have included some common sense distractors in the answer choices to test whether students really understand the basic concepts behind Newtonian physics or if their concept of forces and kinematics are based on those common sense assumptions (Hestenes, D., et al 1992.).

With pre and post FCI scores the normalized gain is computed as follows:

$$g = \frac{\text{Actual gains}}{\text{Maximum possible gain}} = \frac{(\text{posttest score } - \text{pretest score})}{(\text{maximum scores} - \text{pretest score})}$$

The normalized gains calculated form the FCI scores is used as measure of student performance on the FCI. The normalized will simply be referred to simply as gains throughout this study.

### 3.4 Pedagogies Studied

At Georgia State, introductory, algebra-based physics (Phys 1111) is taught in two different pedagogical styles: 1) Traditional, with separate lecture & lab; and 2) Studio-style, with integrated lecture and lab. This provides an opportunity for a comparison of performance between international students and “local students” by pedagogy.

**Separate lecture/lab – Traditional**

The traditional or conventional method of teaching physics at the college level is comprised of separate lecture and laboratory sections. The laboratory sections are often held on a different day from the lecture and with a different instructor. With the conventional/traditional approach the instructor generally lectures while the students sit, listen, and take notes. A
common student complaint is that the separate laboratory sections are often not meaningfully coordinated with the topics that are being covered during the lectures (Belcher, W., 2001). Moreover, physics education research suggests that this approach does not produce as much student learning as an active engagement, student-centered approach. In this study, most of the traditional classes observed at GSU were consistent with this description of traditional pedagogy.

Concerns about lack of student conceptual learning as evidenced by the FCI and other diagnostic tests have led many physics educators to start revising their strategies of teaching towards a more interactive, student-centered pedagogy. One enhanced format of teaching physics with the aim of promoting interactive and active student centered learning is often loosely referred to as “Studio Physics” (Belcher, W., 2001) or “SCALE-UP” (Beichner, R. et al. 2007). Beichner’s data suggest that an integrated Lecture/Lab approach with collaborative student teams results in higher student learning gains for women and minorities.

**Integrated lecture/lab – Studio Physics**

Studio physics is a student centered pedagogy that provides an integrated learning environment where lectures are closely coordinated with hands-on experiments and student interactions. This style of teaching incorporates experiment into the coursework and also allows student to discuss, share ideas, and reflect upon the concepts in the course material (Belcher, W., 2001). This pedagogy promotes active student learning as opposed to the passive learning associated with the traditional or conventional method. Pioneered at Rensselaer University by Jack Wilson in 2004, studio physics is fast becoming a more common pedagogy on many university campuses around the country (Belcher, W., 2001). In the Fall of 2008 Georgia State University began providing the option of studio physics in selected introductory physics classes.
There is evidence that the Studio pedagogy outperforms traditional pedagogy when class averages of FCI learning gains are compared (Upton, B., 2010).

In this study, the performance of international students in this highly interactive classes was assessed vis-à-vis their “local” students counterparts against the backdrop of students’ mother tongue/language and the pedagogical difference between GSU and the home countries of these international students.

5.5 Summary of Data Resources for Each Factor Considered

Table 1 provides a summary of data used to address questions related to our hypotheses.

TABLE 1: Overview of Research Design

<table>
<thead>
<tr>
<th>Factors</th>
<th>What we want to know?</th>
<th>Sources of Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics In High School</td>
<td>1. What percentage of International students take physics in high school compared to all other students taking physics in GSU</td>
<td>Information survey data from a sister study modified to suit the purposes of this study. FCI data</td>
</tr>
<tr>
<td></td>
<td>2. Does taking Physics in high school correlate to learning gains on FCI</td>
<td></td>
</tr>
<tr>
<td>Mathematics In High School</td>
<td>1. What percentage of International students take pre-calculus in high school compared to all other students taking physics in GSU</td>
<td>Information survey data from a sister study FCI data (Pre/Post/Gains)</td>
</tr>
<tr>
<td></td>
<td>2. Does taking pre-calculus in high school correlate to learning gains on FCI</td>
<td></td>
</tr>
<tr>
<td>Language</td>
<td>1. Does language play a major role in determining international students learning</td>
<td>Student interviews</td>
</tr>
<tr>
<td>Pedagogical differences, Classroom Environment and</td>
<td>1. How does differences in pedagogical techniques between GSU and international students</td>
<td>Data from Interview</td>
</tr>
<tr>
<td>Culture</td>
<td>2. How does the different pedagogical techniques (studio vs. traditional) affect international student learning</td>
<td>Data from Interview and FCI</td>
</tr>
<tr>
<td>---------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td></td>
<td>3. How does classroom environment and culture affect int. student learning</td>
<td>Data from Interview</td>
</tr>
</tbody>
</table>

4 Description of Data Collected

Three forms of data were collected:

1) A hand-count of the number of international students in all introductory physics classes (Phys 1111, Phys 1112, Phys 2211, and Phys 2212) in the Fall 2010. All course descriptions are included below. Results were discussed previously in Section 1-4.

2) A read-out from an aggregated, de-identified set of demographic data and pre-post scores associated with students in Phys 1111 and Phys 2211 during the Fall 2010 semester (e.g. native language, math & physics preparation, Studio or traditional pedagogy, class average pre-post FCI scores, and computed learning gains.)

3) Audio data and notes from six student interviews.

4-1 Hand Count of International Students in Introductory Physics

In order to capture the students who fall within this study’s definition of international students, modification to an existing demographic form was made to include a question about whether the student filling the form completed high school outside of the United State. The student’s answer to that question then determined whether he/she is an international student based the operational definition for this study. 815 completed demographic survey forms were collected by the GSU PER group. These demographic forms were analyzed in order to get the exact number of students who self-identify as international students. The physics classes that are
of interest to this study were PHYS 1111K, PHYS 1112K, PHYS 2211K and PHYS 2212K.

Course Descriptions are included in Appendix F.

Table 2. PHYS 1111

<table>
<thead>
<tr>
<th>Section</th>
<th>Total No. of Students</th>
<th>No. of Int. Students</th>
<th>% of Int. Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>47</td>
<td>4</td>
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</tr>
<tr>
<td>2</td>
<td>51</td>
<td>5</td>
<td>9.80</td>
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<td>3</td>
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<td>6</td>
<td>53</td>
<td>4</td>
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</tr>
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<td>7</td>
<td>49</td>
<td>4</td>
<td>8.16</td>
</tr>
<tr>
<td>Total</td>
<td>345</td>
<td>27</td>
<td>7.83</td>
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Table 3. PHYS 1112

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<th>No. of Int. Students</th>
<th>% of Int. Student</th>
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</tr>
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<td>50</td>
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<tr>
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<td>255</td>
<td>22</td>
<td>8.63</td>
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Table 4. PHYS 2211

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<tr>
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<th>Total No. of Students</th>
<th>No. of Int. Students</th>
<th>% of Int. Student</th>
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<td>5</td>
<td>8.93</td>
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<td>2</td>
<td>54</td>
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</tr>
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<td>3</td>
<td>57</td>
<td>4</td>
<td>7.02</td>
</tr>
<tr>
<td>Total</td>
<td>167</td>
<td>14</td>
<td>8.38</td>
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Table 5. PHY 2212

<table>
<thead>
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<th>Section</th>
<th>Total No. of Students</th>
<th>No. of Int. Students</th>
<th>% of Int. Student</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>48</td>
<td>7</td>
<td>14.58</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
<td>7</td>
<td>14.58</td>
</tr>
</tbody>
</table>
4-3  Data from Student Interviews

The collection of data for the qualitative aspect of this study was collected mainly through student interviews. Six students were interviewed. Four of these interviews were done with one student each and the last one was conducted as a focus group with two students to accommodate students’ schedules and availability. Students interviewees volunteered to participate in these interviews. Interviews included questions about students’ experiences in any of the physics courses which they took (or were currently taking) in GSU, students’ experiences in any physics classes they took back home, students background in mathematics and physics from high school and any similarities or differences between teaching styles between GSU and students country of origin etc. Interview questions were designed to allow students to reflect on their experiences in their study of physics here in GSU and thereby allow any important factors to emerge on their own. The complete interview protocol is attached in Appendix B.

Table 6. TABLE OF INTERVIEWEES

<table>
<thead>
<tr>
<th>Student</th>
<th>Pre Score</th>
<th>Post Score</th>
<th>Gains</th>
<th>Class</th>
<th>International High School</th>
<th>Major</th>
<th>Native Lang.</th>
<th>First Lang.</th>
<th>No. yrs in US</th>
<th>No. in GSU</th>
<th>our perception of student’s ranked factor</th>
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5 Data Analysis and Interpretation

5-1 Physics in High School

International students in the algebra base studio course who took physics in high school had almost the same pre scores on the FCI as those who did not take physics (Figure 2). However, the gains for those who took physics in high school was almost three times higher than those who did not take physics in high school (Figure 3). The reason for this trend could be that students for the most part forget most of the physics that they learned in high school but that latent knowledge helps a great deal once they start taking introductory college physics.

Figure 2. FCI pre scores for studio 1111K – studio
This result suggest that Just because someone has a low score on a math pre-test does not necessarily imply that he/she should be placed in a lower level course without first having a careful look at their math records. In the algebra based lecture course however, it appears as if international students who did not take physics in high school rather have higher FCI pre-scores and higher gains than those who had physics in high school. (Figure 4 and 5) Interestingly enough local students who took physics in high school in the algebra base lecture course had higher pre-scores and lower gains compared to those who did not take physics in high school. The data suggest that that since these local students had higher pre-scores, their learning gains was not as bigger as those who did not take physics in high school. But more data from this class needs to be analyses before making any judgments.
Figure 4. FCI pre scores for 1111K – lecture

Figure 5. FCI normalized gains for 1111K – lecture

The data suggest that all international students who took the calculus based course had physics in high school. (Figure 6). It seems for the calculus based course there is no much difference in the gains for local students even though those who had physics in high school had slightly higher pre-scores (Figure 7).
Figure 6. FCI pre scores for 2211K – lecture

Figure 7. FCI normalized gains for 2211K – lecture
5-2 Mathematics in High School

All local students have taken either pre-calculus, calculus or both in high school. Local students who took calculus or pre-calculus in both high school and college turn to have slightly lower pre-scores and gains than those who only took it High school (Figures 8 and 9). A possible reason for this could be that the students who took pre/calculus in both high school and college did not do well the first time in the high school and thus taking it again in college does not seem to give them an advantage over those who only took it in high school. This trend is consistent across all the classes.

Figure 8. Phys 1111K lecture Pre-scores

Figure 9. Phys 1111K lecture Pre-scores
Due to international students’ confusion with the high school pre-calculus and calculus questions on the demographic survey, only the qualitative data will be discussed. All the international students (with the exception of one) said they took mathematics every year from middle school through high school. They said the math that they took in high school comprised of algebra, arithmetic, statistics, and some calculus but they did not specifically take pre-calculus or calculus as a course by itself. Hence, the fact that a student took two or three years of math in high school does not mean he/she took pre-calculus or calculus for that number of years. So when asked if they took pre calculus or calculus in high school, it sounded vague to them since they did not study calculus as a complete course. Some of the international students interviewed did not know exactly what pre-calculus comprises.

For instance in Ghana where I (student researcher) went to high school, we take math in almost all the three years of high school. However, we did not have a full math course that is purely pre-calculus or calculus, as it is clearly differentiated here in the United State. The general assumptions which the GSU’s physics department or the PER group had was that student either took pre-calculus, calculus or that they did not take either one. With this assumption in mind, the demographic survey is designed to ask students specifically if they took pre – calculus, calculus or if they did not take any at all in high school.

This finding is very important since it will inform the GSU Physics Education Research group and the physics department as a whole as to how they will need to frame future questions that aims at capturing the exact level of preparation in math that most international students have prior to entering college.
This important fact was discovered at the later part of the study hence the survey could not be modified to ask the math question in the right way in order to capture the actual experience of international students in mathematics. Due to this finding, I figured that any answers about the math from the survey would not be meaningful in making any statement as it relates to the aims of this project.

Another issue that came up unexpectedly was that some international student especially at the freshman year don’t seems to know the difference between the calculus based physics and the algebra based physics and so they register for any physics course that is available online (in GoSOLAR*). Concerning picking the right physics course for student’s background in math and future academic aspirations, one student who took a math modeling course instead of the calculus based course even though she had the background to take the calculus based course said,

That’s a though thing. You don’t really know so you kind of looking for that guidance and nobody really– so later when you are applying for graduate schools and you have to go back and take this over again. There [are] a lot of people I talked to who are in that position and they’re saying, they made me take this math when I have this background and now I have to go back and you know pay on your own and everything [to take it again]  

It seems like some international students initially do not know that student advisement is available at the physics department until later when they are already registered for classes. Calculus as a stand-alone course. Therefore, in as much a student took two or three years of math

* Georgia State Online Access to Records
5-3 Language Issues

Language seems to play a major role in determining international students learning of physics. During the interviews, there seem to be some confusion about first language and native language. Students often responded with different answers when asked of about their first or native language. Some of these students saw the two as two deferent things. In addition, more that half of the students that were interviewed said that the only major problem they have as international students studying physics in GSU has to with language barriers. When I asked students about the factor that they believe have the greatest impact on their study of physics, one student said, “I think it is the vocabulary. If I understand what every word means, I don’t think I will have a problem”\(^1\) another student said, “the hardest part for me is the English. Some times, I can’t understand the meaning of the question, [for instance] in physics [a word like] isothermal, I don’t know what isothermal means so I use the dictionary”. The first student referred to above also said,

One time during a quiz, I didn’t understand what this particular word mean and I asked the teacher but he didn’t know how to explain [it to] to me again because maybe for him the word was just simple...So I think that’s the problem I have.

When this student was asked if she remembered the word that she had trouble with she said “… I think its is a car slowing down…this is not a physics word it was an English word”.

Keeping in mind that not all international students might be having this level of difficulty with the English language, one student was asked if she felt as equally or less prepared for the physics class than her fellow students who are native English speakers and she said:

\(^1\) All direct quotations from Interviewee’s will be kept anonymous through out the paper to protect the privacy the students.
Not that they [the local students] feel well prepared. Just that I am not familiar with every word, because in physics the words are very important.

When they [instructors] are describing for instance motion, you need to know exactly [what it is] so that you can picture it out. [But] if you don’t know what the words means…you will think it means one thing and it does not.

So some of these students suggested that instructed should allow them to bring dictionaries to the class whiles one student said he actually look up words on his cell phone or his laptop. The problem with the language barrier for some of these international students who I interviewed seems much complicated that it actually looks initially. Some international students said they understand some instructors’ accents much better than they understand others. One student said,

The language difference is terrible for me…so it even made me to decide that every class am going to take now, I am going to keep Chinese or Korean teachers out of my classes. … I can have an American teacher; I can have an Indian teacher that is no problem.

This student said she had to drop a class because she did not understand anything the professor was saying. She said she decide to drop that particular class after she had a C in the first test. She said her problem is with understanding Chinese or Korean accented English. This particular interview was conducted in a focus group style made up of two student interviewees and the student investigator. The other student in the interview said,

Different country students will like different English. Like me I am from Asia [so] probably I will like Chinese English, I will like Korean English, I will like Japanese English, but probably she [from Africa] will like Indian English, she will like American
English but for me Indian English is difficult. The American English is ok for me. That’s the English.

Therefore, for these students, in their own estimation it seems the language issue seems to be the greatest draw back in their study of physics. Some of the students said it helps very much when the instructor invites more questions. Upton (2010) suggested that language could possibly be a factor that determines the learning gains for students from different ethnic groups. Even though most international students need to pass the TOEFL before they are admitted into any course in the university, not all of them come into these classes well prepared to keep up with the spoken English and hence it would be a false assumption to think that all the students are on the same level when it comes to language.

5-4 Pedagogical Style, Classroom Environment & Culture

About half of the students interviewed seem to consider classroom environment and culture as the most important factor that determines their learning success in physics. One students who have never experienced the interactive nature of the studio pedagogy from both her home country and her previous university said that the studio pedagogy is one of her best experiences in her study of physics. Other students said the group work and support system in the integrated studio class helped them in a very significant way. Some of the students said they liked the studio classes because they do not have to worry about a separate lab where sometimes the lectures will be about two to three topics behind the lab. Others liked it because the group work causes them to be actively involved in the class. One student sharing her thoughts about why she preferred the studio class said it is about “the group aspect, sitting in the groups too…it just helps to have that kind of support system in the group…being in a group makes you think
more”. Almost all the students who took the studio class said they prefer that pedagogy better except one student who said the studio class was much chaotic and that he prefers the studio mainly because he does not have to attended classes twice for the same subject as in the case of conventional separate lecture and lab courses. He said that the studio would have been less chaotic if the class size was smaller. He said, “If the class size is reduced, we will get more attention and more help”.

6 Conclusion

6-1 Summary of Major Findings

This study represents the first time that qualitative inquiry was included together with a quantitative study as part of an education research project associated with the emerging Physics and Astronomy Education Research Group at Georgia State University. The companion qualitative study involved interviews with six students from six different countries (i.e. Canada, China, Cote d’Ivoire, Ghana, Kenya and Nigeria), and even with such a small number proved highly illuminating of ways in which the success of international students can be supported, including improvements to instruction, advisement, and the quality of our assessments of student learning.

The general hypothesis for this study was that language issues, and the differences in the pedagogical strategies and classroom culture will have more impact on students’ understanding of physics than factors like prior preparation in mathematics and physics.
A more specific prediction was that language issues and the differences in the pedagogical strategies and classroom culture would have more impact on students’ understanding of physics than factors like prior preparation in mathematics and physics since international students who are on a science track in high school are generally quite strong in those academic areas. Although this hypothesis was largely supported by the results of the study, there were other unanticipated results that emerged related to language and to math and science preparation. The results that emerged in this study are:

1. Student background in physics is a predictor of learning gains.

   In the 1111K studio class, international students’ pre scores were the same for both student who had physics in high school and those who did not. However, the learning gains for students who had physics in high school almost tripled those who did not. Most math placement tests are basically pre tests. This finding implies that if students are placed in some lower level math course only based on their scores on a math placement test without a thorough review of the students’ background in math, there is the possibility of placing students in math courses that will not ultimately help them in the long run. This therefore calls for the need for a more comprehensive advisement and review of international students’ background in math so that they can be placed in the appropriate classes.

2. Most international students do not take calculus, pre-calculus or algebra as separate courses contrary to the current assumptions that inform most of the universities prerequisite requirements. All interviewees reported taking 5 years or more of math
courses, with almost all of them reporting calculus as being one of the many topics they covered.

This therefore suggests that the survey used by the Physics Education Research group about whether a student took pre-calculus or calculus do not make much sense to most international students. The implications of this finding are that:

a. The INFORMATION SURVEY used by the PER group should be modified accordingly in order to capture correct information about the actual prior math experience of international students.

b. Advisement should be done more carefully to ensure that students with the right background in math would be registered in the right courses. There was a case of an Economics Major who did not distinguish between Algebra-based and Calculus-based Physics and so she registered for algebra – based course yet she was mathematically prepared for Calculus-based course.

3. Language and classroom culture & environment emerged as competing factors in determining student’s learning of physics

4. The issue of language barrier in determining student learning is more complex than initially thought of. Some students even suggested that international students who might be having a hard time with the English language should be allowed to bring dictionaries to class and probably for tests in classes that are not English composition or English comprehension.

5. Instructor Office hours emerged as a very useful opportunity for most international students who might hesitate to ask questions in class.
Therefore, in summery, the study revealed that for international students, language issues and the type of pedagogy and learning environment and classroom culture plays a competing role in their understanding of physics in a rather subtle way. For international students who are proficient in English, the kind of pedagogy and classroom environment stands out to be the single most important factor that affects their learning. For international students who are not very proficient in English, language remains the single most important factor that affects their learning of physics in GSU.

6-2 Significance and Limitations of Findings

In order to be of greater assistance to international students taking physics classes here in GSU it is very important that the right research tools are in place and that these tools like the INFORMATION SURVEYS have to be created sensitively to how international students interpret them. For instance:

a.) The question about students’ prior math background in the current Information Survey need to be modified to capture the right information about intentional students background in math from their home countries, rather than giving them choices that do not make much sense to them. If the questions on the survey are meaningless to the students, whatever correlation we make from data collected by this survey will be meaningless as well.

b.) The question on the current Information Survey about language may need to be clearly separated into questions about first language and native language. This is because some of the students interviewed answered differently depending on where they are from.
One limitation in this study is the low numbers (n) of international students available. This implies that most of the statements made cannot be generalized. For instance, one student liked the structure of the traditional course. This is an older student and so this concern might be related to his age or what he might be used to from his home. Hence, more data would be needed to determine if this is a real concern among many international students. Subsequent studies needs to be done along this line with greater numbers of student in order to validate the statement made here.

6-3  **Suggestions for Future Work**

1. Future studies about international students should focus more on interviews rather than focusing only on FCI results. This is because in this study, only six international students were interviewed, yet very valuable information was obtained such as the confusion with the question about students’ previous math background on the INFORMATION SURVEY and the level of complexity that the effect of language has on some international students’ learning of physics. Future work that focuses on interviews with a larger number of students could reveal more information that could be very important in helping international students succeed in their learning of physics in GSU.

2. Future studies about international studies should be done with demographic forms that have the questions about first language and native languages clearly stated. Questions on the Survey form about students’ prior knowledge of math should be designed in a way that allows students to state exactly what their math background is as opposed to giving them choices just between pr-calculus and calculus.

3. Due to how complex language barriers seems to be for some international students, a more in-depth study should be conducted with the focus on how language
barriers can be overcome as quickly as possible for students who might be struggling with the English language. Findings from such studies could help international students to integrate quickly into the mainstream classroom population.

Georgia State University’s center for teaching and learning has a guide called “Tips for Teaching Non-native English speaking Students”. This guide is for instructing who teach non-native English speakers. This study revealed that the accent of an instructor could be a major problem for some international students. Hence, more study should be conducted to evaluate how the language of a non-native English-speaking instructor might influence the learning of a non-native English-speaking student.

4. Also, further studies should consider how the balance between collaborative work and the constant interaction between students in the studio classes might affect the focus and success of other students.
REFERENCES CITED

URL http://link.aip.org/link/?APC/1179/77/1


GSU: Tips for Teaching Non-Native English Speaking Students

The Center for Teaching and Learning


Upton, B. M. (2010). Assessing the Effectiveness of Studio Physics in Georgia State University. *Georgia State University, Atlanta*
APPENDICES

Appendix A - Consent Form

Georgia State University
Department of Physics & Astronomy
Informed Consent

Title: Exploring the Experience of the International Student in Introductory Physics

Principal Investigator: Dr. Cherilynn Morrow
Student Principal Investigator: Eric Appiah

I. Purpose:
You are invited to participate in a research study. You are invited because you are currently a student in introductory physics (Phys 1111, Phys 1112, Phys 2211, or Phys 2212) who has taken physics in high school in a country other than the United States. The purpose of this study is to explore your experience in learning introductory physics at Georgia State and to determine how we can improve our instruction and classroom environment to better serve international students.

II. Procedures:
Participation in the interview process will require about 40 minutes of your time. We will provide a $20 gift card for the GSU bookstore at the end of the interview. After reading this consent form, if you decide to participate, please sign it below. Participation or lack of participation in this study will not influence your grade in any way. Your instructor need not know whether or not you are participating in this study. With your permission the interview will be audio-recorded in case we want to confirm any comments. Your comments during the interview will not be shared with your instructor or anyone else besides the researchers involved in the study. Also with your permission, we will request the scores of the pre-post physics concept tests you have completed as a routine part of your introductory physics course.

III. Risks:
In this study, you will not have any more risks than you would in a normal day of life.

IV. Benefits:
Participation in this study may not benefit you personally. In the broader picture your participation in this interview may help to raise awareness and initiative improvements that better support international students in learning introductory physics.

V. Voluntary Participation and Withdrawal:
Participation in this research is voluntary. If you initially decide to participate and change your mind, you have the right to drop out at any time. If you drop out before the end of the interview, you will not be eligible to receive the $20 GSU gift card, but you will not lose any benefits to which you are otherwise

Consent Form Approved by Georgia State University IRB April 14, 2011 - April 13, 2012
entitled. You are eligible for the gift card whether or not you give use permission to audio record or to consult your scores on the pre-post concept tests in physics.

VI. Confidentiality:

We will keep your records private to the extent allowed by law. Only Dr. Cherilynn Morrow, Dr. Brian Thoms, and Eric Appiah will have access to your comments (via their discussion notes or the audio recording). Information may also be shared with those who make sure the study is done correctly (GSU Institutional Review Board and the Office for Human Research Protection (OHRP)). The information gathered will be stored in a locked file cabinet and on a password-protected computer that is not on the Internet. In addition, your name as well as any comments that might identify you will not be revealed when we present this study or publish its results. The findings will be summarized and reported anonymously. You will not be identified personally.

VII. Contact Persons:

Please feel free to contact Dr. Cherilynn Morrow at cmorrow@gsu.edu if you have questions about this study. If you have questions or concerns about your rights as a participant in this research study, you may contact Susan Vogtner in the Office of Research Integrity at 404-413-3513 or svogtner1@gsu.edu.

VIII. Copy of Consent Form to Subject:

We will give you a copy of this consent form to keep.

Permission to audio record the interview? (circle one): YES NO

Permission to know your scores on the pre-post physics concept tests (circle one): YES NO

If you are willing to volunteer for this research, please sign below.

Participant ____________________________ Date ____________

Principal Investigator or Researcher Obtaining Consent ____________________________ Date ____________
Appendix B – Interview Protocol

In this study, we are interested in finding out the factors that have the greatest impact on fostering conceptual understanding of introductory physics among international students. To begin, would you please state your country of origin, and your first language?

Country of Origin: ___________________________     First Language: ___________________________

1. What is the most advanced math class you’ve taken at GSU?
2. Please tell me what physics courses you have taken here at GSU, and which one are you are taking this semester (Spring 2011)?
   [ ] PHYS 1111   [ ] PHYS 1112   [ ] PHYS 1211   [ ] PHYS 1212
   [ ] OTHER? __________________________
3. Please tell me about your experience in one of these physics classes. Please describe this class, what was it like? [Options for encouraging more: What was the learning environment like? Integrated labs or separate labs? What did the teacher do? What did the students do?]

4... Do you feel the class was a valuable learning experience? Why or why not?
   [a. Options for encouraging more: What did the instructor do in this class that helped you to better understand what was being taught? OR that made it difficult for you to understand?]
   [b. Were there things that you had control over that helped you to enjoy or understand What was being taught? Or were there things that you wished you had control over that would have helped you to enjoy or understand what was being taught?] 

[Please take a moment to reflect on your high school days back home.....]
5. What is the most advanced math class you took in high school?
6. Did you take physics in high school, If yes, for how many years?
7. What was the language of instruction in your high school back home?
8. Can you please tell me about any physics class/classes that you took in high school back home? What was it like? [Options for more: What was the learning
environment like? Integrated labs or separate labs? What did the teacher do? What did the students do?

9. Do you feel the class was a valuable learning experience? Why or why not?
[a. Options for encouraging more: What did the instructor do in this class that helped you to better understand what was being taught? OR that made it difficult for you to understand?]
[b. Were there things that you had control over that helped you to enjoy or understand what was being taught? Or were there things that you wished you had control over that would have helped you to enjoy or understand what was being taught?]

[Ok, so by way of comparison;]
10. When you think about the differences or similarities in the styles of teaching or the classroom environment, comparing GSU to physics teaching in your home country, what factors do you think are most important in enhancing and supporting your study/learning of physics?

11. How do you rate your spoken/oral English on a scale of 1 – 5?
[5- excellent 4-good 3-average/ok or just fine 2- below average 1-not good]

12. Is there anything else you would like to add?
Appendix C: Information Survey

Name______________________________________________________________

What is your present school year status?
__ Freshman     __ Sophomore    __ Junior       __ Senior
__ Post-bac

What is your major?
_______________________________________________________

Have you taken Pre-calculus and if so where?
__ Never
__ High School
__ College/University

Have you taken Calculus and if so where?
__ Never
__ High School
__ College/University

Have you taken a Physics class before and if so where?
__ Never
__ High School
__ College/University

Phys1112K students only:
Did you take Phys1111K at GSU and if so, in what mode was it taught?
__ Took Phys1111K somewhere else
__ Took Phys1111K at GSU as lecture with separate lab
__ Took Phys1111K at GSU as combined lecture and lab in 500 Classroom South

What is your present age?   ______

What is your sex?    __ Male __ Female

What is your race/ethnicity? Mark one or more.
__ American Indian or Alaska Native
__ Asian
__ Black or African American
__ Hispanic or Latino
__ Native Hawaiian or Other Pacific Islander
__ White

What is your native language? ________________________________

Did you attend high school outside of the United States?
___________________

If so, in what country? ________________________________
APPENDIX D – Form of the Aggregated FCI Data for Fall 2010

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<tr>
<td>Phys 2211 pre/post/gain</td>
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**Categories**

- For students who took pre-calc in high school:
  - Local
    - Phys 1111 pre/post/gain
    - Phys 2211 pre/post/gain
  - International
    - Phys 1111 pre/post/gain
    - Phys 2211 pre/post/gain

- For students who took calculus in high school:
  - Local
    - Phys 1111 pre/post/gain
    - Phys 2211 pre/post/gain
  - International
    - Phys 1111 pre/post/gain
    - Phys 2211 pre/post/gain

- For students who took calculus/pre-calc in college (or College & HS):
  - Local
    - Phys 1111 pre/post/gain
    - Phys 2211 pre/post/gain
  - International
    - Phys 1111 pre/post/gain
    - Phys 2211 pre/post/gain

- For students who took Physics in high school:
  - Local
    - Phys 1111 pre/post/gain
    - Phys 2211 pre/post/gain
  - International
    - Phys 1111 pre/post/gain
    - Phys 2211 pre/post/gain

- Pre/gains by Race
  - Phys 1111 pre/post gains by race: Asian, Black, Hispanic, white
  - Phys 2211 pre/post gains by race: Asian, Black, Hispanic, white
### APPENDIX E: Georgia State University international students’ Top 20 Countries of Origin - (GSU’s ISSS report 2009. p 5)

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Appendix F - Introductory Physics - Course Descriptions

PHYS 1111K : Introductory Physics I, a three lecture and two laboratory hours a week course comprising of mechanics, heat, and wave motions course designed for biological and life science students (GSU 2010-2011 undergraduate catalogue)

PHYS 1112K : Introductory physics II, a three lecture and two laboratory hours a week course comprising electricity, light, modern physics course designed for biological and life science students (GSU 2010-2011 undergraduate catalogue)

PHYS 2211K : Principles of physics I, a three lecture and three laboratory hours a week. Mechanics, Heat, and Waves designed for physics, chemistry or computer science majors (GSU 2010-2011 undergraduate catalogue)

PHYS 2212K : Principles of physics II, a three lecture and three laboratory hours a week course comprising of electricity and magnetism, light, and modern physics designed for physics, chemistry or computer science majors, (GSU 2010-2011 undergraduate catalogue)
Volunteers Needed
For A Brief Interview (40 Minutes)
(Physics Education Research-Honors Thesis)

1. Are you currently enrolled (Sp 2011) in an intro physics course (Phys 1111, Phys 1112, Phys 2211, or Phys 2212)?
2. Did you attend high school outside of the United States?
3. Did you take physics in high school?

**IF you answered YES to all three, then you qualify!**

Please contact:

<table>
<thead>
<tr>
<th>Eric Appiah @ 404-749-0008</th>
<th>EMAIL: <a href="mailto:eappiah2@student.gsu.edu">eappiah2@student.gsu.edu</a></th>
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<tr>
<td>OR</td>
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<tr>
<td>Prof. Cherilynn A. Morrow</td>
<td>EMAIL: <a href="mailto:cmorrow@gsu.edu">cmorrow@gsu.edu</a></td>
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**Interview days: April 18th, 19th, and 20th**

Incentive: $20 Gift Card from GSU book store