ABSTRACT

DEVELOPING AND SUPPORTING SELF-EFFICACY IN PHYSICS UNDERGRADUATES AT CALIFORNIA STATE UNIVERSITY, LONG BEACH

By

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Self-efficacy is regarded as a significant predictor of academic success. This study examines the development of self-efficacy in upper-division physics majors within the Physics 310 - Analytic Mechanics course at California State University, Long Beach during the fall semester of 2015. The Sources of Self-Efficacy in Science Courses - Physics (SOSESC-P), as developed by Drs. Heidi Fencl and Karen Scheel in 2002, was administered to students enrolled in the class in a pre-test/post-test format to identify increases in self-efficacy during the course. Students demonstrated a statistically significant increase in self-efficacy on only one subscore of the SOSESC-P. The collaborative nature of the class is thought to have had an effect on the Social Persuasion ($t_{(23)} = 2.11$, $p = 0.023$) aspect of self-efficacy development. Students also reported perceptions of departmental support and participation in department-sponsored activities.

DEVELOPING AND SUPPORTING SELF-EFFICACY IN PHYSICS

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CHAPTER 1

INTRODUCTION

The inspiration for this study comes from a very personal place: the experiences of myself and many of my fellow classmates, or students with whom I later met and swapped stories, during our time at our respective undergraduate institutions. Based on our many discussions and commiserations I began to see a general trend among those of us who had completed our bachelor's degrees within the physics departments of large, research-driven universities. Over and over I heard graduates of these programs express the belief that their professors had been hired for their research contributions and expertise rather than teaching abilities. We felt that courses were taught by disinterested faculty with an air of "you should know this already," rather than an attitude supportive of student learning and exploration. Graduate student teaching assistants rarely appeared interested in the undergraduate experience or even in honing their own teaching skills. Our collective experience had been that the research mattered, not our education. Only the most ambitious or persistent students seemed to emerge from this environment, this "culture of failure," with their confidence and self-esteem intact. I was left, as were many of my peers, with feelings of "imposter-syndrome," self-doubt, and general failure, regardless of GPA or honors earned. We definitely did not "feel like physicists."

The environment at California State University, Long Beach seems to be different.

Students within the Physics and Astronomy Department in general appear to have rather high morale, with graduation and retention rates to match. Education and student outcomes are the priority; research is emphasized inasmuch as it benefits the students through laboratory experience. Student collaboration is encouraged and professor offices are in the same hallways as classrooms and labs, where they interact with students as members of the department as physicists [1].

In 2011, the National Academy of Sciences began tackling the task of identifying "the goals and challenges facing undergraduate physics education" and how to implement changes in undergraduate physics education on a national level. A main issue identified during the course of their meta-analysis of Physics Education Research is that the traditional approach to undergraduate physics education most often practiced at large, research-driven institutions, the "lecture-recitation-laboratory format," is fundamentally flawed for today's students, especially the increased population of women and underrepresented minorities in contemporary universities. The dominant message of their 127-page report? "The traditional educational paradigm for teaching undergraduate physics must change." They found that "lecture-based classroom instruction is not nearly as effective in teaching students or creating positive attitudes toward physics as many have assumed" [2].

The phrase "creating positive attitudes" hit home for me. I had performed well-enough in my undergraduate program, but I did not emerge from it believing myself to be a confident "physicist." This feeling was echoed in the voices of my peers. The problem, it seems to me, is that certain physics students are not developing self-efficacy, or the "belief in his or her capacity to execute behaviors necessary to produce specific performance attainments." This led me to investigate whether or not undergraduate physics majors at Long Beach State are experiencing an increase in self-efficacy during their Analytic Mechanics course.

There is a significant body of research pertaining to self-efficacy within introductory Physics classes, which consist mostly of non-majors. However, only around 1% of the students enrolled in introductory physics courses nationally graduate with a degree in physics and the National Academy of Sciences has called for more physics education research in upper-division courses [2]. As a physics degree-holder myself, I am interested in whether the undergraduates within our major at CSULB are developing self-efficacy. This abbreviated study looks at one semester, Fall 2015, of Physics 310: Analytic Mechanics.

This is a junior level course required of all students seeking a BS or BA in Physics and is a prerequisite to all other upper-division major courses [3]. There is little variation in the core curriculum of any undergraduate physics program in the nation. Prospective physicists, along with other scientists and engineers, enroll in calculus-based lower division physics courses focusing on kinematics, dynamics and modern physics during their freshman and/or sophomore years. Once they advance to upper division courses in their junior year, they proceed into analytic mechanics. This is generally the physics bachelor degree candidates' first upper division course and can serve as a "gatekeeper" or "filter" course, weeding out less interested, dedicated or able students. As an upper division course, it includes native freshmen and first-time transfer students into the physics undergraduate program. While there may be variation in teaching styles, practices and pedagogies, there is little to no variation in content between analytic mechanics courses offered in different colleges and universities and only a handful of textbooks that are used within these courses [2]. Analytic Mechanics is fundamental and consists of the same content across campuses throughout the U.S. This particular course at CSULB is offered once per year in the fall. There is only one section per semester and it is taught by a tenured professor who also acts as the undergraduate advisor. This upper division course is a good class to investigate because it is the first upper division course within the major and contains both native freshmen and transfer students.

A background of the department was formed through a review of the departmental self-studies performed in 2007 and 2014 and faculty interviews, giving me insight into the recent developmental and cultural history of the Physics and Astronomy environment at CSULB. The research instrument utilized in assessing student self-efficacy was the Sources of Self-Efficacy in Science Classes Physics (SOSESC-P) as developed by Drs. Heidi Fencl and Karen Scheel. The SOSESC-P was administered to participants as a PRE survey on the first day of class and as a POST survey on the last day of class. Paired t-tests were performed to look for trends in student self-efficacy. A secondary CSULB-specific, short-answer survey was also administered on the last day of class in order to collect information about student utilization of department resources and student perceptions of support. In addition, the number of students who continued forward in the major, taking the next semester course, was collected. Although this study is small in scope, I hoped to see some correlation and extend the framework to future, more involved studies on a larger scale with a much larger data pool.

Chapter 2 covers the general landscape of physics education, defines self-efficacy, and introduces the Physics and Astronomy Department at California State University, Long Beach. Chapter 3 describes the methodology of the study, including data collection via the survey instruments and analysis. Results are covered in chapter 4 and the implications and limitations thereof in chapter 5.

CHAPTER 2

LITERARY REVIEW

National Landscape of Physics Education

The National Academy of Sciences published a 127-page report in 2013 regarding the state of physics education on a national level. Approximately 500,000 college students per year take an introductory physics course; however, just over 1% of those students ultimately receive a physics degree. Physics as a major has shown only 20% growth over the fifty-year period from 1965-2015, while STEM majors in general have increased by 200% and overall college enrollment has increased by over three hundred 40% [4, 5]. The National Academy suggested that the low numbers of STEM majors, especially in physics, is “detrimental to the intellectual health of the nation” and that the physics community needs to “pursue paths that can lead to improved student understanding of physics, reasoning skills, and attitudes toward physics” [2]. A 2012 report from the President’s Council of Advisors on Science and Technology (PCAST) calls for an additional one million STEM graduates over the next decade to fulfill the needs of our technologically advancing nation. Much of the problem with declining physics enrollment lies in students who initially show interest, but change their majors. The report states, “Merely increasing retention from 40% to 50% would translate to an additional 72,500 STEM degrees per year, comprising almost three-quarters of the 1 million additional STEM graduates needed over the next decade." It is also noted that many students leave the major because they find "teaching methods and atmosphere in introductory STEM classes as ineffective and uninspiring," while those students who have performance issues "would benefit from alternative teaching methods, tutoring, or other experiences" [6].

Students often describe physics classes as "low in stimulation, personal usefulness, social value, historical value, and political value" and complain that laboratories are not exciting or useful, and unsupportive of their lecture lessons [7]. It has been demonstrated many times over that the century-old traditional teaching method of "lecture-recitation-laboratory" results in limited gains in students' conceptual understanding [2] and actually causes a decline in their "expertlike" beliefs [8]. Students in these classes often memorize the results of example problems, then incorrectly generalize those results to other problems [9]. Traditional lecture courses have also been shown to have a negative effect on students' attitudes, beliefs and self-efficacy, which decrease from the beginning to the end of the course [2, 10, 11]. Colleges and universities can be slow to make changes and our physics students suffer for it, experiencing difficulties with sense-making and problem solving [2, 10]. This current paradigm is especially damaging to important groups who are currently underserved in traditional physics programs; namely women, underrepresented minorities, and prospective high school teachers. To top it off, students from these groups at "selective institutions that have a large graduate-to-undergraduate student ratio and that devote a significant amount of spending to research have lower persistence rates than similar students at other institutions" [2].

According to the Digest of Educational Statistics published by the Department of Education, women and minorities made up 75% of college students in 2015 [12]. This "underrepresented majority is a large underutilized source of potential STEM professionals and deserves special attention" [6]. In 2014, white males received 45% of the STEM bachelor's degrees awarded that year; however, STEM fields as a whole represented less than 13% of all bachelor's degrees awarded. Specifically, Physics and Astronomy degrees made up only 0.4% of the total bachelor's degrees awarded, with women and underrepresented minorities receiving less than half of those [5]. The underrepresentation of women and minorities in physics has received national attention. In December 2015, the American Physical Society, a non-profit membership organization working to advance the knowledge of physics, sent a letter to the Supreme Court of the United States in response to disparaging remarks regarding African-Americans in physics made during a court proceeding. The letter states "the process of scientific discovery is a human endeavor that benefits from removing prejudice against any race, ethnicity, or gender" [13].

Such a low number of physics degree holders is not for lack of necessity; just within the field of education there is an extreme deficit of qualified physics professionals. As a nation, we are not producing enough high school physics teachers for the amount of students enrolling in high school physics classes. Sadly, only about one-third of high school physics teachers actually hold a degree in physics or physics education [2]. The lack of skilled physicists teaching high school physics perpetuates the inherent problem. Teachers who are knowledgeable and passionate about physics will inspire more high school students to pursue physics in college, which in turn will produce more skilled and knowledgeable physicists and physics teachers, and so on, increasing diversity in physics and physics teaching while improving the "intellectual health of the nation" [2].

There have been numerous studies published suggesting that changing the way that physics is taught will increase the recruitment and retention of these underrepresented groups, and physics students in general [2, 14–18]. The National Academy of Sciences states that a "theme has emerged from educational research: Learning improves when students are interactively engaged with their peers, their instructors, and the material being learned, and when they are integrating the newly learned concepts with their previous ideas, whether learned in a formal classroom or in everyday life" [2]. In "Engage to Excel," the President's Council of Advisors on Science and Technology reports that "Some campuses have shown that differences in performance and retention between traditional STEM majors and members of the underrepresented majority can be reduced substantially by several simple changes in campus or classroom practices" [6]. Implementation of more engaging teaching methods featuring active collaboration between student and professor has been shown to improve students' attitudes toward physics which, in turn, increases student abilities and retention [2, 8, 14, 15, 19–22].

Self-Efficacy

Self-efficacy is an important factor in student attitudes and is positively linked with changes in confidence, task persistence, interest in physics, and future science study and career plans [15, 23, 24]. This construct, developed by Bandura, is one's belief that she or he is capable of succeeding at a specific task, which influences attempted and avoided behaviors [22, 25]. Self-efficacy is a dynamic attribute that can be increased or decreased through four channels. The first is through prior experiences with task completion; when one accomplishes a task, one feels more effective at completing the same or similar task in the future. This building of efficacy through personal triumphs is referred to as Performance Accomplishment (PA) or Mastery Experience (ME); the latter will be used in this study. Self-efficacy is also developed through Social Persuasion (SP), the external messages one receives from family, peers, instructors, a community, or even society as a whole. A third source of efficacy development for an individual is through watching others succeed at the task at hand. This Vicarious Learning (VL) is often done through classmates during group collaboration, homework sessions, or other social settings in which individuals work together. Lastly, there is Physiological State (PS), originally referred to as Emotional Arousal (EA), which is most often one's anxiety or stress level [10, 22, 25].

Self-efficacy is "one of the primary dimensions of students' overall science identity and contributes to their persistence in physics" [15] and is "very effective at explaining perseverance and success across the educational spectrum, including undergraduate education and science-related majors" [22]. Lent, Brown, and Larkin found that "subjects reporting high self-efficacy for educational requirements generally achieved higher grades and persisted longer in technical/scientific majors over the following year than those with low self-efficacy" and that "self-efficacy was also moderately correlated with objective predictors of academic aptitude and achievement" [26], which was also true for Andrew [27]. Lent, Brown, and Larkin supported these results in later studies and stated that "self-efficacy contributed significant unique variance to the prediction of grades, persistence, and range of perceived career options" [28, 29]. Other studies have supported these findings, but with more moderate results in math and other subjects [30, 31]. Self-efficacy development is of particular interest when it comes to women and underrepresented minorities. Shaw found a significant relationship between self-efficacy and course grade for female students [32], which is supported by Sawtelle, Brewe, and Kramer [10, 15].

Instructional methods that contribute to student self-efficacy can aid in the increase of student success [15, 23]. Methods that have been shown to positively increase students' self-efficacy include implementation of collaborative group work, model development, and interaction between the students and instructor [2, 10, 14]. Tseitlin and Galili found that scientists, often educators themselves, frequently "fail to consider science in an educational perspective." They encourage educators to "humanize" physics and bring new values and pedagogies into physics culture to "rescue physics education from its current crisis." Tseitlin and Galili also stress that physics teaching is often geared toward engineers, focusing on application over theory, but future teachers, scientists and other non-engineers require a different style, of a more fundamental orientation, higher conceptual quality, and theoretical understanding [33].

California State University, Long Beach

Many of these educational values can be found at California State University, Long Beach. The provost's web page states the school's mission clearly, "California State University, Long Beach is a diverse, student-centered, globally-engaged public university committed to providing highly-valued undergraduate and graduate educational opportunities through superior teaching, research, creative activity and service for the people of California and the world" and the school "is committed to changing lives by expanding educational opportunities, championing creativity, and preparing leaders for a changing world" [34]. One of CSULB's core values is educational opportunity, placing great importance on the experience of their students. The Physics and Astronomy department is a leader in awarding Physics M.S. degrees and the undergraduate program seems on track to catch up. Long Beach is already surpassing other CSUs in Physics bachelor's degrees awarded [35].

The department self-studies were read to identify changes in the program, support services, or departmental culture from academic years 2007 to 2014. The 2007 study identified two priorities directly affecting undergraduates: "Undergraduate upper division curriculum priorities for physics majors" and "recruitment and retention priorities for undergraduate physics majors." At that time, the undergraduate options were a minor in Physics, the B.S., and the B.A., which was "designed for the student who expects to teach at the secondary level, or who seeks a high-quality liberal education focusing on science." The B.A. typically had small enrollment numbers compared to the B.S. (5:81) and was geared mainly toward students interested in teaching. There were also two new undergraduate course offerings (dual enrollment with graduate students) and a few courses were revised to generate more interest and meet the changing needs of Physics students. The department had also just begun to "sharpen and make more accessible our introductory offerings in PHYS 151 and 152, particularly in the laboratories in a way that we judge will be more fruitful in terms of recruitment and retention of physics majors." The Undergraduate Physics Experiences Winter Session program was implemented for the first time in January 2006. This program allows select freshman and sophomore students to work with a faculty mentor on a brief research project over the short winter break. The department had also secured funds to begin a Research Experience for Undergraduates (REU) program in the summer of 2017. They were also able to offer a new scholarship, the "John and Terry Milligan Scholarship, established in Spring, 2007, and providing $1000 per semester" to students who are working at least part-time, in order to contribute to their own education costs, and maintain a GPA of 3.0 or better. The study indicates that Physics degrees account for only approximately 2% of the STEM degrees awarded in 2005 and that enrollment in the Physics 310 Undergraduate Mechanics course hovered around 13 students from Fall 2002 through Fall 2007 [36].

By 2014, the department's commitment to improving student experience had paid off by earning them the Award for Improving Undergraduate Education from the American Physical Society. APS also enriched the department with two grants; one to "increase the number of qualified high school physics teachers through the Physics Teacher Education Coalition (PhysTEC)," and the other to "increase ethnic and racial diversity in physics PhD programs (APS Bridge)." The department received the PhysTEC grant during the 2010-2013 academic years and used it to build "a physics-teaching network for physics majors, single-subject credential students, physics and science education faculty, and teachers in LA and Orange counties." Under this grant, two new courses were added to support prospective teachers, and entice majors into teaching, with pedagogical training and incentives. Due to this important partnership with APS, the department had become "the focal point of the high school physics teaching network in Southern California, involving in-service teachers, credential students, physics majors, and faculty." In the five years prior to the implementation of the grant, only a single physics major had pursued a high school physics teaching credential. In spring 2014, the department had 20 designated PhysTEC scholars, physics majors considering high school physics teaching as a career option. The Physics and Astronomy Department also works closely with the Science Education Department to maintain and develop this program and related courses [37].

The other APS grant, for the Bridge Program, was developed to broaden the participation of underrepresented minorities in physics and astronomy. As one of only six Bridge sites, CSULB is the only master-granting institution in the U.S. receiving this grant. The year 2014 is also when CSULB began collaborating with the Cal-Bridge program, "funded by NSF, to increase the number of California State University students completing their bachelor's degree and successfully entering Astronomy PhD programs; three CSULB students have been selected as Cal-Bridge Scholars (30% of all Cal-Bridge Scholars)." Along with these new grants and programs, the B.A. program was modified "to allow curricular flexibility and to accommodate students who seek the broad job opportunities and the academic rigor without the full B.S.-level upper division Physics requirements" and the number of low-completion-rate courses had notably declined from the 2007 review. The department significantly grew in size from 2007 to 2014, with nonmajor FTES increasing from 466.0 to 532.5 and majors increasing from 7.6 to 32.9

FTES. The changes implemented to the B.A. program significantly increased the number of those degrees awarded from none in the 2007-2008 academic year to ten in 2013/2014. B.S. degrees granted also increased during that period, from three to fifteen. The CSULB Physics and Astronomy department also contributes significantly to diversity in physics; during the 2012-2013 academic year the school awarded “1.5% of all Hispanic physics bachelor degrees in the U.S.” [37].

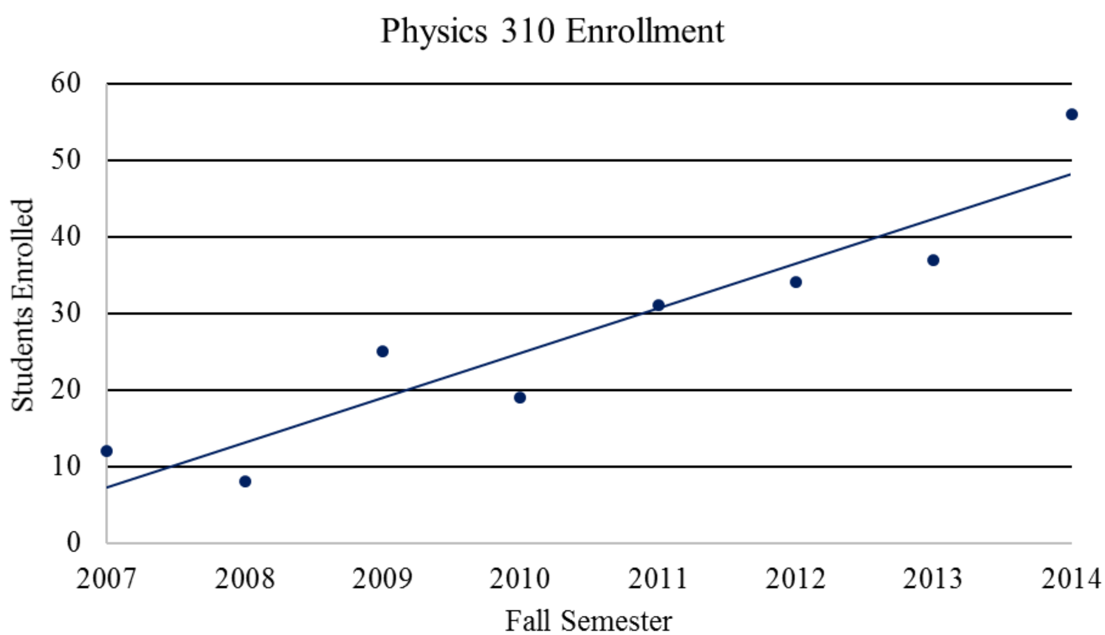

FIGURE 1. Physics 310 enrollment trends from the 2014 Self Study.

Significant to this study are the enrollment numbers in the undergraduate upper-division Physics 310: Analytic Mechanics course, a course taken by both BA and BS candidates. Enrollment in this fundamental class had increased from thirteen to fifty-seven students during the interim period between the 2007 and 2014 self-studies.

During the interviews, department faculty also identified changes that they felt had influenced enrollment and retention. They each touted the revolutionary changes that PhysTEC, APS Bridge, and the revamped B.A. program brought about, but they also shed light on other, subtler differences. The undergraduate Society of Physics students came up often. This society promotes social interaction between students, offers a more creative outlet for development of physics understanding through projects and events, and its members provide tutoring to lower-division students. The department makes an early effort to help students develop camaraderie by grouping the physics majors within the Physics 151/152 introductory physics courses (which also include, biology, chemistry and engineering majors), holding a Winter Physics Program to introduce those students to research during their break, and ensuring that these introductory courses are taught by tenured or tenure-track faculty, rather than adjunct faculty or lecturers. The students also have rooms within the department in which to study or socialize and the department hosts frequent "mixers" to get the students, both undergraduate and graduate, and faculty to mingle and become more comfortable and acquainted with one another. Three departmental faculty members worked together to develop the Koondis online learning system, which encourages students to work together in an internet-based setting on what the team calls "social homework" [1].

Throughout the interviews, faculty expressed a general theme that many changes within the department began even before the 2007 study as new faculty were coming onboard and "the old guard" was retiring and taking their more traditional lecture-recitation-laboratory classroom structures with them. They also provided their own perspectives as to why students leave the major. Aside from the rigor of the coursework, they suggested that students leave due to outside pressures from work or family, lack of "coaching" from peers and/or faculty, feeling "less integrated" due to being physically separated from faculty and graduate students on their campuses, and a lack of perceived career options. Some faculty members felt that students were drawn away by the perception that engineering offers more and higher-dollar job prospects. Most importantly (arguably), the department does not ascribe to the traditional "bottleneck" or "weeding out" courses, often seen in early upper-division STEM coursework, in which classes are intentionally very difficult and harshly graded in order to select only the most dedicated and resourceful students to carry on in the major [1].

Typical Physics Course Sequence

The typical physics program requires undergraduates to complete a math sequence consisting of three semesters of calculus and some combination of linear algebra and differential, offered together or separately, depending on the institution. Once the student has completed their first semester of calculus, they can begin the lower division physics coursework (some schools allow this concurrently). The lower division calculus-based physics series requires one course in mechanics, one in electricity and magnetism, and one in modern physics, each accompanied by a corresponding laboratory. Once they have completed these prerequisites, the student can move into upper division coursework, which begins with analytic mechanics and continues with electrodynamics, thermodynamics, quantum mechanics, and other upper division electives in specialized topics. While other requirements and course offerings may vary from one institution to the next, this core sequence of curriculum is steadfast throughout the nation, and much of the world [2, 37].

The first upper-division course that physics majors see at CSULB is Physics 310: Analytic Mechanics. This course covers "Kinematics and dynamics of mass points and systems of particles. Conservation laws. Harmonic motion. Central force problem. Noninertial frames of reference. Lagrangian and Hamiltonian formulation of laws of mechanics." and is offered each fall and is required of all physics and engineering majors [3]. The course is not taught in a traditional classroom, but rather an "active learning" classroom. Students sit in groups of eight-to-ten at collaboration tables equipped with Windows computers, flat-panel monitors, writable surfaces, and mobile device input connections [38]. The professor instructs from a central teaching station and students are encouraged to actively participate in the class and work together on in-class problems. These are some of the attributes identified as variables that can affect student self-efficacy [2, 10, 14].

<u>Overview of Methods</u>

In order to test for a possible increase in student self-efficacy over the course of Physics 310, I chose to use the Sources of Self-Efficacy in Science Courses Physics (SOSESC-P) developed by Fencl and Scheel for their 2002 (published 2004) study "Pedagogical approaches, contextual variables, and the development of student self-efficacy in undergraduate physics courses." This is a 33-item instrument that measures participant's self-efficacy in regards to physics classes on a five-point Likert scale, with responses that range from "strongly agree" to "strongly disagree." It is a self-reporting instrument, designed for introductory college physics courses, which measures an individual's beliefs about their ability to understand and/or solve physics problems. Overall self-efficacy scores are reported along with a subscore for each of the four identified sources of self-efficacy development: Mastery Experience (ME), Social Persuasion (SP), Vicarious Learning (VL), and Physiological State (PS). Items are distributed among the four sources of self-efficacy as follows: ME 10, SP 7, VL 7, and PS 9. Sum of scores across items are added to get the four subscores. All items are positively worded with fourteen reverse-scored items that need to be adjusted for data analysis. The items consist of statements like:

1. I received good grades on my assignments in this class.

8. I found the material in this course to be difficult and confusing.

19. I identified with the students in this class who did well on exams/quizzes.

The authors developed the instrument as part of a larger study of pedagogies. The SOSESC was "modeled on existing scales and designed to examine the sources of self-efficacy" as defined by Bandura [25]. The SOSESC was administered to a group of 329 introductory chemistry students along with Lent's established tool Self-Efficacy for Technical/Scientific Fields [28]. This parallel analysis "showed both internal consistency reliability and validity via significant associations with an established (although not course specific) measure of science/engineering self-efficacy and the previously described outcome variables" [22]. The instrument has been implemented with success in other studies [10, 11, 15, 24, 38].

CHAPTER 3

METHODOLOGY

Background

My interest in self-efficacy development focuses on students who have chosen to pursue bachelor's degrees in Physics; hence, I found it most relevant to conduct my research with junior-level undergraduates who have begun their upper division coursework. Choosing undergraduate students at this level also ensures that my pool will include transfer students from community colleges, as well as native freshmen. This is particularly important for this study, as 20% of physics majors in the U.S. begin their undergraduate careers in Community Colleges [2]. Students at this level are typically around twenty years old, but many non-traditional students of greater age are often included.

The study was conducted with the Analytic Mechanics course offered in Fall 2015 at California State University, Long Beach. CSULB is a comprehensive, master's degree granting institution. With 31,198 full time equivalent students (FTES) on campus, CSULB is one of the larger campuses in the California State University system and one of the largest campuses in the country. In the fall of 2015, the Department of Physics and Astronomy had thirteen tenured or tenure-track faculty (nine of whom were engaged in research), six lecturers, and forty-five teaching assistants from the pool of sixty-two graduate students. At the time the study was conducted, there were 139 declared undergraduate physics majors, eighty-nine Bachelor of Science candidates and fifty Bachelor of Arts candidates. Of those numbers, seventeen of the BS students and five of the BA students had declared double-majors, with physics not necessarily counted as the primary major. The department has made it quite feasible for the BA students to also pursue a degree in some type of engineering, either as their primary or secondary degree, and many of them do [1]. At the time of publishing, university demographic statistics were unavailable for the 2015-2016 academic year. Of the students who chose to report demographic details to the university (N = 34) for the 2014-2015 academic year, 41% of the physics students were female, 59% were male, 35% of students identified themselves as Hispanic or Latino, 26% Caucasian, 21% Asian or Pacific Islander and 6% identified as more than one ethnicity [39]. Physics 310 is a junior level course required of all students seeking a BS or BA in Physics and is a prerequisite to all other upper-division major courses. The course only appears in the University catalog one other time, as a possible elective for a Math option, so the cohort is predominantly composed of Physics majors, whether they are seeking the major as the primary or secondary degree [3].

This particular class is a "gateway" course that serves as a prerequisite for future upper division physics courses and, as such, all students seeking a BS or BA in physics enroll in it in their first upper division semester [3]. An upper division Analytic Mechanics course is fundamental within all physics programs and is almost identical in content at all institutions offering undergraduate degrees in Physics [37]. There were sixty students enrolled in the course, of which fifty-three consented to be part of the study and responded to the PRE survey. Only forty-one responded to the POST survey. Of this number, I was only able to match 24 PRE and POST surveys due to respondents leaving off or forgetting their personal identification numbers. Demographic data was not collected in this study. The class is relatively small and collection of such data could have unintentionally identified participants.

Data Collection - Departmental Self-Studies and Interviews

Information about the Department of Physics and Astronomy at California State University, Long Beach (CSULB) was provided via two departmental self-studies conducted in 2007 and 2014, and various faculty interviews. Per university guidelines, the Physics and Astronomy Department regularly performs a self-study in order to review its degree-granting programs. Along with describing the program's mission and goals, the self-study reports trends within physics and how the department is responding to those changes and "keeping up with the times." Alterations and additions to the program and faculty are also reported, along with student services, resources, facilities, and other factors that affect the students within the department. Most importantly for my particular research, the self-study reports student learning outcomes and assessment, enrollment and graduation rates and other pertinent information. The Physics and Astronomy Department self-studies are available from the department office.

In order to fill in the timeline between self-studies, I interviewed seven faculty members who have been with the department since the date of the 2007 self-study or prior. I chose faculty members who maintain leadership roles within the department, who regularly teach undergraduate courses, or who otherwise interact with undergraduates on a regular basis. These interviews were conducted simply to develop background and enrich the content of the departmental self-studies and, as such, I have agreed not to directly quote any faculty so that their individual comments may remain anonymous. Each faculty member interviewed was asked one broad question, then five more leading questions if he or she found the initial question too broad. The interview questions are in Appendix A.

Data Collection - Survey Administration

The data collection phase of this investigation was carried out using three survey tools, a PRE and POST version of the SOSESC-P, and a short self-authored survey regarding student perception of department-specific support options. The SOSESC-P itself was detailed in the previous section (II.D). It was slightly modified from the original version provided by its author, Dr. Heidi Fencl, with her permission. The language of the SOSESC-P is such that the respondent should answer based on their experiences in a particular course they have just experienced. This phrasing was appropriate for the POST survey, but in order to create the PRE survey, the wording was altered to present-tense verbiage such that it made sense to participants and evaluated their accumulated Physics experiences to date (Appendices B, C and D).

On 8 August 2015, I attended the first class meeting of Physics 310. I arrived early and placed one Informed Consent document and one SOSESC-P PRE survey at each seat. Once all of the students had arrived, the professor introduced me and left the room. I introduced myself to the class, explained my research, and asked for their participation. As per the Institutional Review Board, participants needed to provide informed consent in order to participate in the study and their participation, or lack thereof, would not impact their grade. Every student was provided with a PRE SOSESC-P and an Informed Consent document, although they were not required to complete them. I answered a few questions from students, set up two ballot-type collection boxes on the center table, and left the room. I waited fifteen minutes, then returned to collect the boxes and thanked them for their patience and cooperation.

I returned to the class on 8 December 2015 to administer the SOSESC-P POST and CSULB-Specific surveys in a similar fashion. I arrived early, placing blank surveys at every seat and set up my collection boxes. Once the students arrived, I reminded them who I was, why I was there, and asked them to remember their personal identification numbers and note them on the surveys. I also reminded them that their participation was not mandatory. Once again, I fielded any questions then left the room for fifteen minutes, returning to collect the boxes, thank them for their participation, and wish them luck on their final exams. The full IRB application, including the script , can be reviewed in Appendix F.

One small, final step was taken in data collection. I attended the Physics 350 course in Spring 2016 and requested that anyone who participated in this research write his or her PIN on a slip of paper and drop it into a ballot box. This was done in order to see how many students from the Fall Physics 310 class continued on to the Spring Physics 350 class.

Research Question and Data Analysis

This study seeks to discover if there are changes in undergraduate student self-efficacy during the course of Physics 310: Analytic Mechanics at California State

University, Long Beach. In preparation, a background of the Physics and Astronomy department at CSULB had to be developed. The department provided copies of its own self-studies from 2007 and 2014. These were reviewed to identify changes in the program, support services, or departmental culture between the self-study dates. Key faculty members were then interviewed (Appendix A) in order to obtain their perspectives and to support and develop the information from the self-studies. These sources were the framework for the development of the CSULB Specific survey, which was designed to garner student perspectives in order to validate the ideas put forth by the department.

Preparation for Analysis

The initial instrument administered to participants was the SOSESC-P PRE survey. The fifty-two completed measures were collected and the responses keyed into an Excel spreadsheet. Individual responses were only identified at the beginning of the row of numerical responses by the student's personal identification number. There were two cases of duplicate personal identification numbers used by students; in each case I differentiated them by adding an "A" or a "B" after the four-digit code. Nine PRE surveys were submitted without personal identification numbers, so these were differentiated by adding a letter only, A through I. At the end of the semester when the forty-one completed POST surveys were collected, duplicate personal identification numbers that appeared again and could be easily match by the respondent's distinct handwriting and specific choice in writing utensil were identified by their same letter, "A" or "B", from the PRE surveys. Extraneous or unmatchable duplicate personal identification numbers were differentiated by adding an "X". Surveys submitted without personal identification number were again identified by a letter only, J through S, continuing the alphabet from the PRE surveys. One survey was submitted with personal identification number "N/A", which did not appear in the submitted PRE surveys. One submitted POST survey, "S", was excluded from the final data analysis of the SOSESC-P surveys. This particular respondent completed the survey by drawing an arrow down the entire column of "1 Strongly Disagree". While it is obvious that this respondent was making a very clear, general statement about their experience over the semester, the manner of the response demonstrates that the respondent did not read each item thoroughly and, as such, these responses cannot be deemed reliable. Respondent "S" did provide some useable responses on the CSULB-specific survey.

Statistical Analysis

Once all of the responses for the PRE and POST surveys were entered into spreadsheets, reverse-scored items were revalued using a simple 6-x, where x is the respondent's original Likert scale value, within the mean value calculations. Each respondent's mean value in the four self-efficacy categories was calculated (Mastery Experience, Vicarious Learning, Social Persuasion, and Physiological State) for the PRE and POST surveys. The overall mean for the PRE responses was then compared to the mean of the POST using a t-test. The Cohen's d effect size was also calculated. The PRE and POST values were evaluated two different ways. The entire set of fifty-three PRE responses was compared to the entire set of forty-one POST responses with an unpaired, two-tailed t-test to see the general results for the overall study. The twenty-four respondents whose results were able to be matched from PRE to POST survey were then separated from the rest and the trends analyzed using a paired, two-tailed t-test [40].

Of the forty-one POST surveys that were returned, thirty-eight of the respondents also completed the attached CSULB Specific Survey. This was a brief five-question survey designed to garner student perspectives about the department. Students were asked if they Planned to continue in the major, if they felt that the department is supportive of the undergraduates, how often they met with the undergraduate advisor, whether or not that had been provided information on options once they have the degree, and what departmental activities that had participated in. Four of the questions were posed as Likert-style questions, with added space for respondents to elaborate their feelings, and the last as a “select all that apply” multiple choice. Student responses were entered into an Excel spreadsheet and responses to each question were averaged to look for a general positive or negative “feeling” among the respondents toward the major and/or the department and services they offer. Short-answer comments were coded using qualitative coding techniques as outlined by Cresswell [41].

CHAPTER 4

RESULTS

SOSESC-P

In order to find out of undergraduate students in the Physics 310: Analytic Mechanics course at CSULB are experiencing developments in self-efficacy, the Sources of Self-Efficacy in Science Courses Physics (SOSESC-P) was administered in the fall of 2015. The SOSESC-P is 33-item instrument that measures participant's self-efficacy in regards to physics classes on a five-point Likert scale, with responses that range from "strongly agree" to "strongly disagree". It is a self-reporting instrument, designed for introductory college physics courses, which measures an individual's beliefs about their ability to understand and/or solve physics problems. Overall self-efficacy scores are reported along with a subscore for each of the four identified sources of self-efficacy development: Mastery Experience (ME), Social Persuasion (SP), Vicarious Learning (VL), and Physiological State (PS). Items are distributed among the four sources of self-efficacy as follows: ME 10, SP 7, VL 7, and PS 9. Sum of scores across items are added to get the four subscores. All items are positively worded with fourteen reverse-scored items which need to be adjusted for data analysis [22].

Preliminary analysis of the full set of SOSESC-P (53 PRE and 40 POST) scores indicated there was no statistical significance on any subscore or the overall self-efficacy score. None of the independent samples t-tests performed were able to reject the null hypothesis. While independent samples t-tests are less powerful than matched pair t-tests, this initial analysis was carried out since so much of the data was unmatched. The analysis of this data is summarized in Table 1.

TABLE 1. Independent t-Test for Entire Data Set

	ME		VL		SP		PS		Total SE	
	PRE	*POST*	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*
Mean	3.843	3.810	3.849	3.939	3.914	4.057	3.673	3.736	3.813	3.870
Variance	0.314	0.309	0.312	0.324	0.214	0.275	0.243	0.259	0.202	0.215
Observations	53	40	53	40	53	40	53	40	53	40
t	-0.286		0.763		1.373		0.601		0.591	
p	0.388		0.224		0.087		0.275		0.278	
Cohen's d		-0.060		0.160		0.293		0.126		0.124

Dependent sample t-test analysis of the twenty-four paired SOSESC-P scores told a similar story. Three of the four subscores showed no significant change and the null hypothesis could not be rejected. Vicarious Learning (VL) and Total Self-Efficacy (Total SE) demonstrated increases that were not statistically significant, but might have been with a larger sample size, noting the moderate Cohen's d score. Social Persuasion (SP) is the only source subscore that produced a statistically significant result, with a p-value of 0.023 and a moderate effect size of 0.326 [40].

TABLE 2. Dependent t-Test for Matched Surveys

	ME		VL		SP		PS		Total SE	
	PRE	*POST*	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*	*PRE*	*POST*
Mean	3.858	3.908	3.881	4.030	3.946	4.089	3.704	3.759	3.840	3.932
Variance	0.151	0.248	0.191	0.295	0.166	0.218	0.118	0.232	0.075	0.171
t	0.517		1.295		2.110		0.485		1.211	
p	0.305		0.104		0.023		0.316		0.119	
Effect Size		0.112		0.302		0.326		0.133		0.263
Cohen's d		0.106		0.264		0.431		0.099		0.247

CSULB-Specific Survey

The CSULB-Specific Survey (N = 37*) was a brief five-question survey designed to garner student perspectives about the department and to corroborate department and/or faculty ideas and assumptions about the undergraduate experience. The first two items were posed as Likert-style questions followed by free-response space for participants to elaborate on their feelings. The third and fourth were simple Likert scales, while the fifth item was a "select all that apply" multiple choice. The free-response comments were coded by response type: Positive/Enthusiastic (PE) for comments that were favorable toward the department or major ("I love Physics"), Ambiguous/Neutral (AN) was assigned to statements which did not communicate a clear idea ("Because"), Negative/Criticism (NC) when students expressed negative feelings or offered constructive criticism ("I'm not good at this subject." or "Im in hell."), and BC for those who responded but left the comments blank. Aside from the four predetermined codes, a fifth code emerged during analysis: Dedicated/Persistent (DP) for those that expressed a desire to finish the program based on personal beliefs about not giving up ("I'm in too deep to stop now."). While still representative of students choosing to continue in the major, the choice to stay due to persistence is decidedly different from choosing to stay out of enthusiasm.

The number of these surveys that were not completed (NR) by participants who otherwise completed the POST survey was tallied for completion rates. Of the original course enrollment of sixty students, 88% participated in the PRE survey, 68% in the POST, and 62% in the CSULB-Specific survey. For the students who filled out the department survey, the PE, DP, AN, and NC codes, and the number of departmental extracurricular activities that respondents participated in, was noted in order to observe correlations between attitude toward the major/department and student involvement [43]. Of the forty-one completed POST surveys returned, thirty-seven also completed the CSULB Specific Survey. Of that number, six did not elaborate on their choices by providing additional comments, choosing only to respond to the Likert and multiple-choice questions. Sixteen of the participants who provided comments praised the faculty, some calling out specific faculty members by name. This does correlate with the faculty's efforts to ensure that all students feel a part of the department and supported within its halls. One student responded that s/he would not be continuing in the major, stating "Im not good at this subject;" however, that same student commented that department contained "nice people!!!" The student who responded with "Im in hell" as their reason for not staying in the major also rated the department as supportive (and drew a smiley face). These particular results support the department's assertion that student experience is a priority; these participants definitely feel supported.

TABLE 3. CSULB-Specific Results

Major & Departmental Support	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I plan to continue in this major.	2	2	1	9	23
The Physics and Astronomy department is supportive of its undergraduate students**	0	0	7	11	18
The department has provided me with information on what I can do with my degree	1	0	8	17	10

*one only filled in the first response area

**one wrote in "Not Applicable"

Advising Frequency	Never	Once	Once/Semester	Twice/Semester	More Often
I meet/have met personally with my advisor an average of:	4	8	10	9	5

Three of the four students who responded that they were not planning to continue in the major had not participated in the PRE survey. The one respondent who did demonstrate increased self-efficacy subscores on Mastery Experience, Social Persuasion and Physiological State, with a single-point decrease on the Vicarious Learning subscore. This same respondent elaborated on the response with "There are ideas I want to develop/find out if worth developing" and squeezed in the additional comment "Work full time, WISH I COULD HAVE [met with advisor] MORE" to the advising question on the survey. It appears this particular student may have external factors contributing to their educational decisions. Of the students who chose to persist, sixteen has positive/enthusiastic comments about their reasons to persist, while nine expressed not wanting to "give up" and were motivated by the time and effort they had already invested.

There were two ambiguous comments that have no bearing on the study, and two with negative comments “Im in hell” and “I’m not good at this subject,” with neither choosing to continue in the major. Sources of support comments were mostly positive, with twenty comments ranging from “great professors” to the facilities and good communication. There was a single negative comment from a student who said they had not been offered any support yet. The remainder of the sources of support comments were either ambiguous (three) or left blank. When asked to indicate areas where more support is needed, one respondent said “I think it’s fine as is” while other suggested computer programming, “networking, friendship, social, math,” and more/larger study spaces. One respondent wrote “everywhere” while another replied “Electrical Engineering!!” The remaining thirty-one did not respond. Student participation in department sponsored activities varied widely.

Follow-Up

When I attended the Physics 350 course in the spring semester to see how many participants continued into the next course, only twenty participants who could remember their PIN were present that day, of which only twelve were part of the useable paired SOSESC-P PRE and POST survey administrations. Without a larger sample, the collection of PINs in Physics 350 and the activity participation data did not reveal anything significant. According to departmental enrollment data, of the fifty-one students who consented to participate in the study, thirty-seven of them continued directly into Physics 350 the following semester. Based on comments from the surveys, I infer that four of the fourteen not enrolled are not continuing in the major. The remaining ten are either changing majors, or electing to take the course at a later date.

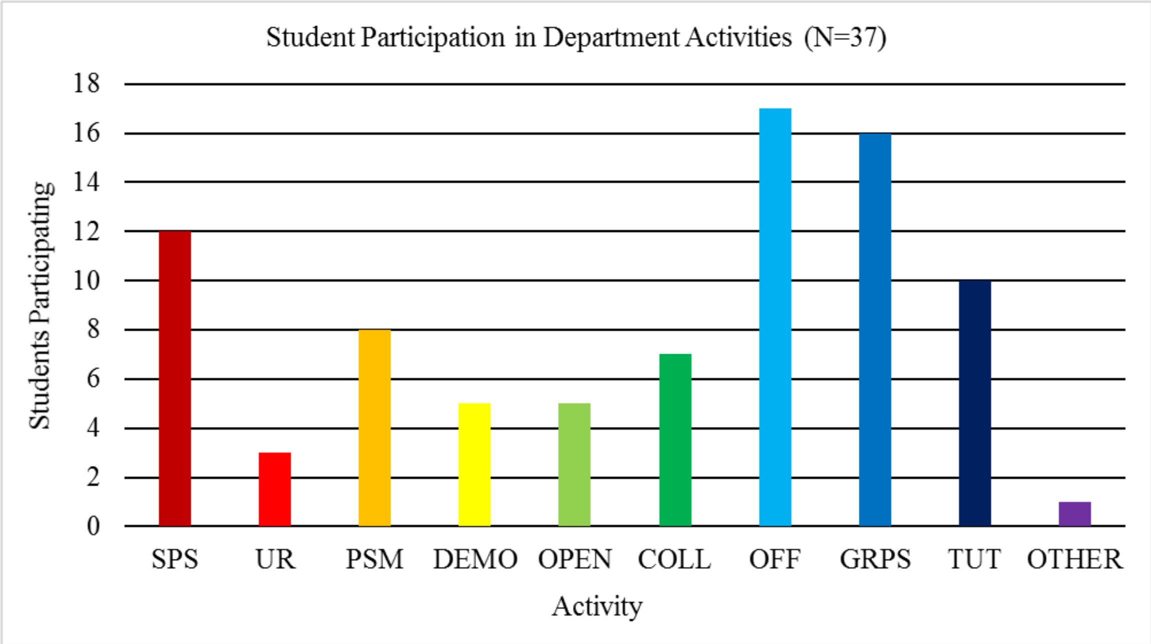

FIGURE 2. Participation in Society of Physics Students (SPS), undergraduate research (UR), physics social mixers (PSM), Physics Demo Day (DEMO), Physics Open House (OPEN), colloquium (COLL), professor/TA office hours (OFF), study groups (GRPS), tutoring (TUT), and miscellaneous other activities (OTHER)

CHAPTER 5

IMPLICATIONS

From the twenty-four useable paired responses one can see slight increases in the scores for Mastery Experience (ME) and Physiological State (PS); however, we are unable to reject the null hypothesis with t-values of $t_{83)}$ = 0.601, p ¿ 0.05 and $t_{(23)}$ = 0.485, p ¿ 0.05, respectively. Also, note that the effect sizes are very small, 0.112 and 0.133, indicating that there was not much change in these areas, whether due to an increase in self-efficacy or simple chance. Vicarious Learning (VL) and Social Persuasion (SP) both show more moderate increases in self-efficacy subscores. The VL statistical results reveal that, once again, the null hypothesis cannot be rejected $t_{(23)}$ = 1.295, p ¿ 0.05, but the obtained value is reaching closer to the critical value of 1.714 and the effect is somewhat larger at 0.302.

Due to the small sample size (N = 24), these results are not exactly surprising. The Cohen's d for each of these subscores is rather small, d_{ME} = 0.1056, d_{PS} = 0.0991, and d_{VL} = 0.2644, indicating that a much larger sample is required for the possibility of statistical significance. It is perhaps more interesting that this small group did produce a statistically significant t-test on the Social Persuasion (SP) subscore $t_{(23)}$ = 2.110, p ¡ 0.05. While the effect size is only moderate at 0.326, it does show that there may, in fact, be something happening here. This score also reflects the highest Cohen's d of the data set, d_{SP} = 0.431.

One could surmise that it is not coincidence that students are experiencing an increase in self-efficacy due to Social Persuasion in this collaborative classroom environment. Even at CSULB, the lower division prerequisite courses are still taught in large lecture halls, most of the courses having more than one hundred students enrolled from various physical science and engineering disciplines. Early upper division coursework, like Physics 310, narrows the group of future scientists and engineers down to those of the same or similar majors. The environment of the active learning classroom at CSULB may be many students' first exposure to group work within the lecture classroom. The focus on collaboration outside of laboratory groups outs students into greater contact with each other to solve and discuss problems and solutions. The students are helping one another through struggles and triumphs.

The significance of the SP score is also reflected in the participants' comments on the CSULB Specific surveys regarding the faculty. Twenty-three respondents wrote comments under "Please indicate sources of support" with sixteen of those mentioning the department's faculty and staff. Students used words like "encouraging" and "inspiring" to describe their experiences with professors in the Physics and Astronomy department. These results are at the very least promising in that, even with a small sample size and brief study, the effect that positive, approachable faculty can have on student self-efficacy. Respected professors treating undergraduates as a priority, as members of the community, as physicists, could have an immediate impact on undergraduate retention and persistence. It is also important to note that, while there was a significant increase in only one subscore, student self-efficacy did not decrease either. Sawtelle, Brewe and Kramer found that, while looking for increases in self-efficacy, student self-efficacy actually decreased in courses taught using traditional instructional methods [11]. The Physics 310 course, at the very least, is not hurting self-efficacy and helps students to maintain the levels of self-efficacy which they already possess.

Limitations

It is unfortunate that there were a number of limitations to this study. The small sample size is arguably the most obvious which is reflected in the low Cohen's d values, as low as $d_{PS} = 0.099$. The largest participation was on the first day of class (N = 53), a day that students typically do not miss class. Any other day of the semester may find students skipping class, out sick, or otherwise absent. Ideally, the entire class of sixty students would have chosen to participate and been present at each administration. Students not creating or forgetting personal identification numbers compounded this problem by decreasing the number of PRE/POST surveys that could be matched.

Another limitation is the lack of a control group. Only one section of Physics 310 is offered per academic year and each time is taught in the same environment, the active learning classroom, with the same professor. A control group of students learning the same material in a traditional setting would have helped to shed light on the implications. A similar result to Sawtelle, et al, may have emerged in which the rather stable self-efficacy scores of the active learning classroom group would have been contrasted with declining scores from the traditional classroom students [11].

This may also be a situation in which this particular group had already cemented a healthy, unwavering level of self-efficacy. On the contrary, the day the participants completed the POST and CSULB Specific surveys was only two days before the date of their final exam. Students may have been feeling especially anxious, tired, stressed or otherwise preoccupied. Such physiological states would definitely have an effect on their self-efficacy at that time [25]. These extraneous variables can be difficult to control and there may be many others that are not immediately apparent at this time.

Future Studies

Self-efficacy is an area that is widely studied in education and science education research; however, not much research has been completed in the area of physics self-efficacy development. Although this study was short and administered to a small pool of respondents, it has shown a little promise and laid the groundwork for future self-efficacy research of a more in-depth nature over a longer scale. I would like to administer these survey tools over multiple academic years, across multiple courses/stages of the physics major and, possibly, multiple campuses in order to increase the data pool and to compare the self-efficacy development of Physics majors in other programs. I would also like to broaden the research design and IRB application to include collection of student demographic data, grades and academic progress.

Students could be tracked through their academic progress, with instrument administration at key points in the undergraduate career. Courses that have a greater impact could be identified and a correlation between self-efficacy and persistence may emerge. The additional collection of demographic data could identify successful and unsuccessful practices for increasing enrollment, retention and persistence of women and underrepresented minorities. Additional measures added to data collection might bring to light issues like stereotype threat, something which Neilock and Ramirez found that underrepresented minorities are especially subject to: “members of an underrepresented group performed significantly worse on a math test when reminded that their particular group is not expected to do well in math” [2].

Student “grit,” persistence, or confidence in their own ability to grow their physics problem-solving skills and abilities, is another attribute that would be interesting to pursue and might be closely related to self-efficacy. Beyond quantitative measures, qualitative research elements should be added to the study to enhance our understanding of these outcomes and to elaborate on the processes through which students develop these attributes, and how we can help them do so.

Measures could be implemented to understand how the Physics 310 students are developing self-efficacy and what steps faculty and administrators can take to encourage the growth and development of self-efficacy in our Physics student body. This would include classroom observation to identify key experiences in the development of self-efficacy; such as, behaviors that contribute to Vicarious Learning (VL) and Social Persuasion (SP) like group problem solving, peer tutoring, or encouragement on behalf of the professor or classmates. Participants with significantly increased or decreased SOSESC-P scores and/or subscores could be identified and asked to participate in semi-structured interviews in order to shed light on their own experiences and perspectives in developing self-efficacy. The same could be conducted with students who leave the major. Such an in-depth study might be useful to build a framework of pedagogy and practices to keep, improve, or remove from the classroom.

APPENDICES

APPENDIX A

FACULTY INTERVIEW QUESTIONS

1. CSULB is awarding more Undergraduate Physics degrees than any other CSU, a trend that has developed rather recently. Why do you think that is?

2. What departmental changes have here been that have contributed to this increase? For better/for worse?

3. What impact do you think the addition of the BA option has had?

4. Do you think that the addition of programs like PhysTEC have changed the program and, if so, how?

5. Do you think there is anything in particular that the department has done to encourage students to be involved and/or stay within the major?

6. What do you think causes some students to leave the major?

APPENDIX B

ORIGINAL SOSESC-P, WITH SCORING NOTES

SOSESC—Physics

Please indicate how strongly you agree with each of the following statements about your experiences *in this course* (including labs, if applicable.)

1. I received good grades on my assignments in this class.

   1 Strongly disagree   2 Disagree   3 Neutral   4 Agree   5 Strongly agree

2. My mind went blank and I was unable to think clearly when working on assignments.

   1 Strongly disagree   2 Disagree   3 Neutral   4 Agree   5 Strongly agree

3. Watching other students in class made me think that I could not succeed in physics.

   1 Strongly disagree   2 Disagree   3 Neutral   4 Agree   5 Strongly agree

4. When I came across a tough physics question, I worked at it until I solved it.

   1 Strongly disagree   2 Disagree   3 Neutral   4 Agree   5 Strongly agree

5. Working with other students encouraged and motivated me in this class.

   1 Strongly disagree   2 Disagree   3 Neutral   4 Agree   5 Strongly agree

6. I have usually been at ease in this class.

   1 Strongly disagree   2 Disagree   3 Neutral   4 Agree   5 Strongly agree

7. Listening to the instructor and other students in question-and-answer sessions made me think that I could not understand physics.

   1 Strongly disagree   2 Disagree   3 Neutral   4 Agree   5 Strongly agree

8. I found the material in this course to be difficult and confusing.

   1 Strongly disagree   2 Disagree   3 Neutral   4 Agree   5 Strongly agree

9. I enjoyed physics labs/activities.

   1 Strongly disagree   2 Disagree   3 Neutral   4 Agree   5 Strongly agree

10. My instructor's demonstrations and explanations gave me confidence that I could solve physics-related problems.

    1 Strongly disagree   2 Disagree   3 Neutral   4 Agree   5 Strongly agree

11. I was rarely able to help my classmates with difficult physics problems.

    1 Strongly disagree   2 Disagree   3 Neutral   4 Agree   5 Strongly agree

12. My instructor encouraged me that I could use physics concepts to understand real life phenomena.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

13. I usually didn't worry about my ability to solve physics problems.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

14. I had difficulty with the exams/quizzes in this class.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

15. I am poor at doing labs/activities to explore physics questions.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

16. The instructor in this course encouraged me to put forth my best efforts.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

17. I rarely knew the answer to the questions raised in class.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

18. Physics makes me feel uneasy and confused.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

19. I identified with the students in this class who did well on exams/quizzes.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

20. I got positive feedback about my ability to recall physics ideas.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

21. I got a sinking feeling when I thought of trying hard physics problems.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

22. I learned a lot by doing my physics assignments/activities.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

23. During this course, I admired my instructor's understanding of physics.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

24. In-class discussions and activities helped me to relax, understand, and enjoy my experience in the course.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

25. My instructor's feedback discouraged me about my ability to perform well on physics exams/quizzes.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

26. It was fun to go to this class.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

27. I could relate to many classmates who were involved and attentive in class.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

28. No one in class has encouraged me to go on in science after this course.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

29. I got really uptight while taking exams/quizzes in this class.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

30. I can remember the basic physics concepts taught in this class.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

31. Classmates who were similar to me usually had trouble recalling details taught in class.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

32. My peers in this course encouraged me that I had the ability to do well on class projects/assignments.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

33. I was attentive and involved in what was going on in class.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

SOSESC—Physics Key

Reverse scored items are italicized.

I. Performance Accomplishments (PA) 10 items

attainment

1. I received good grades on my assignments in this class.

15. I am poor at doing labs/activities to explore physics questions. ***R***

11. I was rarely able to help my classmates with difficult physicians problems. ***R***

4. When I came across a tough physics question, I worked at it until I solved it.

understanding

22. I learned a lot by doing my physics assignments/activities.

8. I found the material in this course to be difficult and confusing. ***R***

17. I rarely knew the answer to the questions raised in class. ***R***

attention

33. I was attentive and involved in what was going on in class.

test-taking

14. I had difficulty with exams/quizzes in this class. ***R***

recall & recognition

30. I can remember the basic physics concepts taught in this class.

II. Vicarious Learning (VL) 7 items

attainment

10. My instructor's demonstrations and explanations gave me confidence that I could solve physics-related problems.

3. Watching other students in class made me think that I could not succeed in physics. ***R***

understanding

23. During this course, I admired my instructor's understanding of physics.

7. Listening to the instructor and other students in question-and-answer made me think that I could not understand physics. ***R***

attention

27. I could relate to many classmates who were involved and attentive in class.

test-taking

19. I identified with the students in this class who did well on exams/quizzes.

recall & recognition

31. Classmates who were similar to me usually had trouble recalling the details taught in class. ***R***

III. Verbal Encouragement/Social Persuasion (S) 7 items

attainment

32. My peers in this course encouraged me that I had the ability to do well on class projects/assignments.

16. The instructor in this course encouraged me to put forth my best efforts.

28. No one in class has encouraged me to go on in science after this course. ***R***

understanding

12. My instructor encouraged me that I could use physics concepts to understand real life phenomena.

attention

5. Working with other students encouraged and motivated me in this class.

test-taking

25. My instructor's feedback discouraged me about my ability to perform well on physics exams/quizzes. ***R***

recall & recognition

20. I got positive feedback about my ability to recall physics ideas.

<u>IV. Emotional Arousal (EA) 9 items</u>

attainment

13. I usually didn't worry about my ability to solve physics problems.

21. I got a sinking feeling when I thought of trying hard physics problems. ***R***

9. I enjoyed physics labs/activities.

understanding

18. Physics makes me feel uneasy and confused. ***R***

24. In-class discussions and activities helped me to relax, understand, and enjoy my experience in the course.

attentiveness

6. I have usually been at ease in this class.

26. It was fun to go to this class.

test taking

29. I got really uptight while taking exams/quizzes in this class. ***R***

recall & recognition

2. My mind went blank and I was unable to think clearly when working on assignments. ***R***

APPENDIX C

SOSESC-P AS ADMINISTERED TO STUDY PARTICIPANTS

PRE

SOSESC—Physics
Please indicate how strongly you agree with each of the following statements about your experiences *in Physics courses thus far* (including labs, if applicable).

Statement	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
1. I am capable of receiving good grades on my assignments in this class.					
2. My mind goes blank and I am unable to think clearly when working on assignments.					
3. Watching other students in my classes makes me think that I cannot succeed in Physics.					
4. When I come across a tough physics question, I work at it until I solve it.					
5. Working with other students encourages and motivates me.					
6. I have usually been at ease in Physics classes.					
7. Listening to the instructor and other students in question-and-answer sessions makes me think that I cannot understand Physics.					
8. I find the material in Physics courses to be difficult and confusing.					
9. I enjoy physics labs/activities.					
10. My instructors' demonstrations and explanations give me confidence that I can solve physics-related problems.					
11. I am rarely able to help my classmates with difficult physics problems.					
12. My instructors have encouraged me that I can use physics concepts to understand real life phenomena.					
13. I don't usually worry about my ability to solve physics problems.					
14. I have difficulty with the exams/quizzes in Physics classes.					
15. I am poor at doing labs/activities to explore physics questions.					
16. My past Physics instructors have encouraged me to put forth my best efforts.					
17. I rarely know the answer to the questions raised in Physics classes.					
18. Physics makes me feel uneasy and confused.					
19. I identify with the students in my Physics classes who do well on exams/quizzes.					

SOSESC—Physics
Please indicate how strongly you agree with each of the following statements about your experiences *in Physics courses thus far* (including labs, if applicable.)

Statement	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
20. I have received positive feedback about my ability to recall physics ideas.					
21. I get a sinking feeling when I think of trying hard physics problems.					
22. I learn a lot by doing my physics assignments/activities.					
23. In past Physics courses, I have admired my instructors' understanding of physics.					
24. In-class discussions and activities help me to relax, understand, and enjoy my experience in Physics courses.					
25. My instructors' feedback has discouraged me about my ability to perform well on physics exams/quizzes.					
26. It is fun to go to Physics classes.					
27. I can relate to many classmates who are involved and attentive in Physics classes.					
28. No one in my Physics classes has encouraged me to go on in Physics after my courses.					
29. I get really uptight while taking exams/quizzes in Physics classes.					
30. I can remember the basic physics concepts taught in previous Physics classes.					
31. Classmates who are similar to me usually have trouble recalling details taught in class.					
32. My peers in Physics courses encourage me that I have the ability to do well on class projects/assignments.					
33. I am attentive and involved in what is going on in Physics classes.					

Thank you for participating in this survey!

Please fold it up and slip it into the ballot box marked "surveys" at the front of the room.

POST

SOSESC—Physics
Please indicate how strongly you agree with each of the following statements about your experiences *in this course* (including labs, if applicable).

Statement	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
1. I received good grades on my assignments in this class.					
2. My mind went blank and I was unable to think clearly when working on assignments.					
3. Watching other students in class made me think that I could not succeed in physics.					
4. When I came across a tough physics question, I worked at it until I solved it.					
5. Working with other students encouraged and motivated me in this class.					
6. I have usually been at ease in this class.					
7. Listening to the instructor and other students in question-and-answer sessions made me think that I could not understand physics.					
8. I found the material in this course to be difficult and confusing.					
9. I enjoyed physics labs/activities.					
10. My instructor's demonstrations and explanations gave me confidence that I could solve physics-related problems.					
11. I was rarely able to help my classmates with difficult physics problems.					
12. My instructor encouraged me that I could use physics concepts to understand real life phenomena.					
13. I usually didn’t worry about my ability to solve physics problems.					
14. I had difficulty with the exams/quizzes in this class.					
15. I am poor at doing labs/activities to explore physics questions.					
16. The instructor in this course encouraged me to put forth my best efforts.					
17. I rarely knew the answer to the questions raised in class.					
18. Physics makes me feel uneasy and confused.					
19. I identified with the students in this class who did well on exams/quizzes.					

SOSESC—Physics
Please indicate how strongly you agree with each of the following statements about your experiences *in this course* (including labs, if applicable.)

Statement	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
20. I got positive feedback about my ability to recall physics ideas.					
21. I got a sinking feeling when I thought of trying hard physics problems.					
22. I learned a lot by doing my physics assignments/activities.					
23. During this course, I admired my instructor's understanding of physics.					
24. In-class discussions and activities helped me to relax, understand, and enjoy my experience in the course.					
25. My instructor's feedback discouraged me about my ability to perform well on physics exams/quizzes.					
26. It was fun to go to this class.					
27. I could relate to many classmates who were involved and attentive in class.					
28. No one in class has encouraged me to go on in science after this course.					
29. I got really uptight while taking exams/quizzes in this class.					
30. I can remember the basic physics concepts taught in this class.					
31. Classmates who were similar to me usually had trouble recalling details taught in class.					
32. My peers in this course encouraged me that I had the ability to do well on class projects/assignments.					
33. I was attentive and involved in what was going on in class.					

Thank you for participating in this survey!

Please fold it up and slip it into the ballot box marked "surveys" at the front of the room.

APPENDIX D

CSULB-SPECIFIC SURVEY

Please indicate how strongly you agree with each of the following statements about your experiences *in the CSULB Department of Physics & Astronomy.*

1. I plan to continue in this major.

1 Strongly disagree   2 Disagree   3 Neutral   4 Agree   5 Strongly agree

Please elaborate why you do/don't plan to continue: ______________________________

____

____

____

____

____

2. The Physics and Astronomy department is supportive of its undergraduate students.

1 Strongly disagree   2 Disagree   3 Neutral   4 Agree   5 Strongly agree

Please indicate sources of support: ______________________________

____

____

____

____

____

Please indicate areas where you would like more support: ______________________________

____

____

____

____

____

3. I meet/have met personally with my advisor an average of:

1 Never   2 Once   3 Once/semester   4 Twice/semester   5 More often

4. The department has provided me with information on what I can do with my degree.

1 Strongly disagree   2 Disagree   3 Neutral   4 Agree   5 Strongly agree

5. What experiences within the department have you participated in? (Check all that apply)

☐Society of Physics Students (SPS)

☐Undergraduate Research

☐Physics Social Mixers

☐Physics Demo day

☐Physics Open House

☐Colloquium

☐Professor/TA Office Hours

☐Study Groups

☐Tutoring

☐Other(s):________________________

APPENDIX E

RAW DATA

PIN	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
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Cells highlighted with this color were originally left blank or marked N/A by the respondent
Gray columns are reverse scored

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2894																																	
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4242																																	
4378																																	
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7133																																	
7489																																	
7731																																	
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0312-X	5	2	5	5	5	5	5	4	5	5	3	5	5	5	5	5	5	3	4	5	2	5	5	4	1	4	4	3	3	5	3	3	5
0316-X	4	4	2	3	4	4	2	3	3	4	3	3	2	3	2	4	1	2	3	4	3	3	5	3	4	2	4	3	3	3	3	3	3
0532	5	3	4	5	4	5	2	4	5	5	2	4	3	1	2	4	3	1	3	4	3	5	5	5	2	5	5	3	1	4	4	4	5
1221	3	4	5	3	4	3	5	4	2	3	5	2	4	5	2	4	5	3	1	1	5	1	5	5	3	1	5	5	1	3	5	2	3
1226-X	5	1	1	5	3	4	1	2	4	4	1	5	4	3	2	5	2	1	5	4	1	5	5	4	1	5	4	4	1	5	3	4	5
blank-N/	5	4	1	5	5	3	1	3	5	5	2	5	4	1	1	5	1	1	3	3	3	5	5	5	1	5	5	3	1	5	3	5	4
blank-J	4	3	3	4	5	4	2	3	2	4	2	4	3	3	3	5	4	2	3	4	3	4	5	4	2	4	3	1	3	4	5	4	5
blank-K	5	1	1	5	5	3	1	4	5	4	1	5	4	3	3	5	3	1	3	4	2	5	5	4	1	5	5	1	3	5	1	5	4
blank-L	5	2	1	3	5	3	2	2	5	5	2	5	4	2	1	5	3	3	4	5	3	5	5	5	1	5	5	2	3	5	3	5	5
blank-M	4	3	1	3	5	4	2	3	5	5	3	5	4	1	3	5	3	2	3	4	3	5	5	5	1	5	3	2	1	3	3	3	4
blank-N	5	2	2	3	5	3	2	4	4	4	3	5	2	3	2	3	2	2	3	3	2	4	5	4	1	4	3	3	3	4	4	3	4
blank-O	3	3	2	4	5	2	3	4	4	4	3	4	3	3	2	5	3	4	3	4	4	4	5	5	2	5	5	2	3	4	4	4	5
blank-P	2	3	2	4	3	3	3	4	3	3	4	5	3	3	3	4	4	2	2	3	2	5	5	3	2	3	2	3	3	3	3	3	3
blank-Q	4	2	3	3	3	4	1	2	3	5	2	4	4	2	2	4	2	2	4	5	2	5	5	5	1	5	5	3	1	5	2	4	4
blank-R	4	4	2	3	4	3	2	4	4	3	2	4	2	3	3	4	3	2	3	3	4	3	4	3	2	4	4	2	2	3	4	3	4
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Cells highlighted with this color were originally left blank or marked N/A by the respondent

Gray columns are reverse scored

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0020																		
0295																		
0312-A	5	Physics is FUN!!!				3	5	1										wrote "Not Applicable" for 36
0312-B	5	I have	5	Dr Pic	Not s	3	4	1			1			1	1	1		Met with advisor more due to being in class
0314																		
0316	5	I've g	4	The p	N/A	2	4								1			
0317																		
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0526	5	It's ea	5	Picke	Electr	4	4							1		1		Wrote "for Physics?" next to 39
0607	5	I love	5	Paying a lot		3	5											
0624	5	Becau	5	Picke	N/A	5	5	1	1				1	1				
0713	5	This is	4	Good	None	2	4		1				1					
0818	5	I wan	5			4	4							1	1	1		
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1234-A	1	There	3	I don't knov		1	3											Work full time, WISH I COULD HAVE MORE
1234-B																		
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2479																		
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6263	5	I love	5			5	5			1								
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blank-S	2	Im in	4	☺														POST arrow down the first column. CSULB partial

APPENDIX F

COMPLETE IRB APPLICATION PACKAGE

APPLICATION FOR CSULB IRB REVIEW

09/16/13

Copies of this application form and other IRB resources can also be found at:
http://www.csulb.edu/divisions/aa/research/compliance/humans/

1. REVIEW TYPE: ☐ **Standard,** ☒ **Expedited, or** ☐ **Administrative**

If the research plan involves review of existing data only, do not use this form. Please use the specific IRB form for review of existing data provided in the CSULB IRBNet Research Library on IRBNet.org or at the website above.

2. PRINCIPAL INVESTIGATOR

Name(s)	**Brooke Erin Duitsman**
Department	**Physics & Astronomy**
Affiliation	☒ **Student** ☐ **Faculty** ☐ **Staff** ☐ **Other, describe:**
Mailing address	**PO Box 628, San Pedro, CA 90733-0628**
Telephone Number	**424-704-1392**
E-mail	**brooke.duitsman@student.csulb.edu**

3. EDUCATIONAL REQUIREMENT

☒ I have completed the Social & Behavioral Research - Basic training module located at: https://www.citiprogram.org/ (CITI)

☐ I have not completed the above module.

Note: The CSULB Federal Wide Assurance issued by the US Office of Human Subject Research Protections and CSULB Executive Order 890 both require that researchers engaged in human subject research receive appropriate education regarding protection of human research subjects. Beginning Fall Semester, 2013 all individuals applying to the CSULB IRB will be required to complete the above training or its equivalent.

4. ADVISOR/FACULTY SUPERVISOR OF STUDENT THESIS/PROJECT

☐ Not applicable; or complete below:

Name:	**Dr. Galen Pickett, Physics & Astronomy**
University Phone No.	**54934**
Faculty e-mail address:	**Galen.Pickett@csulb.edu**

Name:	**Dr. Laura Henriques, Science Education**
University Phone No.	**51408**
Faculty e-mail address:	**Laura.Henriques@csulb.edu**

5. TITLE OF PROPOSED RESEARCH STUDY:

Developing & Supporting Self-Efficacy for Physics Undergraduates at CSULB

6. JUSTIFICATION FOR ADMINISTRATIVE REVIEW IF REQUESTED

☒ Not applicable

OR, check the category below that qualifies this IRB protocol for administrative review:

☐ Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (a) research on regular and special education instructional strategies, or (b) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

☐ Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless (a) the information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (b) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

☐ Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph 2 of this section, if (a) the human subjects are elected or appointed public officials or candidates for public office; or (b) federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

☐ Research, involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

☐ Research and demonstration projects which are conducted by or subject to the approval of government agencies, and which are designed to study, evaluate, or otherwise examine (a) public benefit or service programs; (b) procedures for obtaining benefits or services under those programs; (c) possible changes in or alternatives to those programs or procedures; or (d) possible changes in methods or levels of payment for benefits or services under those programs.

☐ Taste and food quality evaluation and consumer acceptance studies, (a) if wholesome foods without additives are consumed or (b) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture. [45 CFR 46.101 (b) (1) through (6)]

7. HUMAN CONTACT

a. Will there be contact of any kind with living human beings, including: interviews, surveys, mailed surveys and questionnaires, etc., in the course of this research?

☒ **Yes**
☐ **No**

NOTE: Use special IRB form for research using Existing Data

8. USE OF OTHER INFORMATION

a. Other than the information and data created and produced by this research project, will the researcher(s) have access to records or to other forms of information (including previous research data) about the human subjects participating in this research?

- ☐ **Yes**
- ☒ **No**

1) If yes, please explain here:

2) If yes, provide in an appendix signed permission letter(s) from the agency/researchers holding and providing access to such records and information.

9. HUMAN SUBJECT CHARACTERISTICS:

a. Describe specifically the number of subjects studied of each gender and their expected (estimate if necessary) age range.

Gender	Number	Age Range
Female	15 (estimate)	19-25 years
Male	45 (estimate)	19-25 years

b. If children under 18 are involved, describe the legal parent/guardianship status of the children:

Not Applicable

c. Is any adult subject under any form of legal guardianship?

☐ **Yes**
☒ **No**
If yes, Standard Review *is* required.
Please make sure that Standard Review is selected in Item # 1 above and provide detailed description of the special characteristics of the subjects in section (e.) below.

d. If human subjects are not under legal guardianship, is there evidence that any human subjects have developmental disabilities, mental illness, or are there any other unusual circumstances whereby individuals' ability to grant fully informed consent for themselves might be compromised?

☐ **Yes**
☒ **No**
If yes, Standard Review *is* required.
Please make sure that Standard Review is selected in Item # 1 above and provide detailed description of the special characteristics of the subjects in section (e.) below. ***(Do not attach grant applications or thesis proposals, although you should excerpt from them as necessary.)***

e. Describe any other human subject characteristics common to participants that are relevant to being selected as a potential participant or relevant to the research question.

Current CSULB Physics majors enrolled in upper division undergraduate Physics courses: Physics 310 – Analytic Mechanics (Fall 2015) and Physics 350 – Modern Physics (Spring 2016)

10. PURPOSE(S)
a. Briefly describe the purpose(s) of the study, including research hypotheses, if any.

CSULB has a quickly growing Physics & Astronomy department and has been awarding degrees at an increasing rate. This study seeks to discover if there is an underlying methodology and/or departmental "attitude" that is contributing to student success through engendering self-efficacy. As a secondary goal, areas where self-efficacy development is lacking may be discovered and improved upon in the future.

11. SPONSORSHIP AND COLLABORATION

a. If the research is sponsored by a non-University source, indicate below the title of the grant, the funding source, total funding, and time period of the grant or contract.

☒ Not applicable; or complete below:

Grant/Funding information:

Title:	
Funding Agency:	
Total Funding	
Time Period:	

b. If the research is part of a larger study, please describe the circumstances, including any prior approvals by the CSULB or other IRB.

☒ Not applicable; or describe below:

(Do not attach grant applications or thesis proposals, although you should excerpt from them as necessary). Attach other IRB approvals if applicable as an appendix.

12. RECRUITING SOURCE(S)

a. Identify the source(s), e.g., hospitals, institutions, schools, classes, shopping malls, etc. from which subjects will be recruited into the research.

CSULB upper division undergraduate Physics courses: Physics 310 – Analytic Mechanics (Fall 2015) and Physics 350 – Modern Physics (Spring 2016) Note: if the professor of Phys 350 changes, a new permission letter will be obtained and submitted to the IRB.

b. Appendix A: Original letters of approval from all participating organizations (must be on letterhead and indicate specific classes, units, etc. affected). You must append at the end of this application letters of approval from the faculty of any class section, or the appropriate official of any institution or building in which any part of the selection of subjects or the actual research will be carried out, typed on their official letterhead. **The permission statement must contain the full and exact title of your research, your name, and a statement of how the institution will assist you.**

13. RECRUITING PROCESS AND INFORMED CONSENT:

a. Describe in chronological detail the process you will use to invite people to participate in your research. Include the complete, step-by-step, sequence of specific events from initial approach to the point where you have obtained Informed Consent.

NOTE: If oral or written invitations/explanations are used, include the verbatim text (script) in an appendix. If a "flyer" is to be posted, attach to this application as an appendix.

I will attend the first class meeting of Physics 310 at which time Dr. Pickett will introduce me and leave the room.
I will announce the study and its intentions.
Informed consent documents will be handed out to all students present, as well as the PRE SOSESC-P.
Students choosing to participate will fill out the Informed Consent document. Those who choose to abstain may leave them blank.
After the Informed Consent document and PRE SOSSESC-P surveys are handed out, I will leave the room so that my presence does not create pressure for the students to participate.
I will wait outside of the room while the documents and surveys are completed so that I can be available for additional questions, should any arise.
A ballot-type box will be set at the front of the room for depositing all Informed Consent documents, which will be a separate box from the survey ballot box in order to avoid linking the two together.
Blank documents representing students who chose not to participate will be disposed of.

b. Attach proposed Informed Consent form(s) as an appendix. Append copies of all consent forms in all languages used necessary for the subject pool. Include all required elements of informed consent (see example provided in the *CSULB IRBNet Research Library on IRBNet.org*).

14. HUMAN SUBJECT PARTICIPATION

a. Describe what you will do with the human subjects once informed consent has been obtained. Include complete, step-by-step, sequential detail regarding what will happen to the subjects when the research procedures are carried out. Provide separate descriptions for each unique group of subjects if two or more groups are participating.

Students who choose to participate will be allowed to complete the surveys at the beginning of class on the first and last days of the Fall semester. On the first day they will complete the "SOSESC-P PRE" survey and on the last day they will complete the "SOSESC-P POST" survey and the short "CSULB-Specific" survey. The administration of these surveys will follow the same procedure each time and Dr. Pickett will not be present during any part of the survey process. Surveys will be handed to everyone present. Students will create a four-digit identification code for themselves which will be used to link survey responses through the course of data collection. No other identifying information will be included on any of the surveys. Students will be asked to record and store their code for later use. After the Informed Consent document and PRE SOSESC-P surveys are handed out, I will leave the room, but will wait outside of the room while the surveys are completed so that I can be available for additional questions, should any arise. A ballot-type box will be set at the front of the room for students to deposit surveys, whether completed or blank. As noted in item 13, the ballot box for surveys will be separate from the ballot box for Informed Consent documents in order to reduce the potential for linking the two together. The two survey sessions during Fall semester will last approximately twenty minutes; five minutes for the introduction and questions, then fifteen minutes for the students to complete the surveys. During the first class meeting of Physics 350 in the spring, I will hand blank 3"x5" cards to all students and ask that any students who participated in the study write down their personal four-digit code and deposit it in a ballot-type box left at the front of the classroom (students who did not participate may deposit a blank card). There is no actual survey to complete at this stage. The purpose of this step is to see how many participants continued on with the course sequence and connect their progress to their survey responses without any personally identifiable information. This step should take only a few minutes, but will be unnecessary if the entire Physics 310 class moves on to Physics 350.

15. POTENTIAL RISKS

a. Describe the potential risks this research present to the dignity, reputation, rights, health, welfare, or psychological well-being/comfort of the subjects. <u>Number each risk so that you can address how you are minimizing each risk in item 16 below</u>.

1. Personal feelings of self-confidence/self-efficacy could potentially be exposed.
2. Discrimination by the course professor based on student participation in the survey.
3. Dr. Pickett is also the undergraduate advisor. Students may feel pressure to participate because of this.

16. PROTECTING AGAINST OR MINIMIZING RISKS

a. Describe the measures you will take to protect against or to minimize each numbered risk noted above.

1. Participants will create a unique four-digit code that will be recorded on their surveys so that their survey responses may be linked over time. The code will not be linked to the participant's identity, making it impossible to link a response to an individual. No other personally identifying information will be collected.
2. The course professor, Dr. Pickett will not be present during any step in the survey process. He will not have access to Informed Consent documents (if an advisor needs to see them, it will be Dr. Henriques). Dr. Pickett will not see student responses to any of the surveys. He will only have access to aggregate data once the course is finished and final grades have been entered. Surveys and informed consent documents will be handed out to and collected from all students present so that other students will not be able to identify participants.
3. In order to mitigate student feelings of coercion, Dr. Pickett will not be present at any point during the survey process, including the description of the study and introduction to the survey. Precautions outlined in point 2 will also alleviate this.

b. Describe: (1) security and storage, and (2) disposal of research materials by completing the items below.

*NOTE: Title 45, PART 46, PROTECTION OF HUMAN SUBJECTS, §46.115 stipulates that "…**records relating to research which is conducted shall be retained for at least 3 years after completion of the research.** All records shall be accessible for inspection and copying by authorized representatives of the Department or Agency at reasonable times and in a reasonable manner."*

(1) Security and storage

☒ I will store both consent forms and raw data in a secure location for three years after completion of the research.

Describe location and security:

A locked file cabinet at my personal residence.

Describe who will have access.

Brooke Duitsman, researcher; Dr. Laura Henriques, as needed

(2) Disposal of research materials

What will happen to the consent forms and raw data after the three year period?

☒ I will destroy the consent forms & the raw data after three years;

OR explain alternative:

c. If your research project includes a medical, pharmacological, or behavioral intervention or therapy, which is intended to improve the physical or mental health of the subject, then provide a complete "data and safety plan," which includes a Data and Safety Monitoring Board, "stop rules," and explicit provisions for reporting adverse events to the IRB (email to ORSP-Compliance@csulb.edu).

☒ Not applicable;

OR describe data safety plan:

17. BENEFITS

a. Describe any benefits to the subject(s) which may reasonably be expected from the research.

In general, the students participating in this process will not derive any direct benefits; however, the process may help them to recognize positive attributes within themselves (e.g. persistence).

b. Describe benefits, if any, to others, including summary of research findings where appropriate for professionals and participating organizations.

The Physics & Astronomy Department may gain insight into student learning and feelings regarding the major. This could result in changes to curriculum, pedagogy, or other features which may benefit future students. Other researchers in the area of Physics Education may derive similar benefits.

18. RESEARCH DATES AND LOCATION

NOTE: Initial contact cannot occur until after IRB Approval. Initial approval is for one year only. A renewal application (provided in the CSULB IRBNet Research Library) must be completed for projects lasting more than a year.

Approximate Start Date:	**August 24, 2015**
Approximate End Date:	**January 19, 2016**
Location(s):	**Physics 310 and 350 Classrooms**

19. DATA COLLECTION INSTRUMENTS/MATERIALS APPENDIX

a. In a labeled Appendix attach a copy of all tests, questionnaires, surveys, or other instruments and materials to be used.

b. List here each test, questionnaire, survey, or other instruments and materials to be used, providing full publication/bibliographic information.

Sources of Self-Efficacy in Science Courses – Physics (SOSESC-P)

c. If you have adapted or made changes in any of these materials, indicate the changes.

I have altered wording within the SOSESC-P to present-tense verbiage for the PRE survey so that it makes sense to participants and evaluates accumulated Physics experiences to date. The POST survey is presented as published by the authors, Dr. Heidi Fencl and Dr. Karen Scheel.

d. Indicate which instruments, or portions of instruments, you have created.

CSULB-Specific Survey Questions

20. DEBRIEFING OF SUBJECTS AFTER PARTICIPATION

☒ Not applicable; or describe the nature of any debriefing of subjects *after they have completed the procedures:*

21. RESEARCHER QUALIFICATIONS

a. Briefly describe the training and experience that qualifies you to carry out the proposed research.

I am a graduate student in the Physics & Astronomy Department at CSULB with an interest in Physics Education. I have done, and continue to do, Physics Education research as part of my directed studies under Dr. Pickett and have been working with Drs. Pickett and Henriques on related issues.

22. REFERENCES

☒ Not applicable; or provide a reference list of all sources *cited or otherwise identified in this application*, excluding those in Item 19.

23. LIST APPENDICES ATTACHED BY LABEL (e.g., A, B, …) AND TITLE

A. Permission letter from Dr. Galen Pickett, professor teaching Physics 310, Fall 2015, and Physics 350, Spring 2016.
B. Recruiting script to be read at the first class meeting of Physics 310
C. Informed Consent document
D. Sources of Self-Efficacy in Science Courses – Physics (SOSESC-P), both PRE and POST versions, with scoring notes for IRB reference.
E. CSULB-Specific survey created for this research
F. Faculty Supervisor Form signed by Dr. Laura Henriques*
***Please note that Drs. Pickett and Henriques are co-chairing my thesis; however, for purposes of the survey, I will be solely overseen by Dr. Henriques in order to avoid conflict of interest or perceptions of coercion, therefore Dr. Pickett is not submitting a Faculty Supervisor Form.**

24. SUBMISSION

This application must be submitted electronically through IRBNet (irbnet.org). Documents requiring letterhead and signatures, such as agency approval letters or faculty supervisor forms, must be scanned and attached via IRBNet along with your other application materials.

For information on how to register as an IRBNet user or how to submit applications, please contact:

Office of Research & Sponsored Programs
Research Compliance
FO5-111
eMail: ORSP-Compliance@csulb.edu
562-985-8147

Appendix A: Permission Letter

CALIFORNIA STATE UNIVERSITY, LONG BEACH

PHYSICS AND ASTRONOMY

Dr. Galen Pickett
Department of Physics & Astronomy
California State University, Long Beach
1250 Bellflower Boulevard
Office HSCI-260
Long Beach, California 90840-4509

23 June 2015

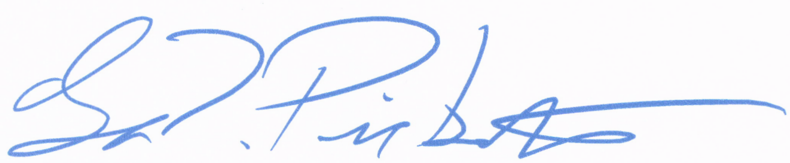
Institutional Review Board
Office of Research & Sponsored Programs
California State University, Long Beach
1250 Bellflower Boulevard
Office FO5-111
Long Beach, California 90840-4509

Re: Brooke Duitsman, "Developing & Supporting Self-Efficacy for Physics Undergraduates at CSULB"

Esteemed Board Members,

Ms. Brooke Duitsman has my express permission to recruit for and conduct research in my classrooms for the following course sections during the 2015-2016 academic year: Physics 310 – Analytic Mechanics Section 01 Class # 4055 and Physics 350 – Modern Physics (Section and Class # to be determined). In order to conduct research for her project entitled "Developing & Supporting Self-Efficacy for Physics Undergraduates at CSULB", Ms. Duitsman will be allowed to not only recruit but also administer surveys during class time at the beginning and end of each semester. If you have any questions or concerns, please feel free to contact me.

Sincerely,



Dr. Galen Pickett
Professor
California State University, Long Beach
(562) 985-4934
gpickett@csulb.edu@csulb.edu

Appendix B: Recruiting Script

To be delivered during the first class meeting of Physics 310 – Analytic Mechanics

Hello! My name is Brooke Duitsman and I am in the Physics master's program here at Long Beach. I am conducting my research within Physics Education and would really appreciate the help of this class. My thesis is about helping Physics undergrads like yourselves to develop self-confidence when it comes to your studies. I would like to conduct a couple of surveys in this particular course to find out how you feel about your classes, the curriculum, the department, and physics in general. The surveys will be conducted during class time today and during the last class meeting of the semester. I will also check in with you on the first day of your modern Physics class next semester to see how many participants moved forward within the major. Your participation is completely voluntary. Whether or not you participate will *not* affect your grade. In fact, Dr. Pickett will have no knowledge of whether you participated or not. You will also receive no compensation for your participation beyond the joy of knowing that you helped me complete my thesis! I have handed you each a copy of the Informed Consent and the initial survey. If you are willing to participate in this research, please read and sign the Informed Consent and complete the survey now. If you do not wish to participate, please feel free to leave it blank, scribble aimlessly on it to feign participation, draw pictures or whatever you see fit. I will step out of the room and leave these two ballot boxes here for collecting surveys so that nobody knows who participated and who didn't, including myself. You will not be asked any personally identifying information on the survey itself. I do ask that you create a four-digit PIN so that I can match your survey from today with the one that you will complete at the end of the semester. Please use something that you can easily remember, like the day you were born and the two-digit year, the last four digits of your phone number, or your dog's birthday, etc…. I also ask that you please record this four-digit number somewhere so that you can use it again in December. Does anyone have any questions…?

If there are no further questions I will step outside and let you complete the Informed Consent and survey. I will be right outside if anyone comes up with a question in the next fifteen minutes.

Appendix C: Informed Consent

CONSENT TO PARTICIPATE IN RESEARCH

Developing & Supporting Self-Efficacy for Physics Undergraduates at CSULB

You are asked to participate in a research study conducted by Brooke Duitsman, BS Astrophysics (UCLA), from the Physics and Astronomy Department at California State University, Long Beach. The results of this study will be part of Ms. Duitsman's master's thesis for the department. You were selected as a possible participant in this study because you are an undergraduate Physics major entering the upper division courses of study and enrolled in Physics 310 – Analytic Mechanics in the fall semester 2015.

PURPOSE OF THE STUDY

CSULB has a quickly growing Physics & Astronomy department and has been awarding degrees at an increasing rate. This study seeks to discover if there is an underlying methodology and/or departmental "attitude" that is contributing to student success through engendering self-efficacy. As a secondary goal, areas where self-efficacy development is lacking may be discovered and improved upon in the future.

PROCEDURES

If you volunteer to participate in this study, you will do the following things:

Complete three surveys, one at the first class meeting and two at the last class meeting, of Physics 310 – Analytic Mechanics in the fall semester 2015. Provide acknowledgment of continuation to Physics 350 – Modern Physics on the first class meeting in spring 2016 by dropping a slip of paper (provided) with a four-digit code into a ballot box in the classroom. All activities will be conducted during class time. The first two survey sessions will take approximately twenty minutes each and the ballot submission will take approximately 5 minutes.

POTENTIAL RISKS AND DISCOMFORTS

Your personal feelings of self-confidence and self-efficacy within the Physics degree could potentially be exposed publicly; however, researchers will make every attempt to safeguard this by avoiding collection of personally identifying information during the survey process. You will create your own four-digit identification code that researchers will be unable to connect with you personally. Informed Consent documents and Surveys will be handed to and collected from all students present, regardless of participation. If you choose not to participate, you may leave these documents blank or feign response so that researchers and other students will not be aware of your personal level of participation.

You may also be concerned that your course professor and undergraduate advisor may be able to discriminate against you based on your participation. The professor and advisor will not be present during any part of the survey process and will not have access to the anonymous results of this study until the course is complete and grades are entered. No one will be privy to your level of participation at any point, unless you volunteer that information to them yourself.

POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

While you personally may not benefit from the outcome of this study, the outcome may serve to benefit future students. Your participation may help to shape instructional design for future courses for undergraduate Physics majors.

PAYMENT FOR PARTICIPATION

There will be no payment or compensation for your participation.

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law.

You will be creating a four-digit code when you complete the survey. I have no way of knowing your code, so I will not be able to link your responses with your name. This should insure that no personal information is connected with your survey responses.

PARTICIPATION AND WITHDRAWAL

You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. Participation or non-participation will not affect your grades, in the named courses or any future courses, or any other personal consideration or right you usually expect. You may also refuse to answer any questions you don't want to answer and still remain in the study. The investigator may withdraw you from this research if circumstances arise which, in the opinion of the researcher, warrant doing so.

IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact the primary investigator, Brooke Duitsman, or the faculty advisor Dr. Laura Henriques using the following information:

Brooke Duitsman	brooke.duitsman@student.csulb.edu	424.704.1392 (voice or text)
Dr. Laura Henriques	laura.henriques@csulb.edu	562.985.4801 (office)

RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact the Office of University Research, CSU Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840; Telephone: (562) 985-5314. eMail: ORSP-Compliance@csulb.edu

Rev. 12/4/2014 MW

SIGNATURE OF RESEARCH SUBJECT

I understand the procedures and conditions of my participation described above. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

____

Name of Subject

____ ___________

Signature of Subject Date

Rev. 12/4/2014 MW

Appendix D: SOSESC-P

PRE

SOSESC—Physics
Please indicate how strongly you agree with each of the following statements about your experiences *in Physics courses thus far* (including labs, if applicable).

Statement	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
1. I am capable of receiving good grades on my assignments in this class.					
2. My mind goes blank and I am unable to think clearly when working on assignments.					
3. Watching other students in my classes makes me think that I cannot succeed in Physics.					
4. When I come across a tough physics question, I work at it until I solve it.					
5. Working with other students encourages and motivates me.					
6. I have usually been at ease in Physics classes.					
7. Listening to the instructor and other students in question-and-answer sessions makes me think that I cannot understand Physics.					
8. I find the material in Physics courses to be difficult and confusing.					
9. I enjoy physics labs/activities.					
10. My instructors’ demonstrations and explanations give me confidence that I can solve physics-related problems.					
11. I am rarely able to help my classmates with difficult physics problems.					
12. My instructors have encouraged me that I can use physics concepts to understand real life phenomena.					
13. I don’t usually worry about my ability to solve physics problems.					
14. I have difficulty with the exams/quizzes in Physics classes.					
15. I am poor at doing labs/activities to explore physics questions.					
16. My past Physics instructors have encouraged me to put forth my best efforts.					
17. I rarely know the answer to the questions raised in Physics classes.					
18. Physics makes me feel uneasy and confused.					
19. I identify with the students in my Physics classes who do well on exams/quizzes.					

SOSESC—Physics
Please indicate how strongly you agree with each of the following statements about your experiences *in Physics courses thus far* (including labs, if applicable.)

Statement	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
20. I have received positive feedback about my ability to recall physics ideas.					
21. I get a sinking feeling when I think of trying hard physics problems.					
22. I learn a lot by doing my physics assignments/activities.					
23. In past Physics courses, I have admired my instructors' understanding of physics.					
24. In-class discussions and activities help me to relax, understand, and enjoy my experience in Physics courses.					
25. My instructors' feedback has discouraged me about my ability to perform well on physics exams/quizzes.					
26. It is fun to go to Physics classes.					
27. I can relate to many classmates who are involved and attentive in Physics classes.					
28. No one in my Physics classes has encouraged me to go on in Physics after my courses.					
29. I get really uptight while taking exams/quizzes in Physics classes.					
30. I can remember the basic physics concepts taught in previous Physics classes.					
31. Classmates who are similar to me usually have trouble recalling details taught in class.					
32. My peers in Physics courses encourage me that I have the ability to do well on class projects/assignments.					
33. I am attentive and involved in what is going on in Physics classes.					

Thank you for participating in this survey!

Please fold it up and slip it into the ballot box marked "surveys" at the front of the room.

POST

SOSESC—Physics
Please indicate how strongly you agree with each of the following statements about your experiences *in this course* (including labs, if applicable).

Statement	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree
1. I received good grades on my assignments in this class.					
2. My mind went blank and I was unable to think clearly when working on assignments.					
3. Watching other students in class made me think that I could not succeed in physics.					
4. When I came across a tough physics question, I worked at it until I solved it.					
5. Working with other students encouraged and motivated me in this class.					
6. I have usually been at ease in this class.					
7. Listening to the instructor and other students in question-and-answer sessions made me think that I could not understand physics.					
8. I found the material in this course to be difficult and confusing.					
9. I enjoyed physics labs/activities.					
10. My instructor's demonstrations and explanations gave me confidence that I could solve physics-related problems.					
11. I was rarely able to help my classmates with difficult physics problems.					
12. My instructor encouraged me that I could use physics concepts to understand real life phenomena.					
13. I usually didn't worry about my ability to solve physics problems.					
14. I had difficulty with the exams/quizzes in this class.					
15. I am poor at doing labs/activities to explore physics questions.					
16. The instructor in this course encouraged me to put forth my best efforts.					
17. I rarely knew the answer to the questions raised in class.					
18. Physics makes me feel uneasy and confused.					
19. I identified with the students in this class who did well on exams/quizzes.					

SOSESC—Physics
Please indicate how strongly you agree with each of the following statements about your experiences *in Physics courses thus far* (including labs, if applicable.)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Statement	**1**	**2**	**3**	**4**	**5**
20. I got positive feedback about my ability to recall physics ideas.					
21. I got a sinking feeling when I thought of trying hard physics problems.					
22. I learned a lot by doing my physics assignments/activities.					
23. During this course, I admired my instructor's understanding of physics.					
24. In-class discussions and activities helped me to relax, understand, and enjoy my experience in the course.					
25. My instructor's feedback discouraged me about my ability to perform well on physics exams/quizzes.					
26. It was fun to go to this class.					
27. I could relate to many classmates who were involved and attentive in class.					
28. No one in class has encouraged me to go on in science after this course.					
29. I got really uptight while taking exams/quizzes in this class.					
30. I can remember the basic physics concepts taught in this class.					
31. Classmates who were similar to me usually had trouble recalling details taught in class.					
32. My peers in this course encouraged me that I had the ability to do well on class projects/assignments.					
33. I was attentive and involved in what was going on in class.					

Thank you for participating in this survey!

Please fold it up and slip it into the ballot box marked "surveys" at the front of the room.

SCORING NOTES

PRE

SOSESC—Physics Key
*Reverse scored items are italicized and noted with **R**.*
I. Mastery Experiences (ME) 10 items
Attainment
1. I am capable of receiving good grades on my assignments in this class.
15. I am poor at doing labs/activities to explore physics questions. ***R***
11. I am rarely able to help my classmates with difficult physics problems. ***R***
4. When I come across a tough physics question, I work at it until I solve it.

Understanding
22. I learn a lot by doing my physics assignments/activities.
8. I find the material in Physics courses to be difficult and confusing. ***R***
17. I rarely know the answer to the questions raised in Physics classes. ***R***

Attention
33. I am attentive and involved in what is going on in Physics classes.

Test-taking
14. I have difficulty with the exams/quizzes in Physics classes. ***R***

Recall & recognition
30. I can remember the basic physics concepts taught in previous Physics classes.

II. Vicarious Learning (VL) 7 items
Attainment
10. My instructors' demonstrations and explanations give me confidence that I can solve physics-related problems.
3. Watching other students in my classes makes me think that I cannot succeed in Physics. ***R***

Understanding
23. In past Physics courses, I have admired my instructors' understanding of physics.
7. Listening to the instructor and other students in question-and-answer sessions makes me think that I cannot understand Physics. ***R***

Attention
27. I can relate to many classmates who are involved and attentive in Physics classes.

Test-taking
19. I identify with the students in my Physics classes who do well on exams/quizzes.
Recall & recognition
31. Classmates who are similar to me usually have trouble recalling details taught in class. ***R***

III. Social Persuasion (SP) 7 items

Attainment

32. My peers in Physics courses encourage me that I have the ability to do well on class projects/assignments.

16. My past Physics instructors have encouraged me to put forth my best efforts.

28. No one in my Physics classes has encouraged me to go on in Physics after my courses. ***R***

Understanding

12. My instructors have encouraged me that I can use physics concepts to understand real life phenomena.

Attention

5. Working with other students encourages and motivates me.

Test-taking

25. My instructors' feedback has discouraged me about my ability to perform well on physics exams/quizzes. ***R***

Recall & recognition

20. I have received positive feedback about my ability to recall physics ideas.

IV. Physiological State (PS) 9 items

Attainment

13. I don't usually worry about my ability to solve physics problems.

21. I get a sinking feeling when I think of trying hard physics problems. ***R***

9. I enjoy physics labs/activities.

Understanding

18. Physics makes me feel uneasy and confused. ***R***

24. In-class discussions and activities help me to relax, understand, and enjoy my experience in Physics courses.

Attentiveness

6. I have usually been at ease in Physics classes.

26. It is fun to go to Physics classes.

Test taking

29. I get really uptight while taking exams/quizzes in Physics classes. ***R***

Recall & recognition

2. My mind goes blank and I am unable to think clearly when working on assignments. ***R***

SCORING NOTES
POST

SOSESC—Physics Key
Reverse scored items are italicized and noted with ***R****.*
I. Mastery Experiences (ME) 10 items
Attainment
1. I received good grades on my assignments in this class.
15. I am poor at doing labs/activities to explore physics questions. ***R***
11. I was rarely able to help my classmates with difficult physics problems. ***R***
4. When I came across a tough physics question, I worked at it until I solved it.

Understanding
22. I learned a lot by doing my physics assignments/activities.
8. I found the material in this course to be difficult and confusing. ***R***
17. I rarely knew the answer to the questions raised in class. ***R***

Attention
33. I was attentive and involved in what was going on in class.

Test-taking
14. I had difficulty with exams/quizzes in this class. ***R***

Recall & recognition
30. I can remember the basic physics concepts taught in this class.

II. Vicarious Learning (VL) 7 items
Attainment
10. My instructor's demonstrations and explanations gave me confidence that I could solve physics-related problems.
3. Watching other students in class made me think that I could not succeed in physics. ***R***

Understanding
23. During this course, I admired my instructor’s understanding of physics.
7. Listening to the instructor and other students in question-and-answer made me think that I could not understand physics. ***R***

Attention
27. I could relate to many classmates who were involved and attentive in class.

Test-taking
19. I identified with the students in this class who did well on exams/quizzes.

Recall & recognition
31. Classmates who were similar to me usually had trouble recalling the detail taught in class. ***R***

III. Social Persuasion (SP) 7 items
Attainment
32. My peers in this course encouraged me that I had the ability to do well on class projects/assignments.
16. The instructor in this course encouraged me to put forth my best efforts.
28. No one in class has encouraged me to go on in science after this course. ***R***

Understanding
12. My instructor encouraged me that I could use physics concepts to understand real life phenomena.

Attention
5. Working with other students encouraged and motivated me in this class.

Test-taking
25. My instructor's feedback discouraged me about my ability to perform well on physics exams/quizzes. ***R***

Recall & recognition
20. I got positive feedback about my ability to recall physics ideas.

IV. Physiological State (PS) 9 items
Attainment
13. I usually didn't worry about my ability to solve physics problems.
21. I got a sinking feeling when I thought of trying hard physics problems. ***R***
9. I enjoyed physics labs/activities.

Understanding
18. Physics makes me feel uneasy and confused. ***R***
24. In-class discussions and activities helped me to relax, understand, and enjoy my experience in the course.

Attentiveness
6. I have usually been at ease in this class.
26. It was fun to go to this class.

Test taking
29. I got really uptight while taking exams/quizzes in this class. ***R***

Recall & recognition
2. My mind went blank and I was unable to think clearly when working on assignments. ***R***

Please indicate how strongly you agree with each of the following statements about your experiences *in the CSULB Department of Physics & Astronomy.*

1. I plan to continue in this major.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

Please elaborate why you do/don't plan to continue: ____________________

2. The Physics and Astronomy department is supportive of its undergraduate students.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

Please indicate sources of support: ____________________

Please indicate areas where you would like more support: ____________________

3. I meet/have met personally with my advisor an average of:

1 Never 2 Once 3 Once/semester 4 Twice/semester 5 More often

4. The department has provided me with information on what I can do with my degree.

1 Strongly disagree 2 Disagree 3 Neutral 4 Agree 5 Strongly agree

5. What experiences within the department have you participated in? (Check all that apply)

☐Society of Physics Students (SPS)
☐Undergraduate Research
☐Physics Social Mixers
☐Physics Demo day
☐Physics Open House
☐Colloquium
☐Professor/TA Office Hours
☐Study Groups
☐Tutoring
☐Other(s):________________________

Appendix F: Faculty Supervisor Letter

Faculty Supervisor's Statement

TO: Institutional Review Board for the Protection of Human Subjects

FROM: Faculty Supervisor: Dr. Laura Henriques
Department of: Science Education
Telephone Extension: 51408

NAME OF STUDENT: Brooke Duitsman

TITLE OF THESIS OR PROJECT: Developing & Supporting Self-Efficacy for Physics Undergraduates at California State University, Long Beach

I am one of Brooke Duitsman's thesis chairs. She has two committee chairs on this project – me and Dr. Pickett. I cannot serve as her sole thesis chair as I am not in the Department of Physics and Astronomy. Dr. Pickett cannot serve in that role for obvious reasons. I have been working with Brooke over the past 14 months and am confident that she knows what she is doing and will do a good job with the study. We have talked at length about what she will do to minimize risk to participants.

SPONSOR'S STATEMENT:
(1) We have identified three potential risks associated with this study:

1. Personal feelings of self-confidence/self-efficacy could potentially be exposed,
2. Discrimination by the course professor based on student participation in the survey, and
3. Dr. Pickett is also the undergraduate advisor and students may feel pressure to participate because of this.

(2) We will address these risks as follows:
Potential Risk 1. Participants will create a unique four-digit code to identify themselves to researchers. No other personally identifying information will be collected; therefore, individual surveys will never be connected to the participant.

Potential Risk 2. This is the largest of the three risks but I believe we have come up with a mechanism to reduce the risk. The course professor, Dr. Pickett will not be present during any step of the survey process. He will leave the classroom while Brooke explains the study and while students complete informed consent documents and the survey. He will never have access to Informed Consent documents (if an advisor needs to see them, it will be myself). Dr. Pickett will not see student responses to any of the surveys. He will only have ever see is the aggregate data, and even that will not be shared with him until the course is finished and final grades have been entered.

The surveys and informed consent documents will be handed out to, and collected from, *all* students present so that other students will not be able to identify participants. This means that students in the class will not know who participates and who does not. As a result, they will not be in a position to inadvertently tell Dr. Pickett whether or not a classmate is a participant in the study.

Potential Risk 3. In order to mitigate student feelings of coercion, Dr. Pickett will not be present at any point during the survey process, including the description of the study and introduction to the survey. Precautions outlined in point 2 will also alleviate this.

Appendix F: Faculty Supervisor Letter

(3) Numerous educational studies involve surveying students about their attitudes towards learning in the discipline, their sense of self-efficacy and knowledge of content. This study follows the fairly standard procedure of a pre and post test format. Ms. Duitsman's study uses a valid and reliable instrument that has been used in other physics education research. The third 'survey' is not a true survey. Since no one will know which students completed the survey, there is no way to track students from one course to another. A goal of the research is to see if students persist in the major. The third survey simply asks students in the next course to write down their self-generated ID number so that Ms. Duitsman is able to know which students were retained as physics majors.

(4) Ms. Duitsman's research is of a low risk nature and in compliance with University policy and federal regulations, and might even qualify for exemption under 45 CFR 46.101, as it will be performed in an educational setting, consists of only three simple surveys, and will not collect personally identifiable information on any participant. The autonomy and privacy of individual participants is respected by the procedures outlined in this application. The minimal risks involved are far outweighed by the potential benefits to all Physics undergraduate students through the possibilities of curriculum, pedagogical, and departmental reform. This study may inspire further investigation into the development of student success in Physics and may even be carried on to other institutions to benefit an even broader student population.

My signature below certifies that I as Faculty Sponsor of this research have read and approve the attached application.

Laura Henriques 7/5/2015

Thesis Co-Chair / Research Supervisor Signature and Date

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BIBLIOGRAPHY

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