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Physics Jam, a Physics Preparation Program to Increase Student Performance and Success in Introductory Physics Courses

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Abstract

Students enrolled in community college science and engineering programs typically have a long path of prerequisites to overcome before they are able to enroll in transfer-level courses. These students are also frequently under-prepared when entering college and lack the study skills necessary for success. The courses required for science or engineering transfer involve many courses with high drop, withdraw, and fail rates, which can lengthen the time needed to complete transfer coursework. At Cañada College, we found that even students that ultimately persisted were attempting courses such as physics multiple times before they were able to successfully pass the course. These challenges inhibit the students' ability to complete the necessary requirements for transfer in a timely manner, if they are able to complete them at all. We have chosen to address these issues by developing a pre-semester physics "bootcamp" to give students the necessary study skills and practice working with physics content before they start their physics course. Additionally, we incorporate directed support during the semester to continue developing the student's ability to succeed.

Physics Jam is a 1 to 2 week free program offered to all students taking first or second semester physics. During the program, students work on reviewing math concepts they will need to be successful in their physics course, developing study skills, and an introduction to the content they will see in their course. A majority of the program is self-paced allowing students to spend more time on concepts they are struggling with. A cornerstone of the program is the intense study-skills workshops which teach students how to approach their upcoming course. Included in these study skills are certain aspects of Reading Apprenticeship to show students how to not only approach their text but the problems they will face during the semester. The goal of the program is to give students a toolbox to use during the semester and the confidence that they can succeed in the course. Continued academic support is also offered during the semester to keep students on track. Preliminary data shows that students who participate in Physics Jam are more successful in physics than their peers who do not.

This paper will discuss the successes, obstacles, and best practices in developing and implementing this pre-semester physics preparation "bootcamp."

1. Introduction

There is a large push from multiple directions to increase the number of students in the United States graduating with STEM degrees. Recent projections show that there must be a 34% increase of students graduating in STEM fields within the next decade to allow the US to remain competitive on the world stage. (1) There are numerous academic routes for students to enter a STEM field. Due to the rising cost of traditional 4-year degrees, including a 40% increase in

tuition, room, and board between 2002 and 2012, (2). Low income and first generation students are seeking out local educational opportunities and many of these students are starting their paths at two-year institutions. Unfortunately, many students starting on the STEM path are underprepared to take challenging STEM courses after they complete high school. (3) Looking at the performance of specific demographic groups in the Silicon Valley region of California, only 24% of Latino and 27% of African American students reached the academic requirements set by The University of California (UC) and California State University (CSU) systems. This is in stark contrast to the 70% of Asian and 57% of Caucasian students that meet the requirements. (4) These trends can be extrapolated to STEM courses specifically as well. Cañada College is a federally designated Hispanic-serving institution (HSI) and serves a diverse population of students that are frequently under-prepared for college-level work, in particular physics and transfer-level STEM courses and their pre-requisites.

As an example, students beginning their preparation for a degree in engineering at Cañada College must complete a series of transfer-level math classes that include Trigonometry, Pre-Calculus, Calculus 1-3, Linear Algebra and Differential Equations. In addition to the math requirements, students must complete at least one semester of chemistry, and the calculus-based physics series. If students start college needing remediation one can see that this under prepared student has a long academic journey with additional challenges before being able to complete an engineering program at Cañada College for the purpose of transferring to a 4-year institution. At Cañada College, like many 2-year institutions, success rates for these pre-requisite gate-keeper courses are low. (5) The poor success rates for select engineering course pre-requisites are shown in Table 1. The success rates are averaged over the 10 years before implementing the comprehensive pre-semester preparation.

Table 1: Success Rates of select Engineering Prerequisite Courses

Course	**Average Success Rate Springs 2002-2012**
Trigonometry	51.39 %
Calculus 1	69.02 %
Physics 1 with Calculus	63.03 %
Physics 2 with Calculus	77.14 %

Cañada College, like many other community colleges, does not offer any course to help students prepare for STEM courses such as Physics. All students must do to enroll in Physics is successfully complete required pre-requisite courses which does not always indicate future success. It was with this in mind that the Embedded Peer Instruction Cohort (EPIC) program, a new in-class support environment, was initiated during the Fall 2013 semester followed shortly by Physics Jam, and a pre-semester physics preparation program was created in the Spring 2014 semester. The EPIC program is based on a modified supplemental instruction curriculum, but

with a major focus on problem-solving during the after class study sessions. The goals of both of these programs are to teach students how to be successful and offer academic support so they can successfully and efficiently complete the engineering pre-requisite courses and move on to their transfer-level engineering courses with a strong foundation. The focus of this paper will be specifically on Physics Jam and its impact on students at Cañada College.

2. Physics Jam – An Overview and Best Practices

The goal of Physics Jam is to improve the success and retention rates of students proceeding through the calculus-based physics series. The initial development involved determining the barriers to physics student success. Much research has gone into trying to determine these barriers, and based on experience with our student population, they have been narrowed down even further. (6) The main barriers were identified to be: poor math foundational knowledge, as well as seeing new math concepts that are needed for a physics course, such as vectors. While also being presented material in a new way than they had traditionally seen it and higher level expectations. To address these issues, a multifaceted approach was taken in developing the Physics Jam program. All physics students were encouraged to participate in Physics Jam, which is a free voluntary one-week (5 days from 9AM-3PM) pre-semester program to help refresh them on previous math knowledge, as well as impart the skills that will be necessary for success in physics. The skeleton of the program uses adaptive online programming that starts students off on a math review and introduction to only the math concepts they will need to employ in their upcoming course. The instructor can set up the math environment to only cover the concepts that are necessary for the particular course that the student is preparing for. The program will then develop a study guide based on students' performance on a pre-test. This math portion takes most students 2-3 days of the 5 day program. Once they have completed the math portion, they proceed to learning some beginning physics concepts that they will be presented with in their upcoming course. And finally, they work on example problems to get practice and exposure to the types of problems they will see in their upcoming course. Based on information from entrance and exit surveys, the program helps to give students the confidence that they can handle the material and encourages the student to think positively about their upcoming course. The program is administered by a Physics instructor, as well as students that will be serving as physics tutors in the upcoming semester. This not only gives the participants an opportunity to meet available tutors but serves to help train and prepare new student tutors in an environment where they have instructor backup if needed. The online modules are supplemented by group activities and mini-lectures given by the instructor. Each of the portions of the program will be discussed in more detail individually.

The math portion of Physics Jam is hosted in the MyMathTest © (http://www.mymathtest.com/) (MMT) environment. Modules are pre-prepared for students by the instructor to only cover the concepts that they will need for their upcoming physics course. For Physics 1, this math review and preparation includes: vectors, basic trigonometry, and basic differentiation techniques. The Physics 2 module includes Physics 1 math but also incorporates integration techniques. The

review of Physics 1 math is especially useful because students may not take the second semester physics course immediately after the first. The MMT program allows the instructor to develop a pre-test that covers questions over all of the previously mentioned topics. Once the student completes the pre-test, the program puts together a study plan based on the questions that they did not get correct. This allows the student to efficiently use their time to brush up on the concepts that they forgot while not spending as much time on concepts that they are comfortable with. The study plan involves more practice problems and examples for the students to work with on the selected topics until they become more competent with the material. Once the students complete their designated study plans on MMT, they take a post-test to evaluate their improvement. Students averaged a pre-test score of 62% and a post-test score of 89% for the Winter 2015 Physics Jam, and these are typical results based on previous iterations. The entire program is self-paced and students are allowed to spend as much time as they want on any one portion as long as they are still making progress throughout the week. For most first semester Physics students at Cañada, this program is the first time that they are comprehensively introduced to vectors. At Cañada College students would be introduced to vectors at the end of their pre-calculus course, but unfortunately, it is a topic that our math instructors do not have enough time to cover well, -or at all-, so most students see vectors for the first time during the first week of their physics course. It is for this reason that in addition to the MMT preparation additional group work and activities at the beginning of the week center on a complete introduction to what vectors are, vector notation, and how to work with them. Feedback from first semester faculty indicates that the students who have participated in Physics Jam are easily identifiable by their enhanced vector understanding, as well as their willingness to help their classmates during the vector introduction in the course. Once students complete their math review, they can continue on to their physics introduction.

The remaining Physics Jam content is contained within Cañada College's online Moodle environment (WebAccess). Schedules, suggested paths, and links to resources and videos are preloaded in the online Physics Jam course. Students are directed to watch some short video lectures over introductory physics concepts from resources such as Kahn Academy, YouTube, and Hippocampus. It is at this point that students can also begin working on some online practice problems through WebAssign. When students are first presented with physics problems, they frequently respond with negativity associated with "word problems" and not understanding what is expected. It is at this point in the week that Reading Apprenticeship (RA) (http://readingapprenticeship.org/) workshops are included. RA is a program developed by WestEd (www.wested.org) and has been shown through research to help students succeed in specific subject area courses by learning from their instructor how to approach the written material that they are presented with. (7) As an example of how RA is implemented by the instructor is to have them read a section of a book chapter out loud while verbally annotating what they are thinking while they are reading to demonstrate to the student how to best read for understanding. These normally internalized thoughts that are being demonstrated aloud are trying to exemplify the connection of new knowledge to previous knowledge, evaluate new vocabulary,

extensively study figures for their intended meaning, not giving up if what you are reading becomes confusing, and to continually question what the text is trying to tell you. The point is to show inexperienced students how they should be approaching written material in a course such as physics. The students then pair up and practice reading in this manner to each other. Initially, this portion was met with a bit of skepticism from the students, but at the end of the program, after students began implementing what they learned, the RA module was highly rated in the student exit survey. Coupled with RA are modules on vocabulary and the importance of the context of the words that the students will be presented with. Sometimes students in physics will not just be faced with new words, but words that have worked their way into the common vernacular but have evolved to have different meanings. The vocabulary module ends up being exceptionally important to students who are English as a second language learners.

We've found that students experience a large amount of fatigue when faced with all day computer based work. This is where the importance to proper staffing and scheduling enters. The program typically aims to have a 5:1 student to tutor ratio so that there is always a tutor available to guide the students and answer their questions. An online adaptive program can only do so much in helping explain a concept. Tutors selected to participate in the program are various degrees through their physics sequence with a minimum completion of the first semester physics and relevant math classes with good grades. These tutors also aid the instructor in breaking up the students into smaller groups to work on particular concepts that they might be struggling with. These human interactions are incredibly important. Cañada has previously experimented with math-related programs having students only interact with a web-based program (without tutor interaction) while having an instructor to oversee and found that students would leave the program quite early in the week. This previous experience led to ensure that Physics Jam would be staffed with an instructor and tutors to make sure that the participants have access to a variety of applications and instruction styles. Additionally, the modules or "mini-lectures" were developed to not just target specific study skills in the context of physics but to also break up the students day so that they are not doing a single activity for too long which allows for a rest of patience and attention span. In addition to the previously described modules students are also presented with tools on how to work through physics problems, how to draw useful pictures for a problem, free body diagrams, as well as fun physics demo videos. A sample schedule for a student's day at Physics Jam can be seen in Table 2.

Table 2: Sample Day Schedule of Physics Jam

9:00-9:30	**Self-Study** (MyMathTest (math), WebAccess (videos), WebAssign (problems))
9:30-10:00	
10:00-10:30	
10:30-11:00	**Mini-Lecture and/or Group Work**
11:00-11:30	
11:30-12:00	**Self-Study**

12:00-12:30	**Lunch Break**
12:30-1:00	**Self-Study**
1:00-1:30	
1:30-2:00	**Mini-Lecture and/or Group Work**
2:00-2:30	
2:30-3:00	**Self-Study**

Getting students to enroll in Physics Jam can be a challenge. It is set up such that participating in the program is completely voluntary and offered when campus is closed, during the inter-session right before the semester starts. Students are encouraged to apply and recruited from currently enrolled physics courses, students that are enrolled in physics for the upcoming semester, and students in relevant math feeder courses. Class visits by previous participants or staff are used to encourage students to sign up and attend. Special effort is made for students currently enrolled in first semester calculus to have them participate and enroll in Physics Jam and not delay their enrollment in physics. This involves a twofold effort between the math faculty and program coordinator to encourage students to enroll in physics as soon as they meet the pre-requisites and to not delay. Additionally, once students register for an upcoming physics course they are contacted via email and encouraged to sign up to prepare themselves for the upcoming semester. During the first iteration of Physics Jam, which ran for 4 weeks during the middle of the summer, only two students completed the program. Obviously, this model did not work for our student population and changes were made to the program to make it into what it is today. These changes were made in recruiting students directly needing to prepare for an upcoming physics course, shortening the duration of the program, and scheduling during intersession to not conflict with other classes or student academic commitments. This lead to around 10 students completing the program during the next iteration. These students were charged with recruiting students for subsequent iterations with excellent results. The most recent Physics Jam session during January 2016 yielded 38 students completing the program and students from neighboring institutions being waitlisted for space. This represents over 25% of students that are currently enrolled in applicable physics courses at Cañada College participating in this voluntary program. Including students who have previously completed Physics Jam in the recruiting process has contributed greatly to encouraging new students to show up.

3. Physics Jam – The Results So Far

With the iterations of Physics Jam already implemented we have seen that students who participate in the program are more successful in their upcoming physics course than their classmates that did not participate. A longitudinal study that explores students' performance in other STEM courses before and after should also indicate the effectiveness of this program and eliminate any questions about how much of student success is dedicated to the program or the fact that successful students are more likely to take advantage of offered resources. Students that

participate in the Physics Jam program succeed at higher rates than their comparable classmates that do not participate. Success rates for students who have participated in the Physics Jam program can be seen in Table 2.

Table 3: Comparison of Success Rates for Students based on participation in Physics Jam

Percentage of Students Successful Completion of Course 2014

Course	Students that participated in Physics Jam	Students that did not participate in Physics Jam
Physics 1 With Calculus	75%	53%
Physics 2 with Calculus	89%	82%

In addition to the overall success of Physics Jam, it is important to see how the program is serving our minority students. As discussed in the introduction, minority students are particularly under-prepared for college courses and thus drop, withdraw, and fail at higher rates that other students. This trend is mirrored at our institution with minority students succeeding at lower rates than their white counterparts. On average between 2002 and 2012, before the start of Physics Jam Hispanic students were only 50% successful in a first semester calculus based physics course while White students' success rate was 72%. For Hispanic students that had successfully completed a first semester physics course, 72% successfully passed the second semester as compared to 81% of white students. At Cañada College, 30% of the student population identifies as Hispanic whereas 22% of students in first semester physics courses identify as Hispanic. An overview of Physics Jam participants shows that approximately 45% of students attending Physics Jam identify as Hispanic. With this data we can show that Hispanic students are signing up at a higher rate than their white counterparts. Though we do not have specific data on how many of these students are native English speakers, a majority of the Hispanic students participating in Physics Jam are English as a second language learners, or come from households where Spanish is the predominant spoken language. With this knowledge the Reading Apprenticeship and vocabulary lessons are exceptionally important in preparing students for their upcoming course. Continued analysis is underway to continue to determine the effectiveness of the program. Since we have offered a stable version of Physics Jam since January 2014 we finally have gathered enough data to more fully evaluate the effectiveness of the program. We are currently working on a project to determine if Physics Jam participants are able to complete the first and second semester physics sequence more quickly than their counterparts that do not participate in Physics Jam.

References

1. Technology, President's Council of Advisors on Science and. REPORT TO THE PRESIDENT ENGAGE TO EXCEL: PRODUCING ONE MILLION ADDITIONAL COLLEGE GRADUATES WITH DEGREES IN SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS. *PCAST.* February 2012, pp. 1-130.

2. U.S. Department of Education, National Center for Education Statistics. *Digest of Education Statistics: 2012.* 2013.

3. *Improving Academic Preparation for College.* Chait, R., Venezia A. 2009, American Progress.

4. *The 2013 Index of Silicon Valley* . Joint Venture Board of Directors. 2013, Joint Venture Silicon Valley, p. 36.

5. *Exploring Mathematics College Readiness in the United States.* Lucas, Nancy J. McCormick and Marva S. 1, Phoenix : Current Issues in Education, 2001, Vol. 14.

6. *Barriers to success in quantitative gatekeeper courses.* Gainen, Joanna. 1995, Vol. 61.

7. Rafael Heller, Cynthia L. Greenleaf. *Literacy Instruction in the Content Areas.* Washington DC : Alliance for Excellent Education, 2007.