Professional Evaluation and Growth Plan

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Contents

Chapter 1

Introduction

1.1 Background

My name is Jordan Hanson, and I am formally submitting my first Professional Evaluation and Growth Plan (PEGP). As required by Whittier College, and in accordance with the regulations in the Whittier College Faculty handbook, the material herein pertains to my first complete academic year as a tenure-track Assistant Professor of Physics and Astronomy. Being new to the Whittier College community, I have included this professional introduction for those readers to whom I have not yet been introduced. I look forward to meeting and working with my colleagues in other departments over the years, and I hope that this brief introduction will explain why I chose to become a professor. Accordingly, I share my vision for teaching physics and scholarship in the area of *astroparticle physics* at Whittier College.

My professors and colleagues in the professional-track physics program at Yale University inspired me to excel beyond what I thought was possible for myself. I was introduced to the world of academic scholarship by faculty who had known they would enter this world from from a young age. I fell in love with physics for the beauty of its theoretical simplicity, and the surge of excitement as observations spark to life through hard laboratory work. After receiving my Bachelor of Science degree, I landed at UC Irvine, the home of the Nobel Laureate who made the first observation of a sub-atomic particle called a neutrino. UC Irvine excels in the study of extrasolar, high-energy sub-atomic particles: *astroparticle physics.* I was introduced to Professors Steve Barwick and Stuart Kleinfelder. Dr. Barwick is a professor of physics in the Department of Physics and Astronomy, and Dr. Kleinfelder is a professor of physics in the Department of Electrical Engineering. Together we embarked on a journey to produce world record-breaking observations of high-energy neutrinos from beyond the solar system.

UC Irvine served as a training ground for my ability to teach, and I began to understand why teachers love to witness the flash of light in a student's eyes. I taught as an assistant under Dr. Barwick, serving students in sections associated with introductory physics courses comprised of several hundred students. During the early semesters in my graduate career, I was teaching physics sections of twenty students each for five continuous hours, three days per week. After concluding my teaching duties, I focused on research for several years. Upon completing my dissertation and receiving my doctorate, I solo-taught an introductory physics course during one of my post-doctoral fellowships. During that summer I learned the difference between *teaching* a course and *creating* a course. I enjoy creating new courses, and I have already created and taught new courses for students at Whittier. Above all else, I hope my work at Whittier will serve to *enlighten* our students.

1.2 General Reflection and Future Directions

Any general reflection for academics at Whittier must begin and end with our students. Over the past year and a half, I have chosen to become an *active participant in this community* and to push beyond what is required of me as a young professor. I have taught introductory physics courses to students who have no prior experience in physics, and created a new advanced computer science course. I've attended conferences to improve and expand my teaching methods, taking advantage of the broad research in physics education. I decided to take a class from a professor in another department for the shear joy of learning, but also to learn methods from an experienced teacher. I've involved a group of students in all facets of my research, including software and algorithm development, firmware development, and digital storytelling. Two of these students won Keck Fellowships and have engaged in summer physics research in my laboratory. We are preparing to become part of a collaboration of researchers who plan to build a world-class astroparticle detector at the South Pole. Additionally, I've become a mentor and advisor to a student organization, and helped serve the Math Department in a tenure-track faculty search. Each action I've taken during these past months has been geared towards serving our students thoughtfully and rigorously, to provide them with a quality education and research environment.

Despite these accomplishments, I am not satisfied with some aspects of my teaching. I was surprised to find that in my introductory courses, a group of students felt that the level of mathematical and technical detail was too advanced, and that the pace of the courses was too rapid. A group of students has been vocal in their assessment of these issues, and I take them seriously. Some of my students in an introductory course actively worked with me in office hours to find common ground. It is my hope that in the coming years, I will be able to implement a pace and difficulty level suitable for the academic environment at Whittier that *does the most good, for the largest number of students.* Although I do not feel it would be right to omit core physics principles from introductory courses, I will rely on the past experiences of my department to find a solution. My hypothesis is that many of my students in introductory courses are not prepared to make logical abstractions of physical systems, and require a larger number of concrete examples and demonstrations before gaining that ability. I will work diligently during the coming academic year to boost the abstract problem-solving ability of my students through leading by example.

Chapter 2

Teaching

2.1 Teaching Philosophy

The heart of the intelligent acquires knowledge, and the ear of the wise seeks knowledge. - Proverbs 18:15

I guess you could call it a "failure," but I prefer the term "learning experience." - Astronaut Mark Watney in *The Martian* by Andy Weir

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Teaching is about beautiful failure. Learning takes place between at least two people where at least one lacks knowledge. A lack of knowledge is an advent to *enlightenment* and is therefore beautiful. Regardless of the teaching methods chosen for a given teacher and student, the student should leave the encounter *enlightened*, with increased knowledge of the truth. The success of the encounter is measured by the varying degree to which the student can retain, apply, understand, and reflect upon the knowledge. I believe that lifting a student learning physics from retention to reflection is beautiful, in that I witnesses a student extending their mind outside *their model* of the world, into *the model* of the world. In general, both the teacher and student succeed imperfectly in imparting ideas about *the model* of nature, and therefore the process will contain periodic failures. Further, the physics model itself may be an imperfect description of true nature. Growing through these "failures" is a hallmark of learning modern physics, a subject built upon increasingly accurate approximations to the truth.

Teaching physics begins with defining the concept of a "system" about which we can make measurements. All physics students must begin at this common place. With well-defined concepts of distance, mass, displacement, and time, the entire subject of *classical physics* may be undertaken. Students who are non-majors usually experience exclusively classical physics. Physics majors grow through the inaccuracies of classical physics to *modern physics*, which includes relativity and quantum mechanics [1]. Mastering these subjects represents maturity made possible through diligent and patient teaching. Teachers capable of bringing students to the advanced level and enlightening beginners are not molded upon the completion of graduate school. Physics teaching requires experiences shaped by failures and successes enlightening students studying classical and modern physics.

A good teacher loves growth. Each semester at the beginning of my introductory courses, I give a speech about learning to embrace failure entitled "It's OK to Be Wrong." The introductory student fears being wrong, losing points, and receiving a low grade. Counter-intuitively, those students who

[1] Students satisfying liberal arts requirements via specialty courses do experience non-classical physics qualitatively.

embrace their mistakes and learn from them turn out to be the strongest students. Converting failure to growth has two components. First, there is no substitute for *hard work and sacrifice*. A good teacher leads by example, pouring effort into the semester until the job is done. A good teacher works to master new skills by attending teaching conferences in his field, consulting students through mid-semester feedback mechanisms, analyzing student evaluations. A good teacher also works to become nimble, switching from method to method, until the suitable vehicle properly engages the student. Second, a good teacher *creates a proper learning space*. In my classrooms, no student is penalized for being wrong, with the single exception of taking exams. By creating a space in which it is ok to be wrong, we take advantage of the learning moments brought forward by mistakes, and make real progress.

A good *professor* is a special kind of teacher, in that he is a teacher that also performs scientific research and serves a college or university. A good professor successfully involves undergraduate students in his research. One crucial fact about myself that I learned during the past two semesters is that I love the *instructive* act of research just as much as I love the *investigative* act. Even when I am conducting research with my students, I should still be instructing them, and I've found that I love it. The instructive act of research lies in *pausing to reflect* upon what our actions in the laboratory imply. Whether a procedure succeeds or fails my laboratory, the student and I must take time away from the procedure to step back and understand *why* we observed the result. I hope to grow as much in the area of research instruction as I will grow in classroom instruction, and to produce students who will become quality researchers.

Instruction of Students in Introductory Courses

The first categorization of physics student at Whittier College is whether they are a liberal-arts *non-major* or *physics major*. Non-majors encounter physics for two semesters in either a *calculus-based* or *algebra-based* environment. We categorize students in this fashion because classical physics at the standard undergraduate introductory level is built upon single-variable calculus, with some multi-variable or vector calculus introduced in the second semester. Students who will not take calculus for their degree can still learn to apply core mathematical concepts like vectors and instantaneous quantities and apply them to physics. Thus, *non-major* students usually take the *algebra-based* version of mechanics, and *physics majors* and students who have chosen another technical degree take the *calculus based* version of mechanics.

Three focuses are relevant for teaching non-majors algebra-based physics:

1. **Curiosity**. I regularly give colloquia at universities, seminars in physics departments, public lectures to children in libraries and adults in astronomical societies. I believe that experiencing people's curiosity is necessary to become a great professor. I've continued this practice as Whittier professor by giving a lecture at Los Nietos Middle School. All people seek an understanding of nature. Further, people have a need to know *that the answers exist*, even if we do not yet fully grasp them as a society. I believe good teaching for non-majors should therefore *convince them that physics is interesting* by enticing their curiosity. I have built into the algebra-based curriculum specific learning activities designed to entice student curiosity. Presenting science articles to the class and presentations on home-built circuit projects are two examples. I regularly give colloquia at Whittier and incentivize my students to participate, thereby exposing them to astroparticle physics research [2].

2. **Improvement of Analysis Skill**. The scientific method is not possible without the skill of analysis. We as physicists best serve Whittier non-majors when we are developing their ability to apply physical theory via problem-solving. The Whittier College physics faculty have several

[2] See supporting materials for notes from students on my spring colloquium.

important tools for developing introductory student problem solving. *Peer Instruction* is becoming a standard method in many American colleges [3], which is laser-focused on analyzing concepts in small groups. *Just in Time Teaching* is an auxiliary method designed to modify class time, focusing on exactly the problem solving strategies the students find challenging [2]. A third analytical tool is PhET (Physics Education Technology) [1], in which students compare analysis results to computer simulations built in conjunction with physics education research. At Whittier we employ an integrated lecture/laboratory format, which is facilitated by the design of the Science and Learning Center. The integrated techniques allow the instructor to provide versatility in problem solving practice, such as group problem solving, checking answers against computer simulations, and verification of analysis results via direct experimentation. A side benefit of the integrated style is that students from different lab groups verify techniques and solutions with each other, and provide much-needed encouragement. Finally, we incorporate *traditional* lecture methods to provide the concrete examples of analysis with which we begin new material for our students [3].

3. **Applications to Society**. Whittier College non-majors gain potential in technically oriented careers if they can qualitatively explain phenomenon using physics. In recent years, our standard open-source textbooks have included material relevant to popular majors (e.g medicine and KNS). I have incorporated special units centered on these practical applications, including human nerve systems (in PHYS135B) and human metabolism (PHYS180). I also use the final group project rubric to allow non-majors who've chosen pre-medicine or KNS as their major to go further in their study of the intersection of physics and the human body. I proposed a new course entitled *Physics of the Five Senses*, designed to be connecteed with KNS courses. I plan to reintroduce this course in the near future when appropriate [4]. Being able to quantitatively understand science is vital for conducting fact-based discussions and economic participation. I included a brief unit on climate change and the solar system in PHYS135B and PHYS180, analytical problem solving and simulations. One additional tool for the non-majors is the inclusion of a individual presentation in which the student summarizes a scientific journal article in 5-10 minutes. The brevity requirement causes the students to focus on important details, decide whether they support the hypothesis, and on identification of the societal implications.

Instruction of Students in Advanced Courses

Physics majors are the second category of students we typically encounter. I broaden my discussion to *Mathematics and Computer Science majors* due to the specific circumstances under which I was hired. The Departments of Mathematics and Physics at Whittier College seek to build a separate Major in Computer Science. Currently, our college allows students interested in computer science to combine computer science with physics or math, or enter the 3-2 program in which they obtain two degrees in five years from Whittier College and The University of Southern California. The advanced course I have taught is Computer Logic and Digital Circuit Design (COSC330/PHYS306), a brand new course at Whittier College I've created. Those who participated were physics majors, mathematics majors, and Whittier Scholars Program majors, all having some connection to computer science. This course is under rapid development in parallel with developments in my research laboratory, as I will explain below.

Three focuses are relevant for teaching physics, mathematics, and computer science majors at the advanced level, in addition to those above for non-majors and introductory courses:

[3] Traditional lecture methods refer to a broad class of instruction methods, but generally refer to the professors performing example calculations on the chalkboard while students take notes and learn through repetition.

[4] The KNS department refused to approve their particular professor for pairing or team-teaching. Subsequently, the number of new students requiring introductory courses increased, and we modified my schedule by dropping my proposed course and adding an introductory one.

1. **Mental Discipline**. Advanced physics, math and computer science courses require discipline. When tackling a hard physics problem involving both advanced math and the cleverness to set up the problem correctly, there is no substitute for grit. However, the professor does have a roll in calling it forth. First, showing advanced students that *consistency beats intensity* is vital, and that value can be communicated in three ways. The first is delivering a rigorous curriculum. Problem sets should be difficult, requiring time and reflection. For example, in COSC330, homeworks were assigned in two-week increments, with both mathematical repetition (to facilitate learning binary) and open-ended design questions (like designing a device that adds two binary numbers). Second, acknowledging the class time is a precious resource, the style of content delivery should be terse, quickly disabusing students of misconceptions and moving forward. Advanced classes in universities sometimes leave the student with a blunt, confusing delivery that merely entices the student to teach themselves in the library. The right path leaves the student *motivated* to fill in gaps in their understanding, with the professor happily rising to the challenge of elevating students' understanding outside of class. For example, in COSC330 my students and I happily debugged digital circuits in simulation software together in office hours, before building them for class presentation.

2. **Strength in all Phases of Science**. Good curriculum in these advanced topics must include the following *phases* of scientific activity: theoretical problem solving, numerical modeling or simulation, experimental design and execution, and data analysis. We may think of these phases as the activity that move the student through the scientific method. In COSC, an example of the incorporation of all four phases occurs in teaching the students to work with binary numbers and code. First, the mathematics for conversion from decimal to binary is introduced along with addition and subtraction techniques, and we work example problems. Second, we model addition and subtraction via 8-bit adders in a computer simulation. Third, we actually build the adders, and fourth, we demonstrate that they work. Thus, the student gains experience in all four phases, more firmly grasping the concept.

3. **Communication**. Two skills that should never go overlooked in technical fields are oral and written communication. Presentations, papers, lab reports, and summarizing peer-reviewed articles for the class are several examples of rubrics that I use in advanced courses to hone communication skills. From personal experience, work in technical subjects would often proceed more quickly if not for the inability of group members to express themselves clearly. When dealing with abstract concepts in engineering discussions, clear communication prevents the introduction of design flaws and the introduction of bugs in software. No matter which advanced class I am teaching, my students will write at least one report, or give one presentation. I often allow students to write for extra credit, going beyond the scope of the course in the subject matter. Any practice in technical writing Whittier majors receive now will benefit them down the line as they proceed to graduate school or private sector engineering careers. [5]

[5] See supplemental materials for examples of student presentations and writing.

Semester	Course	Credits	Students	Curriculum feature
Fall 2017	PHYS135A-01	4.0	24	None
Fall 2017	PHYS150-01	4.0	17	COM1
Spring 2018	PHYS135B-01	4.0	18	None
Spring 2018	PHYS180-02	5.0	19	COM1
Spring 2018	COSC330/PHYS306	3.0	6	Advanced course
–	Total	20.0	–	–

Table 2.1: This table is a summary of the courses I have taught since Fall 2017. The introductory courses carry the course numbers 135A, 135B, 150, and 180. The advanced course, PHYS306, is cross-listed as a computer science course (COSC330).

2.2 Introductory Course Descriptions

Algebra-based physics (135A/B). The algebra-based physics curriculum is designed to achieve xyz.

Calculus-based physics (150/180). The calculus-based physics curriculum is designed to achieve xyz.

2.2.1 Analysis of Student Evaluations

Some text.

Semester	Course	Credits	Students	Curriculum feature
Fall 2017	PHYS135A-01	4.0	24	None
Fall 2017	PHYS150-01	4.0	17	COM1
Spring 2018	PHYS135B-01	4.0	18	None
Spring 2018	PHYS180-02	5.0	19	COM1
Spring 2018	COSC330/PHYS306	3.0	6	Advanced course
–	Total	20.0	–	–

Table 2.2: This table is a summary of the courses I have taught since Fall 2017. The introductory courses carry the course numbers 135A, 135B, 150, and 180. The advanced course, PHYS306, is cross-listed as a computer science course (COSC330).

2.3 Advanced Course Descriptions

Computer Logic and Digital Circuit Design. The computer logic and digital circuit design course curriculum is designed to achieve xyz.

2.3.1 Analysis of Student Evaluations

Some text.

2.4 Proposed Future Courses

Some text.

2.5 Reflections and Future Directions

Some text.

Chapter 3

Scholarship

Hello, here is some text without a meaning. This...

Chapter 4

Service

Hello, here is some text without a meaning. This...

Chapter 5

Advising and Mentoring

Hello, here is some text without a meaning. This...

Bibliography

[1] Phet interactive simulations.

[2] John D.Bransford, Ann L.Brown, and Rodney R.Cocking, editors. *How People Learn: Brain, Mind, Experience, and School: Expanded Edition*. The National Academies Press, 2000.

[3] Eric Mazur. *Peer Instruction*. Prentice Hall, Inc., 1997.