Project BoxSand: Expand, Explore, Collaborate, and Disseminate Evidence-based Instructional Practices

Today the student demographic is more diverse than ever before. To keep pace, education must undergo something of a renaissance; institutions like OSU can pave the way by using evidence-based instructional practices (EBIP) that support learning for a wider range of students. The digital era has seen a plethora of inventive new methods of content delivery and student engagement. I believe we are at a transformative point in history where we can make learning resources open for all, while simultaneously improving and implementing data driven pedagogy.

These ideas have shaped my career at OSU, spurring the creation of an educational data mining (EDM) research group that studies students' engagement with open resources. There is a synergy between open digital resources, analytics, and EBIP that has only just begun to be explored. I believe innovative approaches to content delivery and student engagement, combined with scientific tests of efficacy, can quickly make some of the widest reaching impacts on student learning. ***I propose combining innovative hybrid teaching strategies, open resources, and EDM to create the next generation of EBIP***.

My proposal has four parts and constitutes the roots to grow an entire career. I intend to use this opportunity to leverage my existing projects, ***expanding*** their influence. I will also ***explore*** and test new techniques and models for student engagement and learning. To make this happen, I plan to ***collaborate*** with colleagues from across multiple disciplines so that together we can shape the future of education. I will follow up on several levels of ***dissemination***, branding OSU as a place for innovative EBIP and EDM. My proposal is big but I believe the honor of a position such as the Scholars for Teaching Excellence warrants nothing but the most ambitious.

Expand

My career at OSU has been one of constant growth. The Scholars for Teaching Excellence position provides me with the opportunity to maintain this growth in three specific areas of my current work: 1) expand and improve Project Boxsand with ***student created resources***, 2) expand BoxSand to include the ***calculus-based*** intro physics sequence, and 3) expand BoxSand to introduce an ***Ecampus*** PH 20x course series.

Project BoxSand emerged from my five years of experience in flipping my classroom. When I took over the Introductory Algebra-based Physics series in its traditional lecture format, I knew right away that I wanted to bring in EBIP, like Active Engagement (AE) [1,15,16,17,18] and Peer Learning (PL)[2,3,19], into the classroom through a Flipped Classroom model[4,5]. With this in mind, in the first year I listened to my students, holding informal interviews and focus groups. To address the issue of students' reluctance to use the textbook, and to maintain the ability to tell the story of physics, in the second year I made over 300 pre/post lecture videos. Out of a concern that my flipped classroom structure would fail if students didn't prepare by watching the videos, I pursued and was awarded a L.L. Stewart grant to build a website, boxsand.org, to track my students' video views. In the third year I completely flipped the classroom to a student-focused environment, where they work in groups performing Think-pair-share [6,7] and PL exercises to respond to a carefully scaffolded set of questions; this interaction is enriched by facilitation by instructors, TAs, and LAs. In my fourth year I developed a Learning Assistant (LA) program with help from the Integrative Biology department. Three ESTEME Action Research Fellowships (ARF), a Learning Innovation Grant (LIG), help from over 15 OSU undergraduate and graduate students, and most recently an Oregon Educational Resources (OER) grant, has made BoxSand a budding open resource and EDM project. Last year,

my fifth, was the first year we had not only all of my videos, but also a complete set of open content for the entire series. Data from student surveys and the EDM research has convinced me the site is complete enough that we will be removing the publisher's textbook requirement this coming fall, saving OSU students nearly $70k each year.

Have these changes created a measurable effect? I invite you to boxsand.org/scholars where I share data showing how my efforts have helped students to learn more effectively, better enjoy their experience, and drop out or fail at less than half the rate than when I started.

Flexibility in access to learning tools has been shown to help underrepresented, underprivileged, and first-time college students proportionally more than their peers. One way I want to make BoxSand flexible is by collating and creating a host of different resources. We already have examples of 22 content types, including unique ones like infographic equations, concept maps, and multiple representations. To improve and expand on the current resources I propose to start an official BoxSand ***student created resources*** group. While running my *oSUPREMEd* pre-med physics study group, I made a shared space for students to collate resources for learning physics specific to the medical field. I was impressed by the collaborative efforts of the students and realized this was an untapped opportunity for them: to learn through creation, develop professional working group skills, and contribute to the education of others. I currently have around 10 students working collaboratively on small projects that create resources for BoxSand. These students are creative, and they are eager to gain levels of authorship on the site. We should foster this learning group.

Much of the algebra and ***calculus-based*** physics courses overlap, and a natural progression for the BoxSand site is to incorporate the calculus extension to open source—which could save students another $100k per year. I recently began working with OSU physics instructors Kathy Hadley and Ryan Schierer on this project. I propose to use this award to strengthen the collaboration by financially incentivizing our progress.

Kathy Hadley and I have also been tasked with forming a plan to take the PH20x series online. This is an important because of OSU's land grant directive to bring education to the community. An ***Ecampus*** series would provide an additional revenue stream for the university and an opportunity to brand OSU as a high standard for online EBIP. How I intend to do this will be outlined in my next section, *Explore*.

Explore

I propose advancing my existing projects with exploratory research into three integrated facets of student engagement: 1) comparative adaptive learning, 2) peer grading, and 3) AsyncSync methods for online AE and PI.

Every year at conferences I learn about new and innovative approaches to teaching physics, but nowhere is anyone systematically comparing approaches. At the most recent AAPT meeting, I learned of a number of inventive new learning tools: Interactive Video Vignettes [8,9], Pivot Interactives [12], and Computer Problem Solving Coaches [10]. These ideas have now been added to the set of existing good ideas. But which works best? I propose to start the momentous task of systematically performing **comparative** studies on **adaptive learning**. BoxSand's current state is at the level of Correlation Data Mining (CDM) [13,14], where linear models are informing which variables influence class performance. The end goal is to move to a Predictive Modeling state where machine learning - possibly neural networks [11] - can create custom modules out of the collective open resources that are tailored to students' individual learning. One of the first steps in this process, and one I believe is possible in this project, is to develop a simple formative homework system that incorporates an adaptive learning light approach. Students will have an *Inventory of Mastery* that

consists of all the learning objectives (LO) of the course. They will be able to use different activities on the BoxSand site to satisfy mastery of a LO. Not having to take the same path to mastery will introduce a new degrees of freedom and flexibility previously not available. The process is already underway with support from an Open Educational Resources grant. My hope is to remove the need for Masteringphysics in fall 2019, saving OSU students another $150k per year collectively between the algebra- and calculus-based series.

I also propose an exploration of a summative homework system that incorporates **peer grading**. Currently in my class, I follow up each topic's learning modules with a summative homework event. For physics, this means students demonstrate problem solving that incorporates a synthesis of principles and representations. This work needs to be written out by hand, be graded by a human, and result in partial credit and feedback. This structure provides an opportunity for peer grading. I propose that students work more challenging synthesis problems by hand and turn in a digital copy of their work. Their grade will also be dependent on their grading three other students' work with a provided rubric. I'm developing a novel algorithm and student buy-in incentive program to ensure quality assurance. This concept has been shown to work well; proprietary systems such as Calibrated Peer Review and Peerceptiv already exist, but they add perpetual cost and move in the opposite direction of consolidated open resources and tools. Having an open source system would achieve two major goals: it would decrease the cost of grading homework, and it would provide an important metacognitive step in students' learning where they reflect on what went wrong and what went right. It should also dramatically cut down on response time.

All of these exploratory proposals are relevant to both on- and off-campus courses. They leverage existing ideas to provide a better, cheaper, more efficient education. This next idea, however, addresses a fundamental hurdle in delivering an EBIP-based course online with an innovative approach that has the potential to revolutionize learning. When developing a model for an online course, we surveyed all the EBIP that have made our in-class courses so successful. The one resonating feature that Physics Education Research shows [18] is that learning problem solving and critical thinking is better achieved through AE and PL. Yet this is hard to do in the online environment due to everyone's asynchronous scheduling. Discussion boards work alright in some classes but for science courses, I feel real-time interaction is key. I propose the development of a system I've dubbed Asynchronized Synchronization, or **AsyncSync**. It would be a system that surveys students on the BoxSand site and where they are in the curriculum. It would then match students who are at the same place and let them work together through their learning modules. It would facilitate this with communication channels and a shared virtual whiteboard. The ultimate goal would be to integrate this concept with true adaptive learning where the system intelligently groups students not only based on where they are in the *Path to Mastery* but also by what we know of their past histories. If student A is good at X, and student B is good at Y, then the system will group them and build a custom learning module to address both X and Y by leveraging their individual strengths. This Adaptive AsyncSync idea is truly part of the next generation of EBIP.

Collaborate

My success so far at OSU is largely due to the strong collaborations I've formed through entities such as the Center for Teaching and Learning, the ESTEME at OSU initiative, and informal professional working groups. The ***lightboard studio***, funded by a LIG, is one example of a highly productive cross-discipline collaboration. Dan Rockwell from Mathematics has helped me build the studio, and Devon Quick in Biology is helping us refine delivery methods. There are many teachers from both the University and beyond that have made or intend to start making videos. I propose to

explore creative approaches to campus wide collaboration centered on the lightboard studio. Ideas include producing outreach materials, such as research group promotional videos and starting a science A/V club for Interactive Lecture Demos [20,21].

Along with the large number of existing collaborations I continue to strengthen, there are a host of new relationships that I propose to foster. Through my ARF, I presented on BoxSand research and discussed potential collaborations with colleagues. I propose to open an avenue for Senior ***Computer Science capstone*** projects to foster a robust opportunity for CS and other science students to collaborate on creating and studying next generation learning tools.

I have also recently engaged with Shannon Riggs, Kathryn Linder, and other Ecampus staff about the creation of the online course, specifically regarding approaches to combining open resources and online research. I will be applying to the next cohort of ***Ecampus Research Fellows*** (ERF) and will propose I use those resources to allow me to focus solely on research during the 2018 summer, accelerating many of the efforts in this proposal.

In my outreach ***beyond OSU***, last year I became the Oregon representative to the American Association of Physics Teachers (AAPT); my recent presentation at the national meeting sparked some enthusiastic interest from potential collaborators. Also, Susan Fein, Ecampus instructional designer and Eastern Washington University Ph.D. student, is planning her dissertation research on a mixed methods educational psychology study with BoxSand and some of my learning methods. BoxSand has a long list of collaborators, including most of my former Teaching Internship (TI) students who have moved onto teaching their own classes. They are authoring on the site, and we are developing new innovative scaffolded question paths and working towards coding BoxSand in preparation for adaptive learning. The largest group of collaborations I want to expand on involves my ***students***, since they are what drive me. Between LA's, Supplemental Instructors, BoxSand student authors, TI's, oSUPREMEd, and the lightboard A/V club, I hope to foster a productive, rich student/teacher collaborative space.

Disseminate

Creation without dissemination does not advance science. I propose a four-stage approach to engaging several communities. First, I will continue to present at local and national level conferences and working group events. This includes a planned department colloquium this coming year, events at CTL and ESTEME, and talks at both the regional and national AAPT level. Second, I will leverage the support from my ARF and the ERF to hopefully publish high impact research on the tools and pedagogies explored in Project BoxSand. The third stage will be branding BoxSand, through a national podcast tour and creation of a YouTube channel, highlighting OSU and Ecampus as nationally recognized leaders in open resources and innovative EBIP. The last stage of dissemination will come in the creation of a workshop on digital open resources and innovative EBIP. I intend to deliver this workshop at both local and national levels.

boxsand.org/scholars

I've created a supplemental website to clarify any questions you may still have. It contains summary and detailed video presentations about the project. There are also timelines (for the whole project will extend beyond three years) and outlines showing how my project is exemplary in satisfying the call to action on this proposal request. Please consider me to be the inaugural Scholars for Teaching Excellence Award recipient for the College of Science. Thank you for your time.

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