

STATEMENT OF SCHOLARLY ACTIVITY (ACADEMIC YEARS 2018-2019, 2019-2020, 2020-2021)

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1. IUSE VIDEO PROJECT

In the period under review, I was Co-Principal Investigator for the *Improving Undergraduate Stem Education (IUSE)* Video Project (Principal Investigator Sherry Seethaler, UCSD Division of Physical Sciences). The IUSE Video Project is an NSF-funded project whose primary goal is to produce a collection of interdisciplinary instructional videos which encourage meaning making in mathematics and improve students' understanding of challenging mathematics concepts in the biology, chemistry, and physics undergraduate curricula.

Although many lecture and tutorial videos are available online, such videos are of variable quality and are typically developed by individual instructors rather than interdisciplinary teams. Moreover, the impact of such videos usually remains untested. One of the primary distinguishing features of the IUSE Project is that our series of videos was collaboratively developed, tested, and refined by a team of nine UCSD faculty across four departments: Biology, Chemistry, Mathematics, and Physics. So far, we have completed production on eleven videos, and our final collection will comprise twenty videos. These videos explore four subtopics within the broader topic of rate of change; for each subtopic, there is one biology video, one chemistry video, one mathematics video, and one physics video, and one current research video. I wrote the script for, directed, and acted in two of the mathematics videos. However, every stage of the development of my videos was guided by detailed feedback via weekly meetings with my eight collaborators. The other videos in the collection were produced according to a similar process; for these videos, I was involved in the feedback and editing phases.

To begin testing the impact of our videos on student learning, we have already piloted the use of a subcollection of the videos in selected UCSD calculus and physics courses. Preliminary data suggest that students are learning from the videos, and students' feedback about the videos has been overwhelmingly positive.

Regarding the broader impact of the IUSE Project, the videos will be freely available online, organized according to both discipline and subtopic. The website housing the videos will also connect the videos to specific topics on standard course syllabi, thereby facilitating their use as complements to undergraduate mathematics and science courses. We also hope that the rigorous process through which our videos were developed, tested, and refined sets a higher bar for future video developers. The papers [2020] and [2021] can provide valuable information for instructors, MOOC providers, and others who seek to enhance students' learning through video, including how to develop complementary videos from different disciplinary perspectives.

Below is the complete list of titles in our *Understanding Rates of Change* interdisciplinary video library, with hyperlinks to my two videos. All of the finished videos in our collection can be found at the website <https://sites.google.com/view/iusevideos/home> (a prototype site for internal use only).

(1) Subtopic One:

- *Average Versus Instantaneous Rate and Sign: Biology*
- *Average Versus Instantaneous Rate and Sign: Chemistry*
- *[Average Versus Instantaneous Rate and Sign: Mathematics](#)*
- *Average Versus Instantaneous Rate and Sign: Physics*
- *Average Versus Instantaneous Rate and Sign: Current Research*

(2) Subtopic Two:

- *Moving Among Graphical Representations: Biology*
- *Moving Among Graphical Representations: Chemistry*
- *[Moving Among Graphical Representations: Mathematics](#)*
- *Moving Among Graphical Representations: Physics*
- *Moving Among Graphical Representations: Current Research*

(3) Subtopic Three:

- *Relationship Between Rates and Accumulation (Integration): Biology*
- *Relationship Between Rates and Accumulation (Integration): Chemistry*
- *Relationship Between Rates and Accumulation (Integration): Mathematics*
- *Relationship Between Rates and Accumulation (Integration): Physics*
- *Relationship Between Rates and Accumulation (Integration): Current Research*

(4) Subtopic Four:

- *Differential Equations: Meaning of Terms: Biology*
- *Differential Equations: Meaning of Terms: Chemistry*
- *Differential Equations: Meaning of Terms: Mathematics*
- *Differential Equations: Meaning of Terms: Physics*
- *Differential Equations: Meaning of Terms: Current Research*

1.1. Equity, Diversity, and Inclusion. The National Science Board's Science and Engineering Indicators reveal that only about half of the freshmen intending to major in STEM actually earn STEM degrees. It is well documented that lack of talent does not explain the attrition; some of the best STEM students switch to non-STEM majors or drop out of college. One reason that students, especially underrepresented minorities, leave STEM majors is they perceive the content they are learning in their various STEM courses as disconnected and irrelevant. By exploring conceptual connections across foundational mathematics, physics, chemistry, and biology courses, revealing their relevance in current research and illustrating

practical applications, the IUSE video series directly responds to this reason undergraduates give for leaving the sciences. It is also anticipated that the videos will drive additional curricular and instructional changes, such as increased interdisciplinarity, which improve the learning experience for diverse STEM students.

1.2. **Publications.** In addition to the video library, so far the IUSE project has resulted in two publications; references (with hyperlinks) and abstracts are included below.

- (1) Rabin, J.; Burgasser, A.; Bussey, T.; Eggers, J.; Lo, S.; Seethaler, S.; Stevens, L.; Weizman, H. *Interdisciplinary conversations in STEM education: Can faculty understand each other better than their students do?* International Journal of STEM Education **8**, no. 11, 10 pgs. (2021)

Abstract: Rate of change concepts from calculus are presented and applied rather differently in college mathematics, physics, biology, and chemistry classes. This is not simply a matter of pedagogical style but reflects real cultural differences between these disciplines. We describe the efforts of our interdisciplinary collaboration to understand and reconcile these differences as we designed and discussed instructional videos for students. We summarize our conversations about terminology, notation, functions, rates, units, and sign conventions across the disciplines. We present some strategies that enabled us to communicate effectively, resolve confusions and reach shared understandings. Our work has implications for others involved in collaborative interdisciplinary projects and for STEM educators.

- (2) Seethaler, S.; Burgasser, A.; Bussey, T.; Eggers, J.; Lo, S.; Rabin, J.; Stevens, L.; Weizman, H. *A research-based checklist for development and critique of STEM instructional videos.* Journal of College Science Teaching **50**, no. 1, 21-27. (2020)

Abstract: The technical barriers to video production are decreasing and the popularity of video as an instructional medium in science is increasing. Although a large body of education research is available to inform the selection and design of instructional videos, this research is dispersed across journals, disciplinary traditions and STEM fields, and the practical lessons are not readily accessible to readers. To guide the development and critique of science and mathematics instructional videos, our interdisciplinary team, with members from mathematics, physics, chemistry, and biology, has developed an instrument by synthesizing the relevant education literature and translating it into recommendations for practice. The user-friendly instrument is a twelve-item checklist grouped into the categories of content and sequencing (concepts, logic, story, and language), cognitive supports (visualizations, signals, synchronization, segmentation, and streamlining) and affective considerations (relevance, rapport, and accessibility). The instrument provides a conceptual foundation and evaluation framework for designers of educational videos.

2. NOTEWORTHY PROFESSIONAL ACTIVITIES

In this section, I will highlight some of my most noteworthy service and professional activities during the period under review. For a complete list of my service and external professional activities during the period under review, please refer to my biobib.

2.1. **MDTP.** The Mathematics Diagnostic Testing Project (MDTP) is a joint project of The California State University and the University of California. The overarching goal of the MDTP is to strengthen mathematics education by providing detailed information on student preparedness for continued math study. The MDTP develops and provides diagnostic tools and training to support California mathematics educators in preparing students for success in current and subsequent mathematics courses. The MDTP envisions that all California students will achieve mathematical preparedness for and success in college-level mathematics courses.

The MDTP Workgroup consists of expert educators from secondary classrooms, district and county programs, and the three California University systems; I have been privileged to serve as a Workgroup member since 2008. Our Workgroup meets for a week-long summer conference every year and also convenes for two shorter meetings during the fall and spring. In our summer conference meeting, we write new diagnostic tools and use robust statistical data to revise existing diagnostic exams. Many of our diagnostic tools are used by California middle schools and high schools, but we also provide free diagnostic materials to CSU, UC, and some private and community colleges. For several years, the UCSD Mathematics Department has used MDTP exams as one means of placement of students in UCSD mathematics courses.

During the period under review, I spent two summer Workgroup meetings serving as the chairperson of an MDTP Workgroup committee tasked with developing an entirely new series of diagnostic exams for college students; the goal of this series of exams is to learn details about students' readiness in foundational topics necessary for success in their college math courses. To date, we have developed four new diagnostic exams; these new exams are currently being used in the following UCSD mathematics courses: Math 2, Math 3C, Math 4C, Math 10A, Math 10B, Math 20A, and Math 20B. The UCSD Math Testing and Placement office administers the exams for all students in the aforementioned courses just prior to the beginning of each Fall and Winter quarter, so there is no extra time or effort required of the course instructors. The data from the exams are used in two ways:

- (1) Each student receives instant results regarding their readiness for topics of study in their course; these results indicate topics which the student is encouraged to review prior to the start of their course. The results also contain links to topic-specific learning modules aligned to the exams which students can use to help remedy the errors and misconceptions identified by their exam results. Students are also encouraged to bring their results to the Academic Achievement Hub of the Teaching and Learning Commons so that the tutors can use the results to inform their tutoring.
- (2) After the test window closes, each course instructor receives access to the data results for all students in their class (both instantly online and synthesized). The Director of Math Testing and Placement, Kimberly Samaniego, then offers to meet with each instructor to assist the instructor in interpreting these data and using these data to inform course instruction.

Our UCSD exam project is ongoing. Current and future phases of the project include analyzing exam data and determining effective ways that the course instructors can use the exam results to inform their teaching and support their students. We also continue to develop the topic-specific learning modules aligned to the exams. Additionally, we continue to collaborate with the Triton Achievement Hub to determine how Supplemental Instruction tutors can use the exam results to best support our students and inform the SI sessions.

2.2. Online Teaching Resources. In the wake of the COVID pandemic, the UCSD Mathematics Department created the Remote Teaching Committee. I served on this committee in the 2020-2021 academic year, together with my colleagues Alireza Salehi Golsefidy (chair), Ioan Bejenaru, and Daniel Rogalski. The goal of our committee was to provide support and resources on remote teaching practices to our course instructors during the period of online instruction. During summer 2020, our committee analyzed data obtained in a survey to our faculty, postdocs, and teaching visitors regarding their experiences with remote teaching in Spring quarter 2020. I also scheduled interviews with select colleagues to follow-up on their survey responses. Our committee then used all of this data to produce the resource [A Survey on Remote Teaching Practices](#), which we provided to our colleagues in the Mathematics Department prior to the start of Fall quarter 2020. We also shared this new resource with our colleagues in the Chemistry, Economics, and Physics Departments.

Throughout the 2020-2021 academic year, I continued to serve as a support resource for any colleagues who contacted me with questions about remote teaching, including through my position as Course Coordinator for Fall quarter Math 18, during which I mentored three new SEW postdocs in their first quarter teaching at UCSD. I also pioneered strategies to promote academic integrity, acquiring copious experience in proctoring assessments via Zoom and developing related resources, which I shared with several colleagues at UCSD, as well as faculty in the Mathematics Department at Texas A&M University.

REFERENCES

- [2021] Rabin, J.; Burgasser, A.; Bussey, T.; Eggers, J.; Lo, S.; Seethaler, S.; Stevens, L.; Weizman, H. (2021). *Interdisciplinary conversations in STEM education: Can faculty understand each other better than their students do?* International Journal of STEM Education **8**, no. 11, 10 pgs.
- [2020] Seethaler, S.; Burgasser, A.; Bussey, T.; Eggers, J.; Lo, S.; Rabin, J.; Stevens, L.; Weizman, H. (2020). *A research-based checklist for development and critique of STEM instructional videos.* Journal of College Science Teaching **50**, no. 1, 21-27.