

Empowering Journey Making an Interactive Video Vignette

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We've all experienced it in one way or another: bright, eager students start the year ready to tackle the biggest challenges in physics and life. Yet as the semester wears on and the physics gets more challenging, student enthusiasm wavers. They lose confidence and feel pressure to prove themselves worthy of a difficult and sometimes intimidating major. This pressure can inhibit physics students from performing at their full potential.

We believe that professors can improve the situation by implementing projects in students' freshman and sophomore years that focus on building student confidence. Physics has an intimidating reputation, and empowering students by building their confidence early in their careers can help them overcome traditional hurdles.

Self-confidence is defined as a feeling of trust in one's abilities, and self-efficacy as the belief that one can do something.¹ When students struggle with both self-confidence and self-efficacy, it adds to the difficulty of completing their degree. While we hope that students persevere through challenges, low self-confidence, and self-efficacy can be hindrances that eventually push them out of the field.² This feeling of inadequacy is common among many physics students, and is especially prevalent among women, students of color, and other minoritized groups—groups that physics has struggled to retain.^{1,3–8} On the flip side, students who exhibit stronger physics identity and greater self-efficacy are more likely to be successful undergraduates.^{9,10} A number of factors can affect self-efficacy, including how students perceive themselves within the larger physics community.¹¹ Minority students in particular experience underrepresentation, isolation, and identity fragmentation in ways that challenge both their confidence and their feeling that they belong in physics spaces.¹² For this reason, the extra mentorship that the students gain by participating in undergraduate research can be life changing,¹³ because it offers students a space where they are active researchers and are encouraged by their mentor. Therefore, efforts should focus on inviting these students to participate in projects/research early, to build confidence and a sense of belonging within our departments.

Reports that focus on improving diversity in physics, such as the TEAM-UP report, often cite student research as a viable step for improving both student identity in the physics department and their later physics careers.^{3,14–17} Students benefit greatly from the experience, even when a research project does not align perfectly with career goals.¹⁵ Becoming a teaching assistant for an undergraduate class also yields rich benefits.¹⁸ Unfortunately, many students do not have the opportunity or skills needed to become teaching assistants, or to work on undergraduate research projects, until they are in upper-level courses.

To address all of these concerns, M.W. created sophomore-level projects that would provide a significant boost to physics students' self-efficacy and confidence. The projects involved conducting informal activities within the physics de-

partment, so that students would gain experience and value similar to those gained in traditional undergraduate research projects, while also appropriate for those students' educational levels. One of these projects involved making interactive video vignettes (IVV). The IVV project is the focus of this paper. We offer insights and lessons learned. The details of this enriching experience could provide a prototype for other instructors who want to foster positive experiences for early-level undergraduate students.

IVVs are adaptive learning tools that offer a unique opportunity to make fun interactive physics videos. These online lessons combine text, video, and multiple-choice questions into an active learning exercise.^{19–23} Ultimately, each IVV is accessible via a web link. The entire process is developed in Vignette Studio, a software development tool that is available for free on Compadre.org. Vignette Studio allowed us to create a unique educational experience for individual students based on how they answered multiple-choice questions, similar to a choose-your-own-adventure book. Upon selecting a particular answer, a student is shown a video directly related to that choice.

The experiences and lessons shared below are from the first IVV project that the authors developed together as undergraduate teammates (E.O.-M. and L.C.) and project lead (M.W.). The goal of this project was to develop an IVV that introduced the concept of torque to students in a fun way. We decided to use a single IVV lesson to demonstrate the connection between physics and a seemingly unrelated topic: the knickerbocker air step performed in the Lindy Hop dance.^{24–26}

We saw this particular project as an opportunity to combine the technical skills used in physics with creative skills found in dancing. Both E.O.-M. and L.C. have strong connections to art and music and were excited when invited to build the project. We prepared all of the content to fit into the IVV framework. This included storyboarding the video, planning key aspects of the lesson, practicing and recording the Lindy Hop demonstration, and editing the takes. As early-career students, the team learned significant lessons during the production of the IVV that proved beneficial even after graduation. Here is what we learned in completing the project.

• **Lesson #1: Start with the fundamentals.** There is an adage that says the best way to learn something is to teach it. This was the guiding idea in inviting two students to lead the IVV development. E.O.-M. and L.C., despite having completed introductory classes with high marks, spent a significant portion of time early on in the project reviewing, relearning, and understanding the general physics of torque. This content review process required E.O.-M. and L.C. to reevaluate their understanding of the topic so they could correctly apply the concepts, which reinforced their ability to understand and

explain torque. We had to keep coming back to simpler models in our discussion (i.e., how a door works). We found that these examples could further support the concepts related to torque, so we incorporated them directly into the IVV. In this way, E.O.-M. and L.C. practiced developing and reiterating their own models of torque according to the needs of the lesson. Developing models is an important tool for physics students to learn.²⁵

Being able to apply the fundamental concepts that we covered in class to challenging real-life problems allowed E.O.-M. and L.C. to experience a practical physics application firsthand. This was a revealing moment, and upon reflection, E.O.-M. shared that “it served as proof to myself that I was capable of completing a physics project even if I was still learning physics ... I was persistent and hardworking even when I didn’t have confidence in my abilities or myself as a scientist.”

Month	January	February	March	April	May	June	July	August	Sept.	October	
Activities	Script Writing						Set Up Vignette Layout				Creating Vignette
	Review Literature on the IVV, Testing IVV Software		Drafting Concept Questions		Lindy Hop Training (Long Island Swing Dance Syndicate) Learning the Knickerbocker flip	Knickerbocker practice	Creating Storyboard		Editing Video	Casting	
	Team Building		Torque Research				Script Practice	Video Recording			

Fig. 1. Initial project map for the IVV project. A project map is a summary of tasks found in the project plan. Phrases such as “Team Building” refer to tasks that were developed to build a strong, committed team. These tasks included having the kickoff meeting, developing roles on the team, and sourcing periphery team members for dancing.

• **Lesson #2: Plan the project, but be flexible!**

When we started the project, we created the project plan shown in Fig. 1. As is typical with new research projects, the sequence of events shifted around and did not fall exactly within the planned time windows.

The project plan was a helpful tool used to navigate the technical aspects of the project. For more creative aspects, we used a storyboard to capture our ideas and more. A storyboard is a creative tool that serves as a visual aid, illustrating how scenes should be played out and how they should be recorded to demonstrate the key points of the lesson (Fig. 2). It is essentially a cartoon layout of the scenes in a video.²⁶ For example, our storyboard had to include a panel of the dancers in midair so that the lesson could demonstrate where a dancer’s pivot point was located. However, its effectiveness was limited by our team’s own lack of experience in creating and using a storyboard. In underestimating the importance and

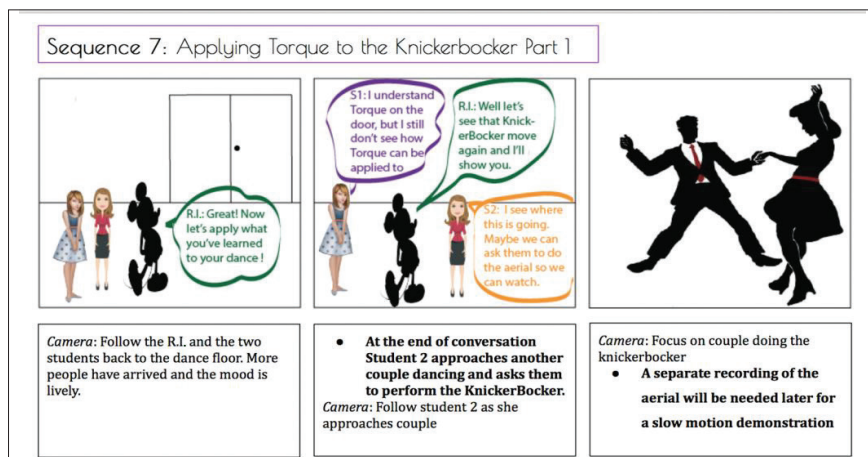


Fig. 2. Storyboard example of Swing Dancing and Physics IVV. R.I. = recitation instructor; S = student.

time needed to create one, our team was less than efficient in completing each element of the overall project. Storyboarding earlier and investing more time in storyboard creation would have allowed our team to better visualize what was both physically possible and needed for the recording process and lesson planning.

Even when the project development did not go as planned, E.O.-M. commented directly on the value of the experience, saying, “The project taught me firsthand how to approach a research project from scratch: you have to decide the scope of material, identify tools and time constraints, manage resources and team members, and research a product. I was able to recognize this process and apply the skills in grad school.” Developing the storyboard was a powerful experience for the team, because it required envisioning the creative details of a project. In this way, E.O.-M.’s and L.C.’s confidence was boosted because they were able to apply

a seemingly unrelated creative skill—something that both students felt was undervalued in science, technology, engineering, and mathematics—to a physics project.

Putting together the storyboard and connecting it to associated physics was an opportunity for the students to both train and gain trust in their creative thought processes. The second author stated, “support from [the principal investigator] ... by allowing me full creative range to design the storyboarding, for example—helped me understand more about my own ambition to lead and solve challenges through creative means. Right after working on the IVV, I felt empowered to be even more ambitious and adventurous with the challenges I took on, to open more possibilities for myself. This mindset led to my pursuit of electrochemistry and novel semiconductor materials, and eventually my move to Poland for an international research project under the lead of Dr. Justyna Widera-Kalinowska, with support from NSF and the University of Warsaw.”

• **Lesson #3: Gain confidence by just diving in and having fun.** Because our team chose a topic in which our student team members had no experience (i.e., Lindy Hop), the team spent considerable time learning the dance moves/learning about the dance. We were only able to complete one IVV during the project window. In contrast, other IVV group projects have taken considerably less time. Nonetheless, the extra time spent on the project was worth the experience gained. The extra time improved the quality of the IVV, developed team unity, and fostered a sense of self-efficacy for the students on the project team. This growth potential is exemplified by a comment from L.C.: “I can look back at it now and still smile. This was one of the defining moments of my physics career, because it made me truly enjoy what I was learning. In my own personal frame of reference, I believe loving what you learn is a key factor in retention—it made physics less intimidating to me, and renewed/sparked my commitment to studying more.” And “In retrospect, I remember all of the laughs I had more than anything else.” She further states, “The experiences above were among the key inspirations that motivated me to take on my master’s at the University of Rochester, in Technical Entrepreneurship and Management.”

Conclusions

Out of the 6760 physics degrees awarded in 2013, only 118 were awarded to African-American, Hispanic, or Native American women.²⁷ This project actively engaged two female first-generation students (Hispanic and Vietnamese American) during their sophomore year. Both of these students gained confidence, graduated, and went on to graduate studies. Our story provides evidence that if we provide students with experiences that empower them and promote a sense of belonging, we can build community and further our efforts in increasing retention!

We believe having students develop quality IVVs as a project for introductory physics will improve educational experiences for both students taking introductory physics and students making the IVVs. Since the Lindy Hop/Torque IVV discussed in this paper was created, it has been used every year in introductory physics classes led by M.W., because it provides an easy and fun introduction to the topic of torque. Using sophomore-level students to develop these IVVs appears to lead to positive outcomes for all of the students involved. L.C. stated, “This project has become one of the defining moments that helped shatter my own limitations surrounding physics and where I can take it, and by translation I also thought more freely about limitations on myself. Indeed, it was an empowering journey.”

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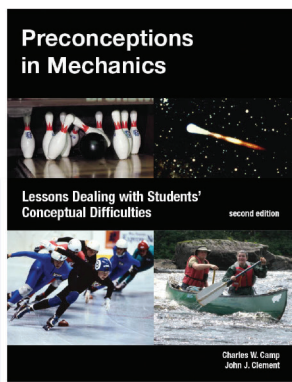
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