Evaluating science identity, communication self-efficacy, value, and skills gained in a hybrid CURE lab

E. Austin Leone & Donald P. French
Oklahoma State University, Stillwater, OK

Subject/Problem

Background

Few science programs include explicit curricula for practicing oral science communication at the undergraduate level (Chan, 2011). Course-based undergraduate research experiences (CUREs), in which students collaborate (Corwin et al., 2015) on group or whole-class projects can provide opportunities for students to practice oral science communication. Students participating in CUREs report improved science identity (Hanauer et al., 2016) and science self-efficacy (Esparza et al., 2020), but few studies describe or assess authentic oral science communication activities within CUREs (Brownell et al., 2015; Sarmah et al., 2016; Reeves et al., 2018). The limited research that explores how research poster activities in CUREs relate to students' science communication self-efficacy (Sarmah et al., 2016), fails to assess the relationship between students' science communication self-efficacy and their science identity in a CURE. In this study, we used quantitative and qualitative strategies to evaluate how students' science identity and science communication self-efficacy develop in a CURE that used research posters as an authentic assessment in a hybrid model wherein students work both face-to-face and virtually. The following research questions guide our study:

1) How does creating and presenting a poster relate to students' science communication self-efficacy and science identity in a CURE conducted in a hybrid format?
2) What are students' perceptions of value and skills gained from a hybrid lab CURE virtual poster activity?

Theoretical Framework

Our study is situated within two theoretical frameworks: the self-efficacy domain of Bandura's (1986) Social Cognitive Theory, and identity development described by Gee (2000). Bandura (1986) posits one's self-efficacy, i.e., one's belief in achieving a certain outcome, is developed through mastering an experience, social comparisons of oneself to others, receiving social persuasion or encouragement, and managing one's physiological responses. Our study focuses on science communication self-efficacy, i.e., one's belief in one's ability to communicate science. Poster presentations during a CURE served as the communication activity in our study. Our other guiding framework, Gee's (2000) identity development, posits one can develop identity through discourse. In our study, students conversed and discussed their research project with their audience in poster format.

Design/Procedure

Design

With IRB approval (IRB-2025), we collected students' **quantitative** self-perceptions of science identity and science communication self-efficacy using a quasi-experimental design with a pre-test and random selection of students for post-tests at one of two time points. We collected **qualitative** perceptions of the poster activity from those students randomly selected for the second time-point survey.

Course Description and Context

We collected data for two semesters from a process-focused plant biology CURE in which students conducted a long-term study of plant phenotypes and response to abiotic stress, connected to ongoing faculty research at a large, public, research-intensive university located in the South-Central United States. Poster presentations were the major lab assessment. In the hybrid model, required during the pandemic, half of each student team (of 4) met face-to-face every other week for 15 weeks. In the first 8 weeks, students identified plant morphology, identified variables to test, designed their experiment, and began data collection. In the remaining 7 weeks, students developed posters while completing data collection and analysis. Student teams presented posters in a virtual symposium during the last week of the semester.

Data Collection

We recruited students (n=355 across two semesters) to complete pre-test (at the start of the course) and post-test questionnaires with quantitative and open-ended response items administered via Qualtrics. We effectively created two treatment groups (Figure 1) by randomly administering post-test 1 to half the subjects before they started any poster-related activity (*Research Only = RO*), and post-test 2 to the remaining subjects after they presented their poster at the virtual session (*Research + Poster = R+P*). We received: n=279 pre-tests, n=103 post-test 1, and n=98 post-test 2. After we removed incomplete responses and incorrect responses to a quality control item, the final sample sizes were n=75 students in *RO* and n=74 in *R+P*. We calculated instrument reliability using n=226 pre-tests.

Quantitative data sources

Science identity. We used 3-items from the Persistence In The Sciences questionnaire (Hanauer et al., 2016), which has a published reliability of $\alpha = 0.87$. Each item offered five Likert-scale response options. Scores range from 3, if students answered all items negatively (limited science identity), to 15, if students answered all items positively (high science identity).

Science communication self-efficacy. We used the two relevant subscales from Anderson et al.'s (2016) instrument. The scientific oral presentation subscale (4 items, $\alpha = 0.89$) and scientific conversation subscale (8 items, $\alpha = 0.89$) each had five response options per item. Scores range from 12, if students answered all items negatively (low self-efficacy), to 60, if students answered all items positively (high self-efficacy).

Qualitative data sources

Three open-ended response items on post-test 2 served as our qualitative data sources: "What skills, if any, did you gain from the entire poster process (making AND presenting)? "In what ways do you think the poster presentation benefited you?" and "What reasons would you have for choosing a poster over other major assignments, or vice versa?" We received a total n=74 qualitative responses to each question.

Analyses and Findings

Analyses

Quantitative

We performed all quantitative analyses using SPSS 26. We calculated Cronbach's alpha reliability of the science communication self-efficacy and science identity instruments in our population. Depending on data normality, we performed parametric or non-parametric repeated-measures analysis of variance (ANOVA) within treatments on raw paired-difference scores (post-pre) to assess how students' science identity and science communication self-efficacy changed within treatments. We then calculated normalized change scores between post-tests and pre-tests and compared normalized change scores between treatments using Mann-Whitney U tests. Finally, we performed Pearson correlations to assess relationships between normalized change in science identity and science communication self-efficacy within treatments.

Qualitative

We used NVivo for analysis. We approached our data inductively and utilized in-vivo coding for our first-cycle coding scheme to create codes for each open-ended question. Authors discussed the generated in-vivo codes, and a co-author analyzed a 10% sample of open-ended responses using the generated in-vivo codes to calculate inter-rater reliability using overall percent agreement and Cohen's kappa (k). Authors discussed codes until they reached agreement. One author analyzed the remaining data and transitioned the data to second-cycle pattern coding using a code map. We identified emergent themes within each data source using the generated pattern codes (Saldana, 2013).

Findings

Quantitative

In our study, reliability for the science communication self-efficacy and science identity instruments were $\alpha = 0.84$ and $\alpha = 0.81$, respectively. Repeated measures ANOVA revealed significant increases in students' science identity in *RO* ($\chi^2_F(1) = 9.62$, $p < 0.05$) and *RP* ($\chi^2_F(1) = 20.90$, $p < 0.001$) treatments (Figure 2). Science communication self-efficacy increased significantly in each treatment: (*RO*, $F_{(1,74)} = 20.82$, $p < 0.001$, $\eta^2_p = 0.22$; *RP*, $F_{(1,73)} = 11.97$, $p < 0.05$, $\eta^2_p = 0.14$) (Figure 3). Normalized change scores did not differ significantly between treatments regarding students' science identity ($U = 3193$, $z = 1.59$, $p = 0.110$) or science communication self-efficacy ($U = 2630$, $z = -0.551$, $p = 0.582$). We found no significant relationships between normalized change scores within *RO* ($r = 0.18$, $p = 0.124$) and *RP* ($r = 0.21$, $p = 0.063$) treatments.

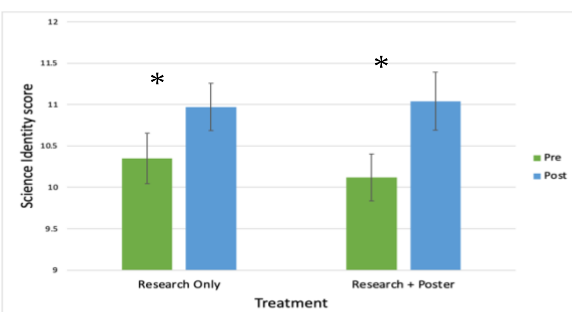

Figure 2. Mean science identity raw pretest and posttest scores between treatments with standard error bars. Significant differences indicated by an asterisk.

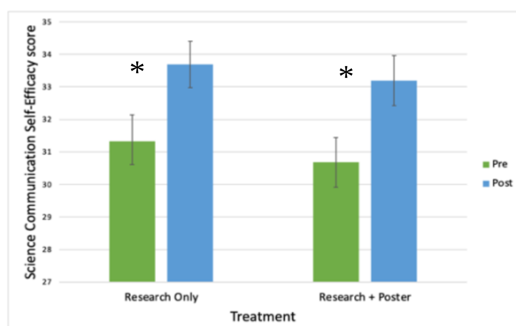

Figure 3. Mean science communication self-efficacy raw pretest and posttest scores between treatments with standard error bars. Significant differences indicated by an asterisk.

Qualitative

Percent agreement between two coding authors ranged from 90% to 100% while Cohen's kappa ranged from k = 0.865 to k = 1.00 when each coder discussed the same 10% of the total data. Three major themes emerged among students' responses for perceived skill gains from making and presenting their poster. *Personal Development:* Students described developing interpersonal skills interacting with peers in their research teams. Regardless of their liking group work, students perceived their peer interactions as impactful. As one student described, "Group work is not my specialty because I like to take over the project so I would say that my team working ability improved over making the poster." *Quantitative Process Skills:* Students indicated gaining skills working with excel and interpreting data. One student commented, "From making the poster I learned about the p-values and how to do those calculations in excel, which I think will be useful in the future." Other students told us about their skill organizing data, "I think the biggest thing I learned was how to use excel to organize the data I collect." *Conversing & Presenting about science:* Students indicated skill gains in verbal communication and presentation skills through comments such as: "As for presenting, it helped me with paraphrasing and giving a general overview of data rather than regurgitating what we had on the poster."

Three major themes emerged among responses to questions about perceived benefits of the poster presentation and reasons they would choose a poster over other major assignments. *Posters are more focused and straightforward:* Students enjoyed working on the poster because, as one student said, "I like that I get to choose one topic and really go in depth and then relate it to what I'm learning in class" or because "The poster was simple and had a layout of expectations which aren't necessarily present for all other assignments." *Improved communication, presentation, and conversations about science*: Some students noted they: "think the poster presentation helped me hone my scientific communication skills." *Posters are authentic & engaging*: Students thought the poster was, "a lot more hands on, requires you to actively participate." Students also hinted at how the poster process might benefit them in the future, "I find making the poster more related to what I'll be doing in the future than writing a paper" and "…a good way to prepare students for future poster presentations and science symposiums."

Contribution

Although our *RO* treatment excluded students still completing their data collection, data analysis, or poster-related activities, students' science identity and science communication self-efficacy increased. Improved science identity in this treatment might result from students participating in activities similar to practicing scientists, as in prior research (Mraz-Craig et al., 2018; Cooper et al., 2020). Students' science communication self-efficacy in our *RO* treatment also increased, which might stem from their practicing science communication within their teams as they discussed literature. Students' science communication self-efficacy gains might also stem from their observing team members succeeding in communicating during team interactions throughout the semester – the experience comparison aspect of self-efficacy development in Social Cognitive Theory (Bandura, 1986).

The hybrid lab CURE model provided student teams with poster presentation opportunities through Zoom to their TA, lab coordinator, and lecture faculty member. Students in the *R+P* treatment reported significant gains in their science identity and science communication self-efficacy. Students' science identity could develop from participating in similar practices to established scientists (Mraz-Craig et al., 2018; Cooper et al., 2020), or from the discourse they experienced when answering questions from their science expert audience – an aspect of identity development posited by Gee (2000). Social Cognitive Theory suggests experiencing a positive, successful outcome greatly boosts one's self-efficacy, which might explain the significant improvement we identified in the *R+P* treatment. Because we found no significant differences between treatments, it appears the virtual poster experience in the hybrid CURE did not add to either self-efficacy.

We did not find a significant relationship between science identity and science communication self-efficacy, suggesting students under our conditions develop their science identity without developing belief in themselves to orally communicate science, or vice-versa. However, students in our hybrid CURE reported skill gains and value from the poster creation and presentation processes, namely, personal development interacting with their research team, conversing about and presenting science, and the more focused, single-topic nature of research posters. Our conclusions align with and extend those of Goldey et al. (2012) that students value focusing on one topic and understanding it at depth more than approaching a breadth of knowledge.

Given how few undergraduate science programs explicitly include oral communication in curricula (Chan, 2011), instructors might consider providing students opportunities to communicate their work orally to a broader audience. However, if limited to a hybrid model and virtual presentation to a very limited audience, we recommend instructors focus on opportunities to engage in science practices and formative rather than summative oral science communication.

General Interest

Our research provides evidence of student affective development and perceptions of value from an oral science communication activity, including implications for instructors limited to a hybrid model of instruction. Our results will be valuable to educators who are interested in improving their students' science identity and science communication self-efficacy, as affective factors strongly relate to students' persistence in science (Hanauer et al., 2016). Practitioners with a deeper understanding of how students develop science identities and science communication self-efficacy, are better equipped to implement instructional strategies, even when limited to a hybrid model, to improve future scientists' confidence communicating research with a scientifically illiterate public.

References

Anderson, C. B., Lee, H. Y., Byars-Winston, A., Baldwin, C. D., Cameron, C., & Chang, S. (2016). Assessment of Scientific Communication Self-Efficacy, Interest, and Outcome Expectations for Career Development in Academic Medicine. *Journal of Career Assessment*, *24*(1), 182-196.

Bandura, A. (1986). The Explanatory and Predictive Scope of Self-Efficacy Theory. *Journal of Social and Clinical Psychology*, *4*(3), 659-676.

Brownell, S. E., Hekmat-Scafe, D. S., Singla, V., Chandler Seawell, P., Conklin Imam, J. F., Eddy, S. L., Stearns, T., & Cyert, M. S. (2015). A high-enrollment course-based undergraduate research experience improves student conceptions of scientific thinking and ability to interpret data. *CBE Life Sciences Education*, *14*(2), 14:ar21.

Chan, V. (2011). Teaching oral communication in undergraduate science: Are we doing enough and doing it right? *Journal of Learning Design*, *4*(3), 71-79.

Cooper, K. M., Knope, M. L., Munstermann, M. J., & Brownell, S. E. (2020). Students Who Analyze Their Own Data in a Course-Based Undergraduate Research Experience (CURE)

Show Gains in Scientific Identity and Emotional Ownership of Research. *Journal of Microbiol Biology Education*, *21*(3). 1-11.

Corwin, L. A., Runyon, C., Robinson, A., & Dolan, E. L. (2015). The Laboratory Course Assessment Survey: A Tool to Measure Three Dimensions of Research-Course Design. *CBE Life Sci Educ*, *14*(4), ar37.

Esparza, D., Wagler, A. E., & Olimpo, J. T. (2020). Characterization of Instructor and Student Behaviors in CURE and Non-CURE Learning Environments: Impacts on Student Motivation, Science Identity Development, and Perceptions of the Laboratory Experience. *CBE Life Sci Educ*, *19*(1), ar10.

Gee, J. P. (2000). Identity as an analytical lens for research in education. *Review of Research in Education*, *23*, 99-125.

Goldey, E. S., Abercrombie, C. L., Ivy, T. M., Kusher, D. I., Moeller, J. F., Rayner, D. A., Smith, C. F., & Spivey, N. W. (2012). Biological inquiry: a new course and assessment plan in response to the call to transform undergraduate biology. *CBE Life Sci Educ*, *11*(4), 353-363.

Hanauer, D. I., Graham, M. J., & Hatfull, G. F. (2016). A Measure of College Student Persistence in the Sciences (PITS). *CBE Life Sci Educ*, *15*(4).

Mraz-Craig, J. A., Daniel, K. L., Bucklin, C. J., Mishra, C., Ali, L., & Clase, K. L. (2018). Student identities in authentic course-based undergraduate research experience. *Journal of College Science Teaching*, *48*(1), 68-75.

Reeves, T. D., Warner, D. M., Ludlow, L. H., & O'Connor, C. M. (2018). Pathways over Time: Functional Genomics Research in an Introductory Laboratory Course. *CBE Life Sciences Education*, *17*(1).

Saldana, J. (2013). *The coding manual for qualitative researchers.* Sage Publishing.

Sarmah, S., Chism, G. W., 3rd, Vaughan, M. A., Muralitharan, P., Marrs, J. A., & Marrs, K. A. (2016). Using Zebrafish to Implement a Course-Based Undergraduate Research Experience to Study Teratogenesis in Two Biology Laboratory Courses. *Zebrafish*, *13*(4), 293-304.