INTRODUCTION

The ability to communicate is a crucial graduate outcome for science students; however, crowded curricula and large class sizes make it difficult to find time to explicitly teach foundational communication skills. In response to these challenges, we developed an online resource called Communication Learning in Practice for Scientists, or CLIPS. CLIPS provides a multi-point mentoring model that has allowed us to successfully integrate the teaching and learning of a complex set of tacitly-understood skills across multiple scientific disciplines. It also provides a flexible way for industry experts, academics, and students to learn from one another’s experiences of, and expertise in, science communication. CLIPS leverages the student focus on assessment; students access CLIPS for pragmatic, detailed, and consistent advice when undertaking assessment tasks. In creating CLIPS, our philosophy was that communication is the core business of any scientific practice, not an add-on after the event. Extensive, repeated use of CLIPS by both students and academics indicates that the resource and its delivery model are considered useful, respected, and impactful for, and by, the intended audiences. We have provided CLIPS to the science education community through www.clips.edu.au.

The “problem” with teaching science communication skills

Support for the teaching and learning of communication skills appears to be most effective when situated within disciplinary contexts, courses, and assessment (1, 8, 9). Within Bachelor of Science degrees at Australian research-intensive universities, communication tasks comprise approximately 30% of assessment tasks (10), suggesting that science academics recognize the pedagogical importance of communication tasks. Unfortunately, many skills for effective communication are not addressed in the instructions or marking criteria associated with these tasks (11). Marking criteria and task descriptions for more-general science assessment items also lack details around communication (12). This absence of articulation suggests that science academics may be unaware of either the nuances of communication skills or the importance of explicitly teaching them. It is also possible that they simply lack the language to describe or decode communication activities (13). These findings indicate that science educators are not fully exploiting assessment to help students learn to communicate. They are also consistent with previous findings (14) that show science academics who teach science often do not feel qualified to teach communication; much of their understanding of disciplinary communication is tacit, based on their experiences.
and many see communication as something “other” than the science in which they have expertise.

**CLIPS is a solution**

In response to these challenges we have developed an online resource called Communication Learning in Practice for Scientists, or CLIPS. The purpose of CLIPS is to help both students and academics learn how to communicate science. In creating this resource, our philosophy was that communication is the core business of any scientific practice and not be treated as an add-on after the event.

CLIPS does not ask science students to learn about communication in a decontextualized manner, nor does it ask science academics to become communication experts. Instead, CLIPS leverages assessment behaviors, since it is well established that assessment drives learning (15). CLIPS resources are specifically built with the assessed student in mind. Students can access CLIPS on-demand for pragmatic, detailed, and consistent advice around communication when undertaking assessment tasks. In addition, students can compare their own efforts with examples of practice; this helps develop self-assessment capacity, considered the single most effective learning strategy (16). CLIPS is also built with assessing academics in mind; academics can refer students to CLIPS for support when they set an assessment item, saving time and effort around creating guidelines. Both students and academics can use CLIPS to develop a robust understanding of expected standards.

CLIPS enables flexible delivery of learning materials and multi-point mentoring for both students and academics as they communicate science. It meets the 21st century students’ expectation of 24/7 access to learning resources and rapid feedback (17, 18) and can be embedded into courses via learning management systems. At the University of Queensland, academics can request CLIPS be added to their course websites, or students can self-enroll. To allow wider community access, we have also built a stand-alone site using Wordpress (www.clips.edu.au).

**CLIPS content**

CLIPS users navigate information in modules, perusing and viewing topics within modules or following related topics. Topics include 1) answering short-answer questions, 2) presenting talks and posters, 3) displaying data, 4) writing in multiple genres, 5) infographics, 6) referencing, 7) communicating with numbers, and 8) communicating with the public. Material is presented in a variety of formats including short (1- to 3-minute) videos and animations, written explanations, annotated exemplars of practice at varying levels of quality, diagrams, and videos where “an academic explains” their personal communication practices and expectations of student work. The site also provides templates for items such as posters and presentations. The content draws on the theory underpinning communication and represents professional best practice (19). Importantly, resources are presented in language that professional scientists use comfortably and commonly. This approach situates CLIPS as a resource that appeals to students and practicing scientists.

**The co-creation of CLIPS**

CLIPS was created with iterative input, feedback, and evaluation from science students, academics, and communication professionals, a process which has enabled the decoding (13) of practices for all involved. The information presented in CLIPS focuses on aspects of communication that are often trouble spots for students. To choose these “troublesome” aspects and exemplars we drew on our personal combined thirty-year history of teaching science at college level (authors SR, KC, LK); we also conducted workshops with teaching colleagues and asked them to suggest communication genres and tools that students found difficult. Interestingly, although our colleagues knew that students frequently lost assessment marks for poor communication practices, when they were asked to define students’ specific difficulties they were often unable to articulate precisely the practices of concern. Colleagues’ suggestions frequently included general ideas about the abilities of students to develop an argument and to write clearly without grammatical errors. Colleagues were also concerned about the students’ abilities to communicate with numbers, to read material closely, and to extract relevant information from short-answer questions.

Author JH, who holds a master’s degree in Science Communication, designed the CLIPS “shopfront” and most of the content. The academics’ concerns provided JH with both the modules for CLIPS and a starting point for the site design. In particular, the academics’ recognition of students’ reading habits meant we made an effort to minimize the amount of written material on CLIPS. Rather than asking students to navigate large amounts of information they do not need, we provide targeted help in a mixed-media form that allows students to rapidly extract useful material from the site.

The CLIPS team (including some students-as-partners) developed material and then asked science academics to comment on items and provide any corrections that they, as disciplinary experts, wanted. Once the home page, early module structure, and initial content upload were completed, we trialed the site with student and academic users, then incorporated their suggestions around site aesthetics, navigation, and usability. Generally, the trial users had very few suggestions for improvement of the material we had already supplied, but they did consistently ask for more video content, more animations, and more exemplars of good practice. They also wanted downloadable templates for items that they would commonly encounter in assessment tasks, such as laboratory reports, abstracts, slide presentations, and posters. We have provided some of these on the site, but the discipline specificity of formats for some
of these items means were not able to satisfy the full wish list. The animations are also slow to make (and hence very expensive), so we had to limit our provision of this form of resource.

**Uptake of CLIPS by students and academics**

CLIPS was launched on Learn.UQ, the online management system for all University of Queensland courses, in July 2016, and, by July 2017, approximately 8,000 UQ users were enrolled. In the first six months of 2017, the site had over 25,000 hits with over 1,200 video views from UQ students. Our site analysis shows around 1,250 UQ students actively use CLIPS. The Wordpress site (www.clips.edu.au) was launched in July 2017. Promoted through Twitter and other social media, it had 3,817 visits from 1,190 users in 50 countries during July alone (Fig. 1).

We examined student use and opinions of CLIPS through an optional feedback survey. The student respondents \((n = 104)\) most commonly use modules on displaying data, answering short-answer questions, writing, and referencing. Students use CLIPS to develop a robust understanding of expected assessment standards (“If I’m unsure about some points, such as the components of figure legends, I can check it quickly. CLIPS provides the standard formats for us”). Over 90% of survey respondents say CLIPS helped them with their assessment tasks (“Helped me to ensure my graphs, in particular, were of a high quality”; “I would not have completed my referencing correctly if not for CLIPS”). Students also reported that “an academic explains” videos are useful (98% agree); one student said, “I find I learn better when I actively listen to someone so these videos were great!” A similar percentage of students reported that CLIPS examples and animations were useful; one said, “They are fantastic! Many details are involved and all of them are brief & clear.” Over 96% of survey respondents say they will voluntarily use CLIPS again. Statements include “I have used it for multiple assignments already” and “Wish I had access when I started Uni a couple years ago. This is a fantastic resource that should be shared!”

Evaluation of the specific impacts on student learning from use of CLIPS is in its infancy and a full report is beyond the scope of this short article. We do, however, have some instances of evaluation we can cite. Colthorpe and colleagues (personal communication) introduced science students to CLIPS by referencing the site in the guidelines for assessment tasks related to laboratory presentations and reports. In this student cohort, data collected before and after the implementation of CLIPS show a positive shift in student performance outcomes on criteria related to writing-skill mastery. We have also conducted one small-scale, controlled trial of a “communicating with numbers” resource; we observed significant changes in pre/post student performance in the use of unit conventions. We have not yet conducted a large-scale trial of the efficacy of CLIPS; our primary evidence for the value of the resources comes from the willingness of students and academics to voluntarily and repeatedly use CLIPS to support their coursework and assessment items.

**What’s next for CLIPS?**

We have recently obtained additional funding to build CLIPS for Work, an extension to CLIPS that will address communication skills sought by science employers. We plan to build modules on group- and team-work, intercultural communication and sensitivity, negotiation, expectation management, committee chairing and behavior, consulting with clients and patients, and conflict resolution. These skills will be useful for communication in the workplace, but also for communication while students complete their science training.

**CONCLUSION**

CLIPS integrates a complex set of tacitly-understood skills and understandings of expectations into a discipline that is often resistant to teaching and learning communication. It is clear from the collected user data that students are using CLIPS frequently and repeatedly, and academics are referring students to the site to support them with their science communication. Although designed and initially intended for science undergraduate students and academics, the resources are useful to, and indeed have been used by, other students and academics interested in science communication. We are happy to provide CLIPS to the science education community on www.clips.edu.au and hope you and your students will enjoy using it.

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