SIGCSE 2023: The 54th ACM Technical Symposium on Computer Science Education
March 15 - 18, 2023
Toronto ON, Canada

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RESEARCH-ARTICLE

How Do I Get People to Use My Ideas?: Lessons from Successful Innovators in CS Education

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ABSTRACT

Improving Computer Science (CS) education requires increasing the meaningful usage of research-supported pedagogy and curriculum. Studies on propagation have largely looked at dissemination and adoption from the perspective of adopters: what motivates them to discover, experiment with, and continue using innovative teaching. This study adds to a growing body of research on approaches to encourage adoption by examining the perspectives and advice of successful propagators—education researchers who have had their innovations widely adopted. Drawing on interviews with fourteen CS education researchers, this paper identifies both points of convergence and unique insights across several broad areas: barriers to adoption, the structure of academia, relevant principles of design and techniques for deployment, and strategies for propagation. Notable findings include: the structure of academia has aspects that both impede and facilitate successful propagation; traditional academic funding sources do not adequately support ongoing propagation; and some successful strategies for getting the word out involve oblique approaches for reaching potential users. This exploration of common successful approaches can serve as a guide for developers and educational advocates when working to attract new users and broaden impact.

CCS CONCEPTS

• **Social and professional topics → Computing education**.

KEYWORDS

Propagation, Adoption, Dissemination, Evidence-based practices

ACM Reference Format:
Christopher Lynnly Hovey, David P. Bunde, Zack Butler, and Cynthia Taylor. 2023. How Do I Get People to Use My Ideas? Lessons from Successful Innovators in CS Education. In *Proceedings of the 54th ACM Technical Symposium on Computer Science Education V. 1 (SIGCSE 2023), March 15–18, 2023, Toronto, ON, Canada.* ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3545945.3569779

SIGCSE 2023, March 15–18, 2023, Toronto, ON, Canada

ACM ISBN 978-1-4503-9431-4/23/03…$15.00
https://doi.org/10.1145/3545945.3569779

1 INTRODUCTION

When properly implemented, student-centered teaching practices[1] are more effective than traditional teaching in fostering student engagement, learning, support, and persistence among a greater diversity of students [5, 15, 20, 34]. Unfortunately, pedagogical approaches in which students passively receive content from instructors‘ lectures, and are assessed through assignments that lack real-world relevance, still feature prominently in computer science (CS) higher education [24]. CS instructors tend to experiment with innovative teaching practices on a limited basis [24] and faculty may consider practices they use to be both student- and instructor-centered [17, 18], but it is imperative that the CS Education community increase the prevalence and usage of innovative, student-centered teaching in higher education.

So the question arises: how can an educational developer increase the adoption of new pedagogy, curriculum, and tools (i.e., “innovations”) that improve student learning, engagement, equity, and inclusion? Prior studies have shown that it takes intentional work and significant resources for an idea to achieve widespread adoption [21] and that many projects do not adequately plan for this goal [31]. In this paper, we present qualitative research findings from interviews with 14 well-known propagators—CS Ed researchers and developers who have successfully grown a user base for their educational innovations. Propagation is crucial because, as one of our participants said, “A good idea on its own is just a good idea.” Our goal is to contribute empirical findings to a growing literature on effective propagation, and to provide actionable suggestions for researchers and innovators to help increase the diffusion of their new, student-centered teaching practices in CS.

Noteworthy findings include:

- The structure of academia is usually viewed as a hindrance, but it also creates opportunities for propagation.
- Nearly all projects received at least some funding from non-traditional sources such as industry.
- Propagators used both direct and oblique approaches such as embedding student-centered practices within other tools.

[1]Student-centered teaching practices are pedagogical or curricular approaches that build students’ competencies and skills by connecting students’ identities, course content, and real-world relevance through interactive learning activities [28].

- Crafting apropos messages that address instructor pain points was seen as more effective than discussing formal evidence.

In the remainder of the paper, we first discuss the structure of our project and our methodology, and then expand upon these and other participant insights.

2 RELATED WORK

To better understand how the CS Ed community can increase the meaningful usage of student-centered teaching, research has examined what influences faculty to find out about, try out, and continue using new teaching practices from the perspective of potential adopters. Studies have found that adopters typically learn of a new practice from departmental peers and disciplinary colleagues with similar institutional contexts or strong reputations for teaching through presentations, workshops, or informal conversations [2, 25], and from their own experiences as students [2, 4]. Motivations for adoption primarily center on concerns for students' learning, engagement, and preparation, and for many, supporting diversity, equity, and inclusion (DEI) [4, 13, 25, 29, 30]. Willingness to use or sustain a new approach is moderated by time and resource constraints; perceived "fit" with existing classroom processes, tools, and resources; impressions of effectiveness; and beliefs about how students learn best and how they will or have responded to the innovation [2, 4, 6, 23, 25, 26, 30]. Instructors' personal attitudes toward students influence their use of student-centered teaching [26], but their perceptions of departmental support for students and community, or of DEI, may not have a direct effect [27].

Insights about potential users must be translated into effective propagation practices in order to improve the transfer of innovations in CS education. However, research in STEM higher education has found that developers and researchers are often unaware of propagation strategies, as well as the time and resource commitments that are required to successfully encourage and support new users in incorporating innovations into their everyday teaching [16, 21, 22, 32]. This paper therefore reports both common and unique considerations and strategies from successful CS education propagators to answer the research question: how can educational developers increase the usage of their innovations in CS education?

3 METHODS

Our results are based on interviews conducted from 2019 to 2022 with 14 developers and researchers who have successfully increased the awareness and use of specific resources, tools, or pedagogical and/or curricular innovations in CS. Their projects include innovations like BlueJ, Peer Instruction in CS, and EngageCSEdu. Edited, truncated transcripts of each interview are part of a series published in ACM's Inroads [7]. The purpose of our present research paper is to aggregate and synthesize findings from the interview series.

Interview questions were developed from an extensive literature review on propagation in CS and STEM higher education [33], and included three major sections. (1) *About the innovation* asked about the innovation for which the propagator is known, including questions about the development context and motivations. (2) *Propagating* asked about how propagation work started, what strategies have been used to recruit and support users, to what degree those strategies have been successful, what challenges were encountered, and how those challenges were overcome. Work by Henderson et al in physics [3, 9, 22] identified both fidelity of implementation—incorporating all necessary components for the practice to be effective—and adaptability to suit a variety of teaching contexts as major concerns in adoption. Therefore, (3) *Adaptation* included questions about how users adapted the innovation to fit their situations, what aspects they changed, and why. Interview questions were intended to elicit rich description of experiences and considerations from the perspective of successful change agents.

Participants were identified and selected by consensus during ongoing team discussions about notable CS education interventions. Requests for participation were emailed directly to potential interviewees; all accepted and participated. Two researchers interviewed each participant in an hour-long, semi-structured format to allow participants to explore topics they felt were salient to their propagation efforts, including those we may have overlooked. Two interviews were recorded in-person; the rest were recorded via Zoom. One interview included two collaborators on the same project; all other interviews were conducted independently. Audio files were auto-transcribed via Temi, edited for accuracy, and then coded in Dedoose using both *a priori* and emergent coding. Initially, a sample interview was coded in its 16-page entirety by every researcher to asses inter-rater reliability; of 98 possible code applications, 15% of text units were coded identically by all four researchers, 22% by 3 of 4 researchers, 21% by 2 researchers, and 41% by a single coder (which was mostly due to unitization differences or applying dual, conceptually-adjacent codes). The coding scheme and text block unitization were then discussed until consensus was reached. Each interview was then coded by one researcher and reviewed by another for accuracy.

3.1 Sample Profile

Of the 14 individuals we interviewed, 4 created the innovation they are propagating, 3 propagate a single innovation developed by someone else, 2 combined original and others' innovations, 4 created repositories, and 1 works at an organization that funds innovative projects in CS education. Of those propagating a single innovation, it was a teaching tool for 3 of them, a pedagogy for 5 of them, and a curricular change for 1 of them. Note that this is a best effort categorization; there was significant overlap between categories, e.g. some participants were involved in more than one project and some repositories included innovations developed both by the participant and by others. Most innovations pertain to higher education, though some also or exclusively pertain to K–12 education; we are not comfortable giving a breakdown due to overlap and lack of data. All participants were affiliated with an institution of higher education. Twelve of their affiliated institutions were in the US and 2 were outside it. Seven participants present as men, seven as women. We did not collect race/ethnicity data.

3.2 Threats to Validity

The biggest threat to this study's validity is participant selection. The project used a convenience sample, so findings are limited by the number and characteristics of respondents. All but two of the subjects are affiliated with institutions in the U.S., and all are affiliated with institutions of higher education, which may limit relevance to other audiences. Two authors and two interviewees are collaborators on the innovations discussed, and most respondents have direct ties to researchers by virtue of membership in the CS Ed community, which may influence results. However, since this study's goal is to share replicable practices and insights from successful propagators, sampling well-known researchers in the field carries unavoidable personal connections. We have minimized the use of direct quotes in this paper because it is nearly impossible to cite specifics without revealing participants' identities. It is also hard to know how big the user base is of any given innovation—indeed, many participants themselves did not know (see Section 4.4.6)—so to a large degree, calling someone a "successful" propagator is subjective.

Another risk is that participants were often aware of existing research on propagating educational innovations, and several have published work in that area. As such, their responses align with research because they are informed by that literature base. However, our focus on grounding insights through specific stories and anecdotes may have helped mitigate participants referencing phenomena that they have not personally observed.

4 FINDINGS

In this section, we discuss findings from our interviews. We first discuss contexts and preconditions—faculty mindset and the structure of academia—and then discuss design considerations and strategies for successful propagation.

4.1 Faculty Mindset

Many of our participants noted that propagation requires developers to address barriers preventing new users from adopting an innovation. One commonly-mentioned consideration is faculty mindset—i.e., personality or emotional traits and motivations. When faculty mindset was a barrier, it was often framed as resistance to change. Three participants told similar anecdotes about faculty members who had tried an innovation (frequently at the request of their department chair), achieved better student outcomes, and still reverted to their previous teaching style. One participant noted that since most faculty succeeded in traditional schooling, they may be less likely to see the need for new methods. Another discussed that even many faculty who seem to appreciate an innovation fail to adopt it due to the effort required.

Another faculty-mindset barrier highlighted by our participants is fear of failure. This included concern about student reactions; faculty may feel that a change is risky when course evaluations are important for their annual review. One participant also noted that the risk of poorly executing an innovation is higher the first try, and a bad first experience may preclude future attempts.

Some participants also described how faculty mindset can have positive impact. One participant mentioned a colleague who had been extremely enthusiastic in adopting their innovation, and wished that more faculty felt that way. Other participants attributed contagious enthusiasm, camaraderie, and people taking training seriously as reasons for successful propagation. One participant described the importance of potential users' open-mindedness, excitement, and ability to see connections between teaching and students' needs.

Several participants also noted that a common point of resistance for potential adopters is having to reduce the amount of content they teach because the innovation takes additional class time. One respondent noted that "covering" material is not the same as students learning it, but class time is still a concern. Potential users may also face constraints based on course requirements and sequencing in the program's curriculum. Finally, even if the innovation can be ported to another place, it may not be as successful if its originator has implicit knowledge or skills that are essential to its success.

4.2 Structure of Academia

Participants described how certain aspects of higher education either benefited or hindered propagation work. Overall, the structure of academia simultaneously creates both opportunities and barriers.

4.2.1 ***Funding.*** Most respondents created and sustained their projects by seeking a series of grants from government agencies like the U.S. National Science Foundation (NSF). However, traditional funding models create significant challenges for innovations that require active maintenance, such as updating software for new OS versions or adding materials to repositories. Even for innovations that do not require active maintenance, propagation requires considerable personnel, time, and financial investment. To be clear, an integral part of NSF grant awards is scaling to new users ("broader impacts"). However, once an initial grant is completed, interviewees found it challenging to find additional funding. From propagators' perspectives, grants are awarded for new research; therefore, each proposal must focus on new features or new uses of the innovation—complimented by research questions, data collection, and reporting. Continually finding new aspects or uses of the innovation that generate generalizable scientific knowledge is difficult, particularly as a project matures. Furthermore, the timing of grant solicitations and awards can leave propagators vulnerable to a "dry spell" in funding streams, in which declined grant proposals may leave them without resources to maintain their innovation. While participants were appreciative of the opportunities to advance projects that grant funding provides, they felt it was challenging to fund educational software maintenance and existing user support.[2]

Many interviewees also received industry or non-profit support. Funding from large tech companies and organizations often supported short-term, task-specific activities such as rewriting materials, though in some cases long-term investment provided resources for personnel and infrastructure necessary to create and sustain the innovation beyond what would typically be possible through a grant's life cycle. Several participants used industry funding for software development and maintenance, and in at least one case, gift money allowed for necessary expenditures that could not be made with grant money. Propagators also appreciated a "quicker response" to evolving conditions (like the pandemic) and fewer conditions that industry support required compared to agency funds. In most cases, companies approached the propagator with targeted opportunities rather than sponsoring open solicitations.

Although existing funding models were most often mentioned as a challenge, some participants found them beneficial for propagation efforts. For example, one participant described having steady

[2]The CCRI program supports "infrastructure" for the computer systems research community that includes software, but this does not include educational software.

employment through teaching, removing pressure that their paycheck might depend on the success of their innovation. Since their innovation did not require a large amount of maintenance or user support, they did less development and propagation work during periods of low funding and ramped up when funding became available. The structure of academia also provided opportunities for propagation-related travel and work: trips to present unrelated work at SIGCSE TS and other conferences also created opportunities to facilitate workshops and informally discuss the innovation with potential users.

4.2.2 ***Socialization and Apprenticeship.*** Participants also described social and organizational aspects in academia that benefit propagation. Many described having informal conversations with other academics that led institutional and disciplinary colleagues to adopt an innovation. Participants also noted that instructors teaching a class for the first time often seek materials from previous offerings and, if the innovation is embedded in those materials, the instructor may adopt it as part of using them. Promoting the innovation to audiences with more malleable teaching habits and styles—graduate students through coursework and teaching assistantships, and/or to new faculty through professional development training—were also common propagation approaches afforded by the structure of academia. Spreading an innovation to current graduate TAs also helps disperse it to new institutions since many of those TAs become faculty at other institutions. Thus, this approach takes advantage of the apprenticeship nature of academic life, as well as the field's high degree of mobility.

4.2.3 ***Course Format Considerations.*** One CS-specific structural barrier is the lack of a standardized curriculum for CS courses. Materials developed in one context may not transfer to another because of varying programming languages, topic-sequencing, or topic inclusion. Propagators addressed this by offering materials in multiple languages ("Everything we do is times four: C, C++, Java, Python."), purposely picking commonly-used languages, and building in modularity. Some variability is mitigated by external organizations such as CC2020[8] that create model curricula.

4.2.4 ***External Organizations.*** Participants referenced the positive role that external organizations in the academic ecosystem can play in propagating innovations. For example, adoption of subject-specific interventions can be boosted when that subject is included in a model curriculum. ABET[1] accreditation is also a driving factor: one participant felt that tracking and assessment metrics such as "drop, fail, withdraw (DFW) rates" or student demographics for accreditation purposes exposed issues and promoted faculty mindsets that are more open to adopting innovative solutions. Another felt similarly about a push among funding agencies for department plans for Broadening Participation in Computing (BPC). While organizations do not necessarily promote specific innovations, participants felt that they encourage faculty and departments to seek out ways to improve.

4.3 User-Centered Design

In this section, we discuss how participants viewed the roles of innovation design and user input in propagation. Three main themes emerged—usability, user feedback, and user support—which map onto a well-established theory of adoption, the Technology Acceptance Model (TAM). The TAM theory argues that adoption of an innovation, especially tools, depends on a potential adopter's perceptions about the innovation's ease-of-use and usefulness [10, 11, 35]. Our participants all took a very user-centered approach in addressing ease-of-use and usefulness.

4.3.1 ***Usability.*** Every participant talked about trying to make their innovations easy for adopters to use and presenting their innovations as not requiring extra work, but helping adopters teach better. Participants discussed ease-of-use in terms of time, money, and equipment. They particularly noted that innovations need to be easy for potential adopters to try, with low overhead and set-up costs. One presented this as a solution to the lack of user time; potential adopters are busy and won't spend much time trying an innovation before deciding whether to adopt it. Making things free was stressed as especially important for innovations targeting the K–12 space.

All but one of our participants made their innovation freely available. Some of our participants did this explicitly by putting their innovation under an unrestricted license (e.g. Creative Commons), but others simply offered free access. This was not universal, however; one of our participants charged for the innovation as a way to get the resources to further its development and support people whose job was its propagation. This participant stressed that charging allowed them to hire support people and make their innovation easier to use, thereby saving instructor time. (Also of note is that this innovation is in a category of equipment traditionally purchased by students rather than the adopting instructors.)

4.3.2 ***User Feedback.*** All but one of our participants discussed the importance of user feedback in designing and maintaining their innovations. Multiple participants solicited feedback through focus groups of potential users who could evaluate its design, and several substantially redesigned their innovations based on user feedback. Seeking input was particularly important when transferring an innovation into new contexts. For example, several professors attempting to transfer innovations to pre-college settings discovered constraints such as the inability to easily switch textbooks or the need to use specific lesson plan formats. There were also differences in terminology or techniques since pre-college instructors are formally trained in education, but most professors are not. Several participants got help for these issues from members of the target population, including by hiring teachers to author or adapt materials, and providing ways for users to share innovation-related materials they develop.

Even though they sought feedback, participants were selective in how they used it. Tool creators discussed a tension between adding user-requested functionality and maintaining the system's simplicity to support ease-of-use. Several talked about declining user requests because complexity could actually make the innovation ineffective. Similarly, other participants noted that providing too many materials was overwhelming for potential adopters, and described the necessity of spending time to curate user-submitted materials. For them, it was more important to provide both new and experienced users with easy access to the best content than it was to provide comprehensive materials.

4.3.3 ***User Support.*** All participants discussed the importance of supporting new adopters in using the innovation. Participants who provided training often said that an initial workshop was not enough support for faculty to adopt their innovations. Propagators found it helpful to also provide extensive mentoring, and in some cases, financial incentives during the first semester of use. Some of the mentoring included having an experienced user attend the adopter's class, either as a co-teacher or as an observer who could provide tailored advice. When propagators were unable to intensively mentor, they provided support through question-and-answer emails that were answered by product team members, and user forums where questions were answered by both developers and other users.

An additional form of support involved materials that incorporated the innovation and provided explicit guidance on how to implement it. Several participants discussed the importance of textbooks, which help new users organize innovation-related activities through an entire course, essentially providing a comprehensive lesson plan. Participants frequently mentioned the importance of providing materials that matched the context and expectations of potential users—especially for K-12 teachers—which included using familiar formats (e.g., lesson plans with learning goals) and preferred media (e.g., printed materials rather than digital).

4.4 Strategies for Propagation

In this section, we discuss specific strategies that propagators used to successfully engage potential users and convince them to adopt. Findings indicate that there is not a single path that all propagators took, but there are commonalities within successful approaches.

4.4.1 ***Building a Community.*** Twelve of our participants mentioned the importance of building a community of users. Common approaches included creating online forums and user groups, organizing workshops and conferences, and leveraging existing communities (see 4.4.2). They tried to create communities with real benefits for members, including technical or emotional support, resources, funding, and career recognition. Some also offered co-authorship opportunities, created proceedings so members could publish, and provided travel support so members could participate in propagation efforts and gain professional recognition. However, community growth also increases the work needed to support it, which can shift the role of the developer.

Community was necessary not only to attract and support new adopters, but also for creating content and sustaining the project. For example, multiple participants mentioned community members creating materials for their innovations, such as creating assignments. Participants described community as a sign of project success and also a key to the sustainability of their projects, with other community members eventually taking leadership positions in the project.

4.4.2 ***Piggybacking Existing Communities.*** In addition to developing communities around their innovations, several participants expressed the value of piggybacking onto existing communities by leveraging existing contacts to promote the innovation. By far the most common community mentioned was the Association for Computing Machinery (ACM), which sponsors two often-used propagation vehicles: ACM's SIGCSE TS conference and the quarterly Inroads publication. SIGCSE TS offers the chance for members to present work to an audience of CS educators, so it is a ready-made venue for propagation. However, one respondent observed that audiences at SIGCSE TS still need convincing, and recommended that presenters explain their project, why it is important, what the mission is, and then model what using it is like for the user. Participants also mentioned other venues for specific audiences, including the National Center for Women & Information Technology (NCWIT)'s annual Summit and Academic Alliance for DEI-supportive audiences, and the Computer Science Teachers Association (CSTA) for K-12 educators. However, participants often noted that a presentation was not always sufficient; most participants found workshops and/or demoing in vendor booths to be critical so that potential adopters could interact with the creators, other users, and the innovation itself.

4.4.3 ***Hustle.*** Many participants described the necessity of talking to many potential adopters, which often involved travel. Participants mentioned that conferences dedicated to CS education—especially SIGCSE TS—are great opportunities to reach potential users using strategies such as holding workshops, being on panels and giving presentations, staffing booths, or simply handing out promotional materials to attendees. However, interviewees also discussed the difficulty of tracking how effective these strategies were in yielding new adopters. In addition, participants traveled to other institutions to give talks or hold workshops, frequently doing so free of charge using their own funding to travel. Interviewees also took advantage of their own departments to recruit adopters, using proximity to discuss and "sell" their innovations to colleagues. Online, they used social media to raise awareness of their innovations, including by following and retweeting specific accounts and piggybacking off existing CS education-related twitter communities.

For these interactions, participants felt it was important to exhibit clear passion and enthusiasm for their projects, which is consistent with studies showing that instructors' enthusiasm for material has a positive impact on students' attitudes [36].

4.4.4 ***Marketing.*** While developing "brand name recognition" through swag and promotional materials was helpful, participants stressed the importance of crafting apropos messages: speaking to the goals, needs, and pain points of potential users. For example, one participant discussed seeking input from department chairs about their goals for a workshop and then using this information to shape the project's messaging. One participant used different selling points for faculty from R1s ('it's more efficient') versus teaching-focused institutions ('it improves teaching'). Others discussed how useful consulting with members of the target audience was when transferring to new user communities (e.g. from higher education to K–12). This allowed the participants to use messages with appropriate terminology and goals to reach members of the new community.

Echoing existing research [2, 13, 25], participants noted that research showing an innovation's effectiveness were not sufficient to convince others to adopt it. Formal results were seen as important for ensuring innovation effectiveness, but not for attracting users.

Participants also mentioned that specific terminology may create resistance, especially the term "repositories." One participant avoided calling their project a repository, even though the term fit. Another participant described overcoming the bad reputation of repositories by inviting potential users to first serve as reviewers or contributors so that a positive first experience could ease them into becoming users. Small-scale involvement also lowers stakes and time commitments for novices, which is beneficial.

4.4.5 ***Trojan Horsing.*** Several participants discussed their success using indirect strategies in which the innovation is embedded within another strategy or tool. One common example was the use of textbooks. Despite various innovations and variability of courses, most instructors use textbooks in their courses, and writing a textbook using new pedagogy or tools was seen as a clever way to sneak good teaching into a classroom. Education research also shows instructors are influenced by textbooks [14, 19]. Within this topic, there was variation in approach between our participants: some have chosen to keep their materials free, while others published the materials commercially; some have encouraged customization while others provided the textbook as a completed document.

Technical tools (IDEs, eBooks) were also cited as effective ways to implicitly promote a teaching innovation. Once a tool is in place in a course, new content can be added gradually over time. This also ties in with the idea of piggybacking communities — many innovations such as these rely on having a set of materials to use, so once the tool is widespread, adopters can be encouraged to share their materials and grow the community.

4.4.6 ***Measuring Impact.*** Once a propagator has gotten the word out to potential adopters, it would seem logical to try to measure the extent of the propagation and its impact on students. However, many participants said that this was not a priority for them. Notably, measuring propagation was seen as especially difficult since there is often a lack of explicit feedback loops to discover that instructors have adopted an innovation, and if there is feedback, the time frame can be quite long. Projects that include a website can count visitors but this is a crude metric. Techniques such as requiring users to have unique accounts would allow more accurate measurement, but several of our participants saw logins as a deterrent to adoption because of the extra effort needed to access and initially try the materials. In addition, it was not clear to our respondents that explicitly measuring impact has great value: the motivation to continue propagating does not depend on exact numbers, and propagation is generally excluded as "research" in tenure and promotion cases.

5 DISCUSSION

Perspectives of successful propagators align with findings from prior work on the perspectives of adopters, and generated new insights that can advance evidence-based propagation strategies. Aligning with prior work [33], participants discussed the utility of building and leveraging community for recruiting and supporting users, producing materials, and sustaining the project long-term. Respondents provided practical advice on how to create and leverage communities, and how to piggy-back off existing communities. While many of the venues and vehicles for propagation our respondents mentioned have been identified elsewhere in research [2, 25], interviewees provided specific advice that can help propagators effectively leverage these opportunities by including specific information in talks, focusing on demos and workshops rather than paper presentations, etc. Marketing through messages containing information on how to implement the innovation—necessary time and logistics; potential dysfunctions or points of student resistance; and how the innovation can be integrated into existing practices—were frequently mentioned as being necessary and extremely valuable to propagation work. We also identified that ingraining innovative practices into materials such as textbooks or existing course syllabi, which faculty naturally seek out when designing a course, effectively "trojan-horses" student-centered teaching and facilitates adoption by lowering the amount of effort required. We believe that this novel strategy has strong potential to increase adoption, though more research is needed.

Echoing others' findings [2, 21, 25], we found that formal evidence of an innovation's effectiveness was not considered sufficient to encourage adoption; evidence is necessary to make sure an innovation works, but it does not motivate new users on its own. Surprisingly, innovations in repositories did not necessarily involve rigorous scientific studies—largely because developers do not have resources and it may not be practical to run experiments on every assignment, the rewards for doing so were underwhelming, and establishing causality is nearly impossible in the real world. Many participants relied on correlation: specific materials were based on techniques that had proven effectiveness, but the specific materials themselves were not tested. Because of this, we suggest that "research-supported" might be more appropriate than "evidence-based" when describing certain innovations.

Despite conventional wisdom in CS education that repositories are prolific and largely unused, several participants successfully propagated them, reflecting other work that shows repositories *can* in fact be successful [12]. However, participants stressed that merely building a repository was not sufficient; all had done significant work in building community around their collection, and worked to manage perceptions about it.

The structure of academia was primarily seen as a hindrance, because propagation work does not fit neatly into the definition of traditional research and securing funding to maintain projects is challenging. Specifically, participants described struggling to design novel research extensions to their work that could be competitive for NSF or other agency grants. All of our successful propagators received funding from sources outside academia, mostly in the form of corporate gift money. However, the traditional model was also helpful as participants took advantage of both faculty and TA communities at their institutions to propagate their innovations.

Finally, all of our participants stressed the importance of luck in their successful propagation. Fortuitous events they described included funding windfalls, the increase of CS students (which created opportunities for innovations), taking advantage of large classes as an opportunity for research, and, in one case, a well-timed snowstorm that created connections and opportunities for collaboration. We characterize much of this "luck" as hustle and taking advantage of opportunities.

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