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Teaching Technical Topics Effectively: How Teaching Humanists Has Changed How We Teach Everyone

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The continued discovery of applications for digital tools and techniques in fields outside the physical sciences reveals ongoing challenges in the delivery, instruction, and comprehension of technical topics. Why is learning technical topics difficult? Are there unique challenges with the nature of the content? Does the environment for novice learners of these materials suffer from unwelcoming aspects of the culture and attitudes surrounding advanced technology? Does the difficulty vary depending on the discipline and academic background of the learner? As a way to circumvent these challenges, there are many established methods for teaching technical topics, particularly in programming and computation (Wang 413; Cercone 138; Xinogalos 560). These methods may give rise to acceptable learning environments to educate future computer scientists (T. Clarke and E. Clarke 396) but may be diminished in their effectiveness when applied to a classroom of humanists, political scientists, or interdisciplinary learners. By improving the teaching methodology of a new technical tool, the learning curve can be shortened, thus increasing the likelihood that researchers will use this tool in their research workflow. (Antonićević 110). This article explores experiences of teaching groups of novice learners from disciplines beyond the boundaries of the physical sciences, and identifying through the experiences five problem areas for teaching technical topics. In seeking to address these areas and improve the learning environment for learners from outside the physical sciences, it was discovered that many of the changes could be applied to all learners, regardless of discipline, with continuing, positive results. These results reflect the need to continue to study and evolve the pedagogy of teaching technical topics from many perspectives, reflecting the diverse landscape of fields and disciplines that benefit from incorporating increasingly advanced technology in their research.

The challenges and teaching solutions presented in this article are gathered through the experiences of teaching several series of live-coding workshops. These are workshops in which learners code along with the instructor by typing appropriate syntax of the subject programming language into their own computer. The instructor provides live feedback and instruction such that each learner has their own functioning program, which they have written themselves, upon completion of the workshop. The learners for the observed workshops included academic faculty, graduate students, undergraduate students, and librarians, with the majority joining from institutions within Atlantic Canada.

The exploration of teaching technical topics to learners from outside the physical sciences began due to poor workshop registration numbers and constructive feedback from learners in humanities research. Specifically, the feedback addressed issues of accessibility for novice learners, especially learners new to programming and advanced digital tools. To address these issues, direct consultation with the humanities and social sciences research communities was undertaken. The goal was to develop an accessible training program for learners from outside the physical sciences research communities. Through this consultation process, and by observing participants and soliciting feedback at each of the subsequent workshops, five major problems were identified that were inhibiting the effectiveness of teaching these technical topics. These five problems were initially identified only for learners without a scientific academic background; however, focused observation of learners

from the physical sciences and those with an interdisciplinary focus, revealed that most of the problems were endemic. The problems manifested slightly differently and with greater or lesser subtlety depending on the discipline and previous technical experience of the learner.

The first problem identified was barriers to registration. The marketing materials and session descriptions were ineffective and sometimes deterred learners from registering. This problem was the only issue present outside of the classroom. The second problem was varying degrees of discomfort experienced by the learners during the sessions. The premise of this problem is that learning new skills and acquiring a deep understanding of new concepts is particularly difficult when uncomfortable (Bledsoe and Baskin 35–36). This was the most challenging problem to mitigate and required the largest portion of in-session time to address. The third problem was poor vocabulary by the instructor during the workshop. Vocabulary that is demotivating or unnecessarily complex may have a significant impact on learners' motivation and ability to comprehend and retain new concepts (Ambrose et al. 177). The fourth problem identified was the general lack of confidence that learners exhibited when engaging with technical topics. This was especially true when addressing programming errors, such as how to troubleshoot when the output expected was not the output received. The fifth and final problem that arose was the use of examples that were unrelatable. Lesson content for workshops that teach technical skills such as programming are often designed for learners from the physical sciences or computer science. As a result, their examples and exercises are often unrelatable for learners from other disciplines. If learners are unable to engage with the lesson materials it may negatively impact their retention of that material, and the positive outcome of applying it in their own work later (Ambrose et al. 68).

Adapting the workshops and addressing these problems for all learners, even those from fields where knowledge of technical topics is expected and required, has improved observed learner experiences and outcomes. The experience and knowledge gathered while teaching humanists, interdisciplinary learners, and learners from other non-physics related fields directly facilitated a deeper understanding of problems in teaching technical topics.

Barriers to Registration

Barriers to registration were driven by issues with the design and content of the marketing materials. The feedback received on the marketing materials used in the previous year's workshops considered the workshop descriptions and titles to be inaccessible, inapplicable, and intimidating. There were concerns with the use of technical terms in the description that were not commonly known or understood. There were also concerns about prerequisite skills that might be required, and questions of applicability to fields beyond the strict traditional boundaries of the physical sciences. Some prospective learners could not extract avenues for applying the subject matter into their own research and teaching from the workshop descriptions.

Removing Jargon

The first step taken to revise the workshop marketing materials was to remove any terms or phrases that contained jargon. It is difficult to comprehensively identify jargon for one's own field due to the "expert blind spot" phenomenon (Ambrose et al. 99). To mitigate this phenomenon, in-depth evaluation and discussion of every word used in the title and description was completed, and feedback was solicited from individuals with minimal programming experience. The use of jargon will be explored more fully later in this article, but its use in the title and description of workshops presents an acute barrier. In the context of marketing materials, jargon is not usually defined. Furthermore, interactive questioning and dialogue is often impossible. For example, a prospective learner seeing a workshop advertised on a poster may misunderstand the description if jargon is present and does not have the opportunity to ask questions and receive clarification.

Engaging the Audience

The second step was to engage the target audience for the workshop by specifically addressing the target research disciplines in both the title and description. This change was implemented to help prospective learners recognize that the workshop was designed for them, combating intimidation barriers and encouraging them to feel welcome. A clear statement was also included about the expected experience of the prospective learners, which specifically stated if there was no previous programming or technical experience required. Another addition was to list practical, recognizable applications in fields such as humanities, social sciences, and education for the specific digital tool explored in the workshop. In order to overcome registration barriers, prospective learners needed to easily understand the description, identify the workshop as being designed for them, confirm they had the prerequisite skills to succeed, and recognize the usefulness and applicability of the material.

Barriers to Registration for the Physical Sciences

Barriers to registration did not clearly manifest for workshops targeted towards learners from within the physical sciences. Further investigation would be required to reveal whether addressing barriers at registration could increase participation in learners from physical sciences fields that are more recently established in the computational research landscape, for example environmental sciences. Further exploration in improving workshop registration accessibility could include emphasizing the interdisciplinary design of the workshop, instead of targeting a specific discipline such as humanities, which might encourage more engagement in computational research from across academia.

Discomfort in Learning

The second problem stems from the assertion that it is difficult to learn new things, build confidence and give feedback when uncomfortable (Bledsoe and Baskin 35–36). The experiences gathered from teaching technical topics to those new to the microcosm of advanced technology confirm that learner discomfort inhibits material

retention, confidence building, and the ability to give constructive feedback. Discomfort manifested variably for the learners, and different mitigation techniques did not have uniform effects. A complex, multi-pronged approach was necessary to improve learning and feedback. Approach details varied depending on the teaching medium (online vs. in-person), workshop size and length, and the dynamics within groups of learners. What remained consistent in the approach was a focus on five concepts: understanding learning barriers, teaching to novice learners, creating a comfortable learning environment, soliciting feedback, and taking time to pause.

Learning Barriers

Learning barriers manifest variably for different learners and contexts (Ambrose et al. 13). In applying these findings to future teaching endeavours, a list of learning barriers is maintained, adding new barriers as they are observed. In the context of live-coding workshops observed barriers include imposter syndrome, misconceptions around magnitude of difficulty, anxiety, previous lack of access, lack of support, fear of failing, and fear of initiating a catastrophic failure on one's computer. Imposter syndrome is a state of mind in which the individual believes they do not possess the requisite skills or knowledge to belong in a particular environment, despite being qualified for it. This phenomenon has been studied in the context of academia and more specifically in the field of computer science (Rosenstein et al. 30). During the sessions, emphasis was placed on inspiring feelings of belonging in learners, both as members of a social group made up of the workshop learners and instructors and, more broadly, belonging in the microcosm of technical topics and advanced technology. Verbal messaging was employed to support these feelings of belonging. Examples used in the workshops include: "You are all programmers now—you belong here" and "You are already a part of the advanced digital world." This was done to address imposter syndrome, lack of access, and lack of support. To address misconceptions around magnitude of difficulty and fears of failing or destroying one's computer, low-risk high-reward exercises were chosen for the beginning of the workshop, so learners could experience early successes. Learners were also explicitly reassured that they would not break their computer during the workshop, and that if something unexpected happened, instructors were available to work with them one-on-one to resolve things.

Novice Learners

In addressing novice learners, it was imperative to engage them at their skill level, and in doing so prove the accessibility of the material. Because of the diverse academic backgrounds that the learners possessed, they had widely varying aptitude and pace for understanding various technical topics. To ensure learner understanding it was necessary to gauge the technical level and abilities of the specific group in the workshop and adjust the pace of delivery and material content accordingly. Learners were often pleasantly surprised by their own abilities and success in a workshop when the instructor adapted to the learners' different technical levels and expertise.

Understanding the “Why?”

To keep the materials engaging and relevant for the novice learners, it was helpful to understand why they had chosen to attend. Common reasons included receipt of a recommendation from a colleague and interest in expanding their general knowledge. When the “Why?” for the presence of novice learners was understood, it became easier to engage them in the content and tailor questions and responses. An effective technique used to solicit the “Why?” was a collaborative e-document. Learners were invited to add their names, explain their background and research area, and include a couple of sentences detailing what they were hoping to learn in the workshop and how they intended to apply it afterward.

Early Dialogue

Another technique to help engage novice learners was to encourage them to speak as early as possible in the workshop. Dialogue with the learners early in the session (often before any content was presented), facilitated increased learner participation in questions and discussion later. Smaller groups of learners were encouraged to introduce themselves verbally and share about themselves and why they had chosen to attend the workshop. For online groups this was called a “mic check” which encouraged some more hesitant learners to participate.

Comfortable Learning Environment

The third response to address issues with learner discomfort in the classroom, was improving learning by creating a comfortable learning environment. Some of the steps discussed previously may assist in creating a comfortable learning environment, which includes encouraging learners to speak, welcoming them to share why they are there, and adapting to their technical experience and aptitude (Ambrose et al. 183). There are a few other techniques that can be employed to increase comfort level in the classroom, even for learners more experienced in the subject matter.

Variety of Material Modes

The first technique is for the instructor to use a variety of modes when presenting the workshop material. This technique facilitates learner understanding and acknowledges that learners grasp concepts in diverse ways (Ambrose et al. 4). Some examples of different modes of material presentation include providing written text and diagrams, explaining concepts in multiple ways, and working through interactive exercises. This approach gives learners multiple avenues and opportunities to expand their understanding.

Asking Questions

The second technique addresses an important part of learning – asking questions (Rumohr 226; Chin and Osborne 2–3). If learners do not feel comfortable asking questions, it becomes challenging for the instructor to keep the material accessible and engage with the learners (Chin and Osborn 5-9). There are many researched strategies for encouraging learners to ask questions and feel comfortable doing so (Chin and Osborne 29). Teaching with a co-instructor may be helpful for answering questions, especially in an online classroom. The

co-instructor can answer questions in the chat promptly, and flag relevant questions to the primary instructor so those questions can be discussed on-mic with the entire class. In online instruction the chat lends itself well to peer-to-peer learning, as other learners may answer or reiterate the need for individual questions in the chat before the instructors address them. Open dialogue in the chat may help create a positive community and camaraderie among the learners. During the workshops, learners started to apply the material to their own disciplines, leading them to pose questions that were outside the individual expertise of the instructor. These specific questions provided an opportunity for other learners to add their own knowledge to the instructors' answers if they had some experience in that subject area. This collaborative dialogue supports a strong community experience in an online environment that often struggles to provide personal connections (Angelino et al. 10).

Individual Help

The third technique to facilitate a comfortable learning environment is to offer individual help. This is usually only possible with multiple instructors or co-instructors, but it is particularly valuable in an online environment. The functionality of breakout rooms was used in the online workshops to provide one-on-one help for participants who were struggling. Many learners struggled at various points during the workshops and were unable to move forward without assistance. This is a frequent occurrence in live-coding workshops due to complexity of topic and the propensity for unforeseen technical difficulties when teaching live-coding. To overcome these difficulties, it was essential to offer learners the privacy and focused help of one-on-one time with an instructor in a breakout room should they require it.

Soliciting Feedback

The fourth response to addressing issues of learner discomfort in the classroom was soliciting feedback. Feedback takes many forms, and soliciting feedback after a session is completed is a valuable tool for future improvement (Ambrose et al. 124). The focus of this response, however, is to solicit feedback during the live session with the goal of improving the current learning environment. Learners as a group are not homogeneous (Cercone 138), and even the most prepared and experienced instructors are imperfect (Ambrose et al. 2). It may be tempting as an instructor to obsessively optimize and adjust one's teaching pedagogy by altering pace, scope, mode of delivery, and vocabulary, resulting in a standard of preparedness that guarantees perfection in delivery; however, the nature of learners and instructors indicate that perfect instructional delivery for all learners simultaneously is out of reach. Soliciting and adapting to feedback during a live session may mitigate these issues. Immediately applying constructive feedback may tailor the session to address the challenges of that specific group of learners, and self-correct the imperfections of the instructor. Successfully soliciting and applying feedback during a live session may be a daunting task. Several approaches for successfully soliciting feedback were explored. Asking often, every 10–15 minutes depending on the situation, was helpful in keeping learners engaged, and providing correction on issues such as pacing. By creating the expectation that the instructor expected questions (for example, using language such as “What are your questions?” versus “Do you

have any questions?”), learners were encouraged to ask questions which helped identify when they were struggling with their understanding of the content. The provision of multiple avenues for feedback, including different approaches for online and in-person teaching, helped to ensure accessibility for all learners.

In-Person Feedback

Effectively soliciting feedback during in-person teaching may be strongly influenced by the attitude of the instructor. By keeping an attitude of openness and embracing an environment of group discussion, instructors may help facilitate constructive feedback. Requesting clarification of learners’ understanding, expanding upon the questions they are asking, and asking them questions helps to promote this dialogue (Ambrose et al. 186). Providing exercises for the learners that allow them an opportunity to apply what they have just learned helps to solidify the concepts, but also serves to inform the instructor regarding learner comprehension. When learners can immediately give feedback on their experience with an exercise, instructors can quickly identify which learners need assistance and which concepts need more attention. A simple method for quickly soliciting this feedback is asking for a thumbs up if things are going well and thumbs down if learners are struggling and want assistance. Another method is to give every learner a green and red post-it note and ask them to stick the appropriately coloured note on their laptop: green if they are done and everything is going well, or red if they are struggling and would like some help.

Online Feedback

Soliciting feedback in an online environment requires some different techniques than in-person, and suffers from the constraints of the technology, particularly the inhibition of relationship building (Barry 166). Building a rapport with the learners as early in the session as possible is crucial in obtaining useful feedback during the session. There are different methods available for building that rapport including some already discussed, for example inviting introductions. Other tools could include collaborative interactive platforms such as Menti-meter. Online instruction allows for many avenues to receive feedback, though online platforms have variable features to accommodate this. Learners should be introduced to all the feedback avenues available on the specific online conferencing platform being used. This is important to ensure participants are aware and comfortable with the technology they will need to use to provide feedback. Common avenues for providing online feedback are on-mic, in the chat, using a reaction, or virtually raising a hand. Make as many avenues of communication accessible as possible so learners can choose the avenue that is the most accessible for them. Exercises may also be employed in an online environment to aid the instructor in monitoring learner comprehension and understanding. There are several ways learners can provide answers to exercises, including chat, e-document, or polling. Polling is a feature available in most web conferencing platforms and provides an anonymous way for learners to respond to questions. Although the anonymity inhibits the instructor’s ability to direct help to specific learners, it may encourage participation from timid learners.

Time to Pause

The fifth response to addressing issues of learner discomfort in the classroom was taking time to pause. Pacing is a difficult dimension of instruction, and it is a critical piece of the puzzle in teaching technical topics effectively. The experiences of teaching live-coding workshops indicate that for most learners, understanding technical concepts takes time. Furthermore, novice learners and learners new to digital tools and techniques require more time to understand technical concepts. Taking the time to pause is invaluable for raising the frequency and quality of session feedback and engagement from learners (Rumohr 231–230). When asking questions of learners and soliciting feedback it takes time for learners to process the question and more time to formulate a response. Pausing after questions and resisting the urge to pressure responses facilitates learner engagement, understanding, and thoughtful feedback (Rowe 44-45). An instructor may engage in a welcoming and accessible way, for example by asking “What are your questions?”, but if a pause is not taken to allow learners time to mentally formulate their question and then articulate it, the opportunity for engagement is lost.

Discomfort in Learning for the Physical Sciences

Learners from fields within the physical sciences were not obviously experiencing challenges with discomfort in the workshop learning environment; however, the workshops were sometimes very muted, with some learners completely disengaged. After implementing the changes to create a more comfortable learning environment, learners from all disciplines and interdisciplinary backgrounds seemed more engaged in the material, they asked more questions, and the atmosphere of the workshops felt more relaxed. Making the effort to intentionally create a comfortable learning environment was universally beneficial.

Poor Vocabulary Choices

Vocabulary choices, specifically jargon, were previously discussed in addressing barriers to registration. Poor vocabulary choices and extensive use of jargon during a session were noted in feedback as negatively impactful for learner experiences and outcomes. Three types of vocabulary were identified as problematic during a live workshop: jargon, demotivating language, and cognitively taxing words.

Use of Jargon

Jargon refers to technical terms that are used only within certain fields or have a particular meaning and context unique to certain fields. In a live session exploring a technical topic, use of jargon is often necessary as some terms are endemic to the field and it is imperative that novice learners are introduced to them. Examples of these types of jargon in programming workshops include: “run,” “execute,” “script,” and “syntax.” To help learners who were unfamiliar with these terms, all jargon was defined when it was first introduced. Introductions to jargon were also spread throughout the lesson, so learners did not have to learn several unfamiliar terms at once. A suggestion made in one of the last workshops was to include a glossary. Lists of

programming commands and their functions are available during the workshops, but the addition of a glossary of technical terms and definitions is being considered for future workshops.

Demotivating Language

The second type of problematic vocabulary, demotivating language, is language that is dismissive, patronizing, or does not acknowledge the challenges associated with learning new skills. Learning new skills in technical topics is difficult, especially as a novice learner (Rosenstein et al. 30). Language that fails to recognize that difficulty, such as “this is trivial,” “just do this,” “don’t worry it will be easy,” or “this is really straightforward,” may be demotivating and disheartening for learners. They may not feel that what they are learning is trivial, easy, or straightforward (Ambrose et al. 177). It is also problematic to present technical topics as being so difficult as to be out of reach. Using language of that nature, for example “this topic is so difficult, most of you won’t understand it,” is not helpful or motivating for most learners (Ambrose et al. 177). There is a middle ground where the instructor acknowledges the challenges of learning the topic and still presents it as accessible, for example “this topic can be a bit tricky the first time, so we are going to take our time with it. Please don’t hesitate to voice your questions on-mic or in the chat. We will figure this out together.”

Cognitively Taxing Words

The third type of problematic vocabulary is cognitively taxing words. These are complex words that are not commonly used in everyday speech and conversation. They are distinct from jargon for the specific topic being explored, but they could be jargon for a different field. Examples of cognitively taxing words in a programming workshop include: “juxtaposition,” “anthropomorphize,” “obfuscate,” and “tractable.” Unnecessarily complex terminology may take longer for learners to mentally process, even if they are familiar with it (Glaser). This extra time spent processing these complex terms may cause learners to fall behind in the workshop, especially as they are trying to learn new concepts and necessary jargon. This is not an incitement to avoid all complex and specific language in teaching. It is instead a call to recognize the unique challenges and time-constraints present in live workshops and make thoughtful choices about what complex vocabulary is included. Complex terms should be avoided if their inclusion does not directly benefit the learner.

Vocabulary Choices and the Physical Sciences

This approach of using thoughtful and motivating vocabulary choices during live sessions was also effective when teaching learners from the physical sciences. Though some of the learners were familiar with the jargon, many were not and benefited from the time taken to define the terms. The elimination of unnecessarily complex language was especially helpful for groups of students for whom English was a second language and those who came from interdisciplinary backgrounds. They tended to have unique collections of technical vocabulary that they were comfortable with. The use of demotivating language in teaching is pervasive in

mathematical and physical sciences fields (Ambrose et al. 177). The absence of such language was noticeable to the learners and reflected in their engagement and feedback.

Confidence and Technical Topics

Lack of confidence was frequently witnessed in the live-coding workshops for learners from humanities, social sciences, education, and interdisciplinary fields. It was also noted, though less frequently, in learners from physics, biology, chemistry, and computer science. Lack of confidence while learning feeds into other issues, such as imposter syndrome and difficulties in future application (Rosenstein et al. 30). Lack of confidence in learners is difficult for instructors to address as learners may struggle with their confidence even in a comfortable learning environment (Ambrose et al. 81).

Beyond creating a comfortable learning environment, two adjustments were made to workshop materials and delivery to build confidence in learners. Pausing for active troubleshooting during live-coding workshops proved to be an effective way to build learner confidence. This opportunity occurred when an instructor attempted to demonstrate the effectiveness of a new piece of code and it did not work as expected. Instead of panicking or skipping that part of the lesson, the instructor took the time to troubleshoot the problem with the learners, talking through the different steps and methods being used. This helped the learners understand how to approach the process of troubleshooting their code. Working with digital tools, particularly programming languages, requires a significant amount of troubleshooting. It is important for learners to understand the problem-prone nature of technical topics and tools, so that they have the skills and confidence they need to address problems themselves. Otherwise, they may become discouraged when later applications do not go smoothly. Learners were much more comfortable sharing their own code, asking for help, and going through steps to find their mistakes after they witnessed instructors making mistakes and receiving assistance from the class.

The second adjustment was building up small accomplishments by facilitating early successes. Helping learners achieve small victories early was crucial for building confidence. The lessons were designed such that early tasks required only one or two steps, for example typing a single command, and had a satisfying result such as receiving an expected, recognizable output. Establishing these early victories helped learners feel like programmers, which built their confidence and empowered them to try more complex commands later in the lesson.

Building Confidence for the Physical Sciences

Live troubleshooting had the most obvious positive results when attempting to build confidence in learners from the physical sciences. This organic live demonstration of the challenges associated with programming confirmed for the learners that even instructors make mistakes, removing the pressure for immediate perfection from the learners. Treating the troubleshooting steps as a normal, necessary part of being a programmer had a positive effect on learner confidence.

Unrelatable Examples and Exercises

Examples and exercises are an integral part of studying technical topics, particularly in a live-coding setting; however, unrelatable examples create unnecessary difficulties for learners. An unrelatable coding exercise for a humanist learner would be matching a list of velocities to items in a list of masses. In attempting to complete the described exercise, the humanist must not only understand the programming structures and commands for merging lists, but they may also feel compelled to recall the physics of velocity and mass. Examples and exercises can be flavoured such that the learners feel a familiarity with the material because it incorporates subject matter they have studied previously. A relatable example for teaching about list structures in programming could be a list of molecules for a biologist or a list of book authors for a humanist.

The experiences of developing introductory programming workshops for learners from the humanities and social sciences revealed that most of the existing, high-quality curricula for these types of workshops use examples and exercises flavoured for learners from the physical sciences. To adapt the curriculum, all the examples and exercises were re-written, keeping the same programming format but adjusting the flavour so it was relatable. A single live-coding workshop for social sciences was delivered without re-written examples. Much of the feedback received from that workshop was critical of the relatability of the material. Re-writing examples to match the academic backgrounds of the learners is an important part of making technical topics accessible (Ambrose et al. 27–37). Flavour of examples should enhance the learner experience instead of making the material even more challenging and inaccessible. Further exploration could be completed in designing examples that are relatable to many disciplines.

Unrelatable Examples for the Physical Sciences

Initially, the problem of relatable examples and exercises was only identified for learners from disciplines outside the physical sciences. The materials used in workshops for learners from the physical sciences already contained examples relatable for them, so it was unclear how they would react if they encountered an unrelatable example. During one workshop for physical sciences learners an example was used that had been rewritten for humanists. A learner in the workshop immediately asked for a second example, “one with numbers,” as they were having trouble fully understanding the example presented. Learners with interdisciplinary backgrounds seemed to struggle the least with discipline targeted examples, even if the example was flavoured towards a field that they were very unfamiliar with. Example relatability has an important role to play in making technical topics accessible for all learners (Hirsch 25), and further study could be undertaken to understand better how learners from interdisciplinary fields interact with differently flavoured examples, potentially providing critique to improve example relatability for all learners.

Conclusion

Technical topics may be inherently difficult for many learners, but the environment and culture surrounding how they are taught has a significant impact on whether the learners overcome that difficulty. Specific changes

made to primary aspects of the learning environment for technical topics can address challenges with technical training and knowledge dissemination. Observed benefiting learners were from many different research fields including the humanities, social sciences, education, chemistry, physics, ocean sciences, and many interdisciplinary specializations. Given the rise of interdisciplinary research, and the continuing de-siloing of academic fields of study, it is imperative to explore and develop teaching strategies that are effective for all learners, regardless of their disciplinary background. Evolution and application of teaching pedagogy to live-coding workshops for all academic disciplines could improve learner experience, retention, and application of digital skills. This could also be effective in continuing to breach the traditional barriers between fields and may encourage more engagement and equitable participation in computational research, particularly as the branches of arts and technology continue to evolve and intertwine. The continuing and growing leadership of disciplines such as humanities, arts, education, and social sciences have and will continue to expand, enrich, and transform the landscape of technical research. Our experiences suggest the leveraging of interdisciplinary collaboration provides opportunities that are essential for shaping an equitable, effective, and expansive future for technical research.

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