Investigating Adoption and Collaboration with Digital Clinical Simulations by Teacher Educators

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Abstract: In this study, we examine the outcome of a four-day workshop with 24 Teacher Educators (fellows) who were supported in using two tools - Teacher Moments (TM) and Eliciting Learner Knowledge (ELK). The tools are designed for authoring, implementing, and research Digital Clinical Simulations in education. The simulations centered around issues of equity in K-12 computer science education to provide in-/pre-service teachers with opportunities to practice high-stakes interactions in low-stakes settings. We operationalize the technology adoption of the fellows through the notions of self-efficacy, help-seeking, and technology concerns to recognize the potential barriers they faced in transitioning from authoring to implementing and research design. Finally, we note the fellows' implementation plans in the ensuing academic year and examine potential collaborations amongst them using social network analysis. Our results reveal how a small group of fellows, spanning major regions of the U.S., generate a broad range of scenarios, as well as clusters of scenarios, enabling simulation-based research supported by collaboration.

Keywords: Digital Clinical Simulations, Collaborative Technology Adoption, K-12 Computer Science Education

Introduction

In this paper, we tackle issues of equity in computer science for U.S. K-12 classrooms. Equity issues in K-12 classrooms in the U.S. are frequently multi-faceted and contextual and arise from various scenarios (Gretter et al., 2019; Ryoo et al., 2019). Each classroom not only has different distributions of student demographics (e.g., race/ethnicity, socioeconomic status, English language learners) but are also subjected to different regulations based on the State and school district. For example, a classroom in Texas is very different from a classroom in Arkansas. Moreover, mandatory classroom policies aimed at broadening participation places the challenges of equitable access to Computer Science education on the schools and subsequently on the teachers, most of whom lack the means to do so in terms of resource or skills (Cao et al., 2020; Mark et al., 2020; Sauppé et al., 2019). To address issues of equity, we need to find ways to deal with these networks of challenges (Hillaire et al., 2020).

A viable solution to tackle the diverse challenges lies in how we prepare teachers. While there are a wide variety of K-12 schools, there are substantially smaller teacher education programs (Kawas et al., 2019; Yadav et al., 2016). It would be beneficial to work alongside Teacher Educators since they are likely familiar with the diverse range of equity issues in K-12 CS Ed arising from different contexts. However, such a distributed approach may be inefficient since it could potentially yield several disparate and disconnected efforts. Another key challenge specific in preparing teachers is a lack of opportunities to practice high stakes interactions in low stakes settings. Grossman et al. (2009) found that other professions in social sciences provided ample opportunities to practice high-stakes interactions in low-stakes settings. In contrast, Teacher Educators have historically had access to practicums where they practice teaching with actual students. These are high stakes interactions and not an ideal place to learn how to handle issues of equity.

To address these challenges, we leverage Digital Clinical Simulations (DCS) platforms, designed to support teacher educators to author, implement, and research via simulations in the classroom (Hillaire et al., 2021). In previous work, the relatively simple format of simulations in Teacher Moments, a DCS tool, was conducive for authoring simulations pertaining to issues of equity (Hillaire et al., 2020). Related work also examined the help-seeking behavior of teacher educators when using Teacher Moments for authoring, implementing, and researching digital clinical simulations (Hillaire et al., 2021). We extend this work by examining new functionality in Teacher Moments as well as the additional DCS tool ELK (Eliciting Learning Knoweldge) which facilitates role-play. We examine the technological adoption of the DCS authoring tools by the fellows through the quantitative metrics of self-efficacy, help-seeking, and technological concerns replicating the measurement and analysis previously reported for the first cohort of fellows (Hillaire et al., 2021). Additionally, we perform thematic analysis of their feedback experience to understand the best possible ways to provide support. We examine the results of a planning session in the second year of the INSPIRE CS-AI project, where 12 fellows returned for the second year of the fellowship and 12 additional fellows were recruited to begin scaling up the use of the platform.

Help-seeking is an important dimension to consider for technology adoption because technology can only be effectively implemented when teachers understand the entire process and are aware of the whole cycle of the technology they use in the classroom (P. A. Ertmer & Ottenbreit-Leftwich, 2010). It was observed that “peer-feedback” was the only theme of help-seeking that spanned the three aspects of authoring, implementation, and research. Consequently, collaboration with peers, could facilitate technology adoption by Teacher Educators.

In our current study, we examine the factors that are beneficial to supporting peer-collaboration amongst teacher educators. To encourage collaboration between fellows, the additional 12 fellows were recruited using the recommendations of previous cohorts. In addition to this recruitment strategy, we had various workshop activities that assigned pairs of teacher educators to work together. We also established affinity groups where fellows expressed common topics of interest. Finally, with the recruitment strategy and workshop activities designed to foster collaboration, we examine the resulting implementation planning at the end of the workshop to see which of these elements of recruitment and workshop design resulted in collaborative implementation plans. Social network analysis over the implementation plans reveals a high degree of mutual collaboration. Furthermore, collaboration appears to be related to affinity groups formed during the workshop more than any other factors analyzed.

Related Work

Simulation Based Research: Many studies have used simulations in education, some of which have been informed by clinical simulation work in medical training. (Dotger and Ashby, 2010; Dotger, 2013). In clinical simulation work, there has been a transition from questions focused on the efficacy of simulations in medical education to considering new research opportunities made possible by using simulations - referred to as simulation-based research (SBR) (Lamé and Dixon-Woods, 2020). Such simulation-based research has been employed in several avenues of K-12 CS Ed, like computational thinking (Adler and Kim, 2018; Reich et al., 2018), critical incidents (Pieper et al., 2020), and even problems of practice (Borneman et al., 2020; Robinson et al., 2018).

In this study, we focus on SBR for multi-center studies, which are studies where clinical simulations are replicated across multiple sites as a means to examine the extent to which simulations can be generalized across contexts. We apply this approach to the use of simulations in Teacher Education. To connect the use of clinical simulation to the concept of multi-centered research, we next describe digital clinical simulations, which provide tools for distributed authorship (Hillaire et al., 2020).

Digital Clinical Simulations (DCS): DCS approximates the real-life interactions of a participant (say a teacher) by making them interact with an agent through scripted conversational prompts (Hillaire et al., 2020). The agent is considered unintelligent since the scripted prompt is static and does not depend on the participant's response. DCS derive their inspiration from clinical simulations in medical education to create authentic patient interactions between a medical student and a mannequin or a paid actor (Dotger, 2013; Hamstra et al., 2014). In addition to providing a platform to play-test the scenarios, DCS should also enable the participants to revisit their play-testing to observe their choices and reflect upon what they could have done instead. This ensures individual reflection on their own responses.

Finally, DCS should also include support for group reflections by providing features that enable authors (Teacher Educators) to collectively examine participant responses and compare and contrast different play-testing strategies. Thus, the system should facilitate authors to broadcast and share their experiences and findings with other pre-service teachers, Teacher Educators, and researchers. Teacher Educators can help facilitate discussions based on their depth of knowledge around issues of equity for which the simulation was designed (Sullivan et al., 2020).

DCS Tools

The Entire Cycle of Digital Clinical Simulations

As observed in (Hillaire et al., 2020), Teacher Educators exhibit curricular expertise, i.e., the ability to contextualize content-appropriate material to the learner (Ennis et al., 1994). Moreover, by supporting Teacher Educators as authors, it situates the simulation around topics for which the Teacher Educator has expertise. This, in turn, supports discussing pre-service teachers' behavior within the simulation (Sullivan et al., 2020). Teacher Educators have skills suited for authoring and, in doing so, could create simulations for which they could effectively facilitate implementations. However, previous work found that they needed support, particularly in the form of peer-feedback, throughout all phases of authoring, implementing, and researching the use of DCS (Hillaire et al., 2021). While support for technology adoption is a potential barrier, the desire for peer-feedback promotes generating a network of Teacher Educators. To consider the technology adoption of DCS for simulations, we first detail two tools and then consider how to support technology adoption. We illustrate the four phases of DCS in Figure 1. In this work, we focus on two such platforms that act as DCS authoring tools, namely, (i) Teacher Moments for single user simulations with unintelligent conversational agents (Hillaire et al., 2020) and (ii) ELK for two user simulations. (Reich et al., 2018). In this study, we examine how workshop recruitment and workshop activities influence collaborative implementation planning.

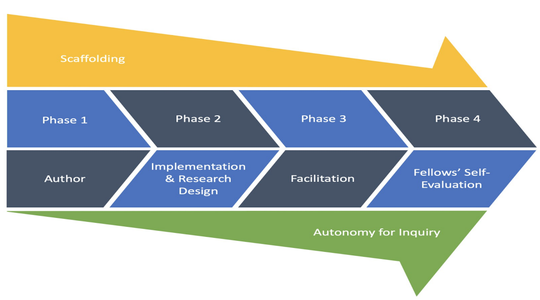

Figure 1 : An info-graphic illustrating the four phases of adopting DCS. Phase 1 refers to authoring scenarios, while Phase 2 refers to prospective plans of designing implementation and research plans with DCS. Phase 3 refers to facilitating the implementation/research plans and finally Phase 4 talks about analysing their implementation/research to reflect and refine their beliefs on equity. In this work, we focus on Phase 1 and Phase 2.

Teacher Moments (TM): TM is an open-source, online authoring platform for DCS and provides opportunities for improvisational interaction with scripted character(s). Previous work with TM supported authoring simulations that follow a simple linear path meaning all participants go through the same set of interactions in the same sequential order. While this positions the simulation's story as lower in terms of complexity, it makes authoring the simulation similarly straightforward (Hillaire et al., 2020).

In this paper, we explore the capacity for Teacher Educators to author branched scenarios (hereby referred to as Branched) using the new branching functionality in the TM platform. Branching increases the story's complexity and opens up new opportunities by considering improvisational responses to dynamic narratives (Smeda et al., 2012). While the increased complexity in the simulation narrative opens up new avenues as a DCS authoring tool, we consider how the increased complexity in narrative impacts Teacher Educators' ability to author branched scenarios.

Eliciting Learner Knowledge (ELK): ELK is an online simulation game between two participants (Reich et al., 2018). One assumes the role of a teacher, and the other assumes the role of a student. The platform supports chat/discussions between players through a text-based interface. At the beginning of each simulation, ELK provides each player with their corresponding background details and an overview of the scenario; the teacher receives a learning objective. The student receives a learning profile with a list of the said student's conceptions and misconceptions. The players then engage in a synchronous 7-minute conversation and take the same true/false quiz at the end of the simulation, which scores whether the participant role-playing the student could portray themselves accurately and whether the teacher was able to estimate the student's understanding.

Although primarily designed to help pre-service and in-service teachers understand questioning strategies and learn about possible student misconceptions (Reich et al., 2018; Wang et al., 2020), ELK can also be used in role-play scenarios to facilitate discussions on problems of practice. Since the design of such scenarios, including the crafting of the questions, require curricular expertise, we observe that the ELK satisfies the first criteria of DCS.

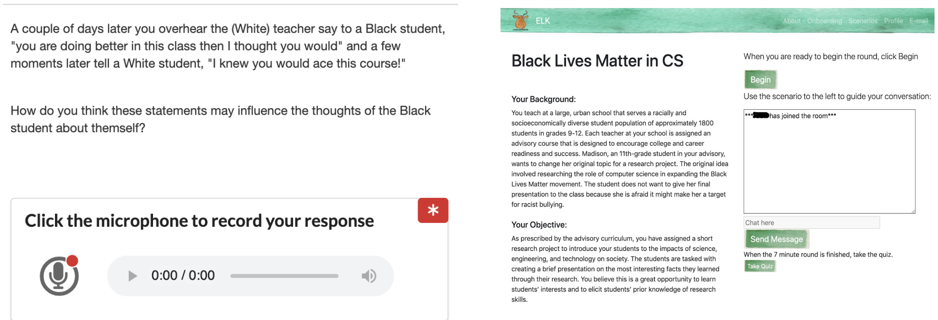

Figure 2 : Snapshot of scenarios of Digital Clinical Simulation (DCS) authoring tools. Teacher Moments (TM) is shown on the left and ELK from the perspective of a teacher is shown on the right.

Secondly, based on the chat platform's dynamic nature, ELK allows the participant (especially the teacher) to receive immediate feedback on their conversation exchanges. We emphasize that although role-playing is not strictly scripted, as in TM, the scenarios played out by the student are indeed the same. The variability stems from the individual idiosyncrasies/ characteristics of the student, which imparts fidelity to the simulation, in addition to authenticity (Nestel and Tierney et al., 2007; Thompson et al., 2019). We believe that preparing pre-service teachers to respond to the students' varying needs is of paramount importance, especially when discussing problems of practice. ELK also provides functionalities for individual participants to download and browse through their past transcripts to probe and reflect on their conversation exchanges. Moreover, the teachers also receive direct feedback from the true/false questions at the end of the simulation, which helps them objectively assess the student's understanding

Finally, ELK provides Teacher Educators with functionalities to analyze conversation exchanges in bulk, enabling them to compare and contrast different strategies about a scenario or strategies across different scenarios. It provides a platform for Teacher Educators to identify the most successful simulations and the reason behind them. It presents them with the opportunity to share their findings with the community and lead to collective reflections.

Technology Adoption of DCS

We consider Teacher Educators' technology adoption of DCS by examining three aspects: 1) self-efficacy, 2) help-seeking, and 3) concerns. Self-efficacy is essential because one can only effectively integrate technology if they understand the overall process (Ertmer and Ottenbreit-Leftwich, 2010), which is authoring, implementing, and researching the use of DCS for teacher education. Similarly, help-seeking is vital because teachers require help when adopting technologies that innovate pedagogical practice (Ertmer and Ottenbreit-Leftwich, 2010). The Concerns Based Adoption Model (CBAM) suggests evaluating concerns to evaluate technology adoption (Hord et al., 1987).

Methodology

Participants: 24 Teacher Educators participated in a four-day workshop on authoring digital clinical simulations using Teacher Moments and ELK. 12 fellows had previously participated in a year-long fellowship (INSPIRE CS-AI) wherein they used Teacher Moments by authoring, implementing, and researching the use of DCS for Teacher Education. The 12 first-year fellows were responsible for recruiting second-year fellows to foster collaboration, so the 12 second-year fellows were all recommended by first-year fellows. None of the 24 fellows had previous experience with ELK.

Workshop Schedule: The workshop took place over four days in July 2020. The first day focused on authoring simple linear Teacher Moments simulations. The second day focused on authoring branched Teacher Moments simulations. The third day focused on authoring ELK scenarios, and the fourth day discussed plans for implementation and research using DCS for Teacher Education. At the end of each day, we administered a survey that examined self-efficacy, help-seeking, and technology concerns focused on the authoring activity of the day: Teacher Moments, Teacher Moments (branched), and ELK.

Table 1: Questions asked in the exit-tickets to document the authoring experience of the fellows.

Question	Mode
I am capable of authoring scenarios for DCS	Likert scale
I require supports to author scenarios in DCS	Yes/No
If yes, what supports can help you author scenarios	Text-box
I think DCS could benefit from additional supports	Yes/No
If yes, the supports I would like to see added to DCS are	Text-box

Table 2: Questions in Day 4 exit tickets to document the implementation and research plans of fellows.

Question	Mode
I am capable of planning a [lesson/research study] that implements DCS in my class	Likert scale
I require supports for [implementation plans/research] using DCS	Yes/No
If yes, the supports that I need to help me [implement/research] scenarios in my class and/or professional sessions	Text-box
I think [ELK/TM] could benefit from additional supports for [implementation/research	Yes/No
If yes, the [implementation/research] supports that should be added to [ELK/TM]	Text-box

Materials

Day 1, 2, & 3 fire-hose slides: We document the scenarios the fellows have authored for a particular DCS in their corresponding fire-hose slides. For each scenario, we ask the fellows to provide a summary/description and the problems of practice associated with it.

Day 1, 2, & 3 exit tickets: We also document the fellows' feedback on the first three days of the workshop on authoring different DCS in the corresponding exit tickets. The questions in the exit tickets are provided in Table 1 and were framed as either a Likert-scale, a binary Yes/No question, or a Text-box to record general textual response.

Day 4 Implementation Plan: We formalize an implementation plan, spanning the next 12 months, for the fellows to implement and research the scenarios they had authored during the workshop. We created affinity groups wherein fellows could identify common themes of interest to facilitate collaboration among peers. The implementation plan outlines all the scenarios that a fellow is interested in implementing and its tentative schedule.

Day 4 exit ticket: The exit ticket on Day 4 outlined the fellow's future endeavors in using different DCS tools for lesson implementation and/or research. The questions posed in the exit ticket are shown in Table 2. We show the same questions for both implementation and research design but for the sake of brevity, we refer to them as [implementation/research] in Table 2.

Research Questions

(RQ1) How do Teacher Educators describe the experience of authoring, implementing, and researching DCS in terms of self-efficacy, help-seeking, and technology concerns?
(RQ2) How do Teacher Educators project collaborating on their implementations?

Results

RQ1. How do Teacher Educators describe the experience of authoring, implementing, and researching DCS?

During the workshop, the fellows authored 46 Digital Clinical Simulations spanning both ELK and Teacher Moments. Out of the 46 simulations, the fellows authored 17 ELK scenarios, 19 Linear TM scenarios, and 10 branched TM scenarios. We report the participant's adoption of Teacher Moments and ELK along the dimensions of self-efficacy, Help-Seeking, and Technology concerns for authoring in Table 3 and those concerning implementation and research in Table 4.

Of the 66 responses to exit surveys from each of the four days of the workshop, 22 mentioned seeking help, and 44 indicated technology concerns. 11 of the help-seeking responses were for authoring, 3 for implementation, and 8 for research. The breakdown across phases for the technology concerns responses was 21, 11, and 12, respectively. Three raters coded these responses, and in a consensus rating, the four themes of ***peer-feedback***, ***ideas/examples***, ***feature requests***, and ***tech support*** emerged. These themes were prevalent in both help-seeking and technology concerns across the phases of authoring, implementation, and research design.

Peer-feedback refers to responses in which participants expressed a desire to discuss their ideas or have their work reviewed by others during the authoring, implementation, and/or research process. One participant stated, "It would be great to have someone discuss my ideas and have feedback on what may or may not work." This aligns with findings from the first year of the fellowship (Hillaire et al., 2021). Participants who asked for ***ideas/examples*** felt that they needed more time to form ideas, that they wanted help in brainstorming ideas, or that they would have benefited from examples of scenarios, implementation methods, or past research to use as a starting point. For instance, a participant was "not sure how best to facilitate this online and would love ideas for thinking about reflection." ***Tech support*** encompasses responses from participants who did not have specific questions or requests at the time but would like for help to be available if they run into difficulties in the future. One such response was, "just check-ins when I encounter challenges - no specific support needed at this time." Finally, ***feature requests*** included descriptions of new features for DCS, which participants would find helpful in any of the three phases, such as "more open-ended questions along with the true-false/yes-no responses" in ELK.

Table 3: Technology Adoption for Authoring

Authoring	**Self-efficacy**	**Help-seeking**	**Concerns**	**#Scenarios**
ELK	6.46	15.38%	61.54%	17
TM (Linear)	6.27	42.85%	46.67%	19
TM (Branched)	5.71	21.42%	42.85%	10

Table 4: Technology Adoption for Implementation and Research

Authoring	**Self-efficacy**	**Help-seeking**	**TM-Concerns**	**ELK-Concerns**
Implementation	6.33	25.00%	25.00%	75.00%
Research	5.58	75.00%	45.45%	63.63%

Table 5: Codes for help-seeking and technology concerns across authoring, implementing, and researching for the two DCS tools. Counts of the corresponding concerns are shown beside the concerns.

Phase	**Help-Codes**	**Tech-Codes**
Authoring	Tech support (6), **Peer feedback (4),** Ideas/examples (2)	Feature requests (5), Documentation/tutorials (4), Tech support (3), Workshop clarification (2), Ideas/examples (1), Peer feedback (1)
Implementation	**Peer Feedback (1)**, Tech Support (1), Ideas/examples (1)	Feature Requests (4), Tech Support (4), Feature Requests (4), Data collection (2), Documentation/tutorials (1), Workshop clarification (1)
Research	Tech Support (4), **Peer feedback (2),** Data collection (1), Feature requests (1), Ideas/examples (1), Workshop clarification(1)	Feature Requests (3), Peer feedback (3), Tech Support (3), Workshop clarification (3), Ideas/examples (1), Data collection(1)

RQ2. How do Teacher Educators project collaboration on their implementations?

To foster collaboration, we requested that each fellow implement four simulations per semester in the coming academic year (4 per semester). If all 24 fellows implemented 8 simulations, this would result in 192 implementations in the coming year. During implementation planning, fellows scheduled a total of 102 implementations, with more implementations scheduled for the fall (71) than for the spring (31)

For the 102 planned implementations, 17 were cases where the fellow indicated they would implement a simulation without specifying which simulation they would use, 29 were cases where fellows planned to implement their individual simulation, most notably for this study 56 indicated they would implement a simulation authored by a peer comprised of 44 unique pairs of author and implementer. 32 times the implementer plans to use one simulation from the same peer author, while 12 times the implementer plans to use two simulations from a peer author.

We formalize the authors' potential collaborations with other fellows in the *implementation plan* by constructing a social collaboration network, as illustrated in Figure 3. The nodes represent fellows as specified by their numeric id, and the directed edge from one node (say 14) to another (say 12) indicates that '14' wants to work with '12'. The directed edge weight denotes the number of scenarios of '12' that '14' wishes to implement.

Global analysis: The collaboration network comprises 24 fellows and 44 edges, out of which only five fellows have no incoming or outgoing edges, i.e. they do not wish to collaborate with anyone else. The network has a high global clustering coefficient score (Wasserman et al., 1994) of 0.275. A high gcc implies the existence of triads (links between one's neighbors) and thus hints at increased collaboration between one's neighbors. 17 out of 24 fellows comprise 12 unique triads, implying that 17 fellows are willing to collaborate on at least two other scenarios. The network exhibits a high reciprocity score of 0.273, implying that if a fellow A is willing to author a fellow B's scenario, there is a 27.3% probability that B will also author A's scenario. This score indicates high levels of mutual interest.

Year-wise analysis: We also distinguish between returning and new fellows and observe the network characteristics of these two sub-groups. We observe that both the mean in-degree and out-degree new fellows (1.33 and 1.5 respectively) are lower than those of the returning fellows (2.33 and 2.17 respectively). We posit that although the new fellows are unsurprisingly, more hesitant to collaborate, the differences are not statistically significant. In fact, the new fellows displayed a greater interest in collaborating with existing fellows (12 edges vs 6 edges), which highlights their inclination to collaborate with experienced fellows.

Potential Reasons for collaboration: We further investigate the potential reasons for collaboration amongst the fellows along the lines of previous recommendations, workshop activities, and affinity groups.

In the recruitment strategy, we investigated if recommendations from previous fellows led to improved collaboration efforts. We observe a moderate effect along these lines with, 5 out of 12 new fellows planning implementations with the fellows that recruited them. Thus, there is a reason to adopt a similar recruitment strategy to foster collaborative implementations when supporting Teacher Educators to adopt novel pedagogical approaches.

In a comparative analysis, we examined if the paired workshop activities where fellows were assigned into pairs to try out the technology led to better collaborative implementation plans than the affinity group activity. 14 out of 44 collaborative implementation plans consisted of participants that were assigned as pairs during the workshop. However, affinity groups relate to 35 out of 44 collaborative implementation plans.

An affinity group caters to a specific research theme put forward by the fellows and broadly aligns with the problems of practice they wish to implement and research. It resulted in 12 distinct affinity groups, as shown in Table 6, along with the corresponding number of fellows who wanted to participate in that affinity group. This suggests that when designing a workshop to support technology adoption, affinity groups appear more productive in implementation planning for collaborative technology adoption. From these results, we would suggest that during workshops to support technology adoption, affinity group activities promote more collaborative planning than assigned paired activities. While both have some influence, if workshop planners need to choose between the two, then affinity groups would be a better use of time.

Table 6: Emergence of specific affinity groups.

Affinity Groups	**Fellows**	**Affinity Groups**	**Fellows**
Culturally responsive pedagogy	10	Engaging preservice teachers with equitable online teaching	5
Equity/Social Justice	9	Digital Citizenship	4
Elementary CS	8	Queering the CS curriculum	3
Elementary Teacher Education	7	Bi/Multilingual learners in the CS classroom	3
Cyber Security	6	Engaging Students with impairments in classroom	3
Artificial Intelligence in K-12	6	Neurodiversity / UDI	2

Conclusion and Future work

In this work, we examine the adoption of Digital Clinical Simulation authoring tools by 24 Teacher Educators across the USA. We perform quantitative and qualitative analysis to identify the capabilities of fellows to adopt DCS for authoring, implementation, and research and potential collaboration among the fellows.

A quantitative analysis highlighted high self-efficacy scores in authoring, implementing, and researching DCS. A subsequent thematic analysis on the fellows' feedback and social network analysis revealed high inclinations for collaboration, thereby making this an ideal scenario for multi-center studies. These results from the first two phases of adopting DCS demonstrate the generation of a network of solutions that may help address the network of equity problems in K-12 computer science education. Future work will address the last two phases of DCS adoption, namely facilitation of the said implementations and equipping fellows with the skills to research and reflect on problems of practice and issues of equity.

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