Effects of Scaling Up Apprentice-Style Research: Perceptions from Mentors and Mentees

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ABSTRACT

Access to undergraduate research is limited. One approach to broaden access is scaling up the mentee-to-mentor ratio (e.g., course-based undergraduate research experiences have a classroom of student mentees being led by one professor mentor). However, some mentors and mentees may prefer apprentice-style research, which is defined as research with a small mentee-to-mentor ratio. Pulling influences from non-scaled and scaled approaches, we implemented and evaluated the Community College to PhD (CC2PhD) Scholars Program, which was a community college research program. CC2PhD was designed to scale up non-personalized aspects of apprentice-style research while maintaining personalized one-on-one mentoring. The scaled non-personalized aspects of CC2PhD included the predefined mentoring curriculum and the research methods workshops. They were "scaled" in the sense that few people were involved in curriculum development and workshop instruction. These scaled resources can then be used by a large number of mentor-mentee pairs. We interviewed and surveyed seven mentor alumni and six mentee alumni to understand the effects of the scaled aspects of CC2PhD. We identified four themes: (1) improved time-related issues by saving time and facilitating time management, (2) influenced meeting content, (3) helped beginner mentors and mentees, and (4) increased mentors' willingness to volunteer. Future researchers can further scale-up and digitize our scaled research-apprentice model. For example, the mentoring curriculum and workshops can be adapted into a MOOC, which mentor-mentee pairs can reference from.

CCS CONCEPTS

• Applied computing → Education → Collaborative learning

KEYWORDS

Apprentice-style research at scale; Undergraduate research; Mentoring; Community College to PhD Scholars Program

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1 Introduction

Engaging in research is a high-impact educational practice that can improve undergraduate student success [12]. However, access to undergraduate research is limited, especially at community colleges [5, 14]. Pierszalowski et al.'s [2021] systematic literature review identified several broad barriers to undergraduate research opportunities, which include lack of physical resources, faculty and student time, faculty incentives, student's research readiness and competency, student interest and awareness, student finances, and institutional commitment to undergraduate research.

The traditional model of research training is apprentice-style, where "one or a small number of students work with an individual or small group of [more senior-level researchers] on a research or design problem, typically outside of the classroom" [14]. Apprentice-style research has a small mentee-to-mentor ratio. There are two models for scaling up this ratio. There are course-based undergraduate research experiences (CUREs) with a classroom of students being led by one professor and (if included) teaching assistants [1, 4, 9, 11, 20, 23, 26, 27]. CUREs are broadly defined as "a course in which students are expected to engage in science research with the aim of producing results that are of interest to a scientific community" [4]. The second approach is engaging citizen science participants in more authentic research experiences that provide them with more autonomy [22, 24]. Notably, Vaish et al. [2017] developed Crowd Research, which is a "crowdsourcing technique that enables open access for a global crowd to work together on research under a principal investigator (PI). Crowd Research participants collaborate online as one large team to brainstorm research ideas, execute solutions, and publish scholarly articles." Their mentee-to-mentor scale is massive: thousands to one.

However, faculty may be wary of implementation issues regarding scaled research [6, 17, 24]. For example, faculty identified CURE-specific implementation issues like the curriculum approval process, pushback from other faculty, large

class sizes, research ethics, lack of CURE guidelines, and limited time in the course curriculum for research [6, 17]. On the other hand, undergraduate mentees may prefer apprentice-style research because they will apply for PhD admissions where the quality and depth of letters of recommendation can play a large role [7, 18].

Pulling influences from non-scaled and scaled approaches, we implemented and evaluated the Community College to PhD (CC2PhD) Scholars Program. CC2PhD was designed to scale up non-personalized aspects of apprentice-style research while maintaining personalized one-on-one mentoring. We interviewed and surveyed mentor and mentee alumni to understand the effects of the scaled aspects of the program. We identified four themes: (1) improved time-related issues by saving time and facilitating time management, (2) influenced meeting content, (3) helped beginner mentors and mentees, and (4) increased mentors' willingness to volunteer.

2 Study Context: CC2PhD Scholars Program

The CC2PhD Scholars Program was a 7-month undergraduate research and PhD preparation program hosted at the University of California, Los Angeles. CC2PhD outreached to and served about 25 community college social science students each year. Short-term [16] and mid-term [15] outcome evaluations suggest CC2PhD improved students' technical research skills, ability to apply to *other* research opportunities, and PhD preparation.

Among other program deliverables, CC2PhD guided students through the process of conducting an interview research project. Students were the lead researchers on their project (i.e., in charge of conceptualizing the topic and conducting all the research steps). To ensure students were making timely progress on the research project, students were assigned approximately 40 hours of scaffolded research assignments and readings every month [3, 10]. Monthly assignments were submitted to an online portal at the end of every month, which program staff and mentors had access to.

Community college students had monthly videoconference meetings with a graduate student mentor, transfer student peer mentor, and community college faculty mentor. There were prescribed meeting agendas, which generally revolved around asking for feedback on rough drafts of their monthly assignments before they were turned in at the end of the month. Students also received a $200 research grant, 7-hour in-person monthly workshops led by professors and administrators, optional office hours with the program director, and active online discussion forums. The support services were designed and structured to guide students on how to complete each month's particular program assignments. For example, one of the February assignments included conducting thematic analysis of interview transcripts. So, in February the mentor meeting agendas, workshop topics, and readings covered thematic analysis, among other things.

2.1 Scaling Up Aspects of the CC2PhD Program

The CC2PhD program was designed to scale up non-personalized aspects of apprentice-style research. The goal was to address two of the barriers that hamper mentors' willingness to participate in undergraduate research: lack of mentors' time and students' research preparedness [17]. The *personalized* aspects of CC2PhD maintain a small mentee-to-mentor ratio (e.g., one-on-one meetings to provide individualized feedback on the mentee's research project). The *scaled non-personalized* aspects of CC2PhD included the predefined mentoring curriculum and the instruction of the interview research methods workshops. The mentoring curriculum consists of the scaffolded monthly assignments, workshops, readings, and prescribed mentor meeting agendas (see supplemental materials). They were "scaled" in the sense that only a few people had to develop the mentoring curriculum and only one instructor at any one time had to teach the workshops. These scaled non-personalized resources can then be used by a large number of mentor-mentee pairs. This is opposed to each mentor taking the time to develop their own mentoring curriculum and provide instruction on research basics.

The mentees' research project methodology (interviews and thematic analysis) was predefined by the program director so that the assignments, workshops, readings, and meeting agendas could be standardized and applicable to all the mentees. However, this setup can be adapted to different research methodologies.

3 Methods

The purpose of the evaluation was to study the effects of scaling up non-personalized aspects of apprentice-style research on CC2PhD mentors and mentees.

3.1 Participants

We recruited mentee and graduate student mentor[1] alumni from the 2018-2019 cohort of the CC2PhD Scholars Program, which was the final academic year CC2PhD was implemented. We sent the call for study participants via email and text message. Seven graduate student mentor alumni (MENTOR_1 – MENTOR_7) and six mentee alumni (MENTEE_1 – MENTEE_6) participated in this study. Participants received a $30 gift card.

3.2 Procedure and Analysis

This study's data was collected in 2021 (about 2 years after alumni completed the CC2PhD program). First, study participants reviewed a CC2PhD timeline document that outlined each month's workshops, readings, assignments, and prescribed mentor meeting agendas. The purpose was to jog their memory. Then mentee alumni (but not mentor alumni) completed survey questions. Finally, mentor and mentee alumni were interviewed.

We used Otter.ai, which is an automated transcription service, to transcribe our interviews. We then went over the automated

[1] We restricted mentor interviews to graduate mentors because CC2PhD was designed to have graduate mentors serve as the primary mentor. Mentee survey data (collected in 2019 *outside* of this paper's study) seems to agree with this sentiment. 19 mentees rated to what extent individual program components contributed to their gain in skills and knowledge. In descending order: workshops (4.74), readings (4.33), graduate mentor (4.16), peer mentor (3.45), and faculty mentor (3.30). Response options ranged from "Not at all" (1) to "A great deal" (5).

transcript and fixed transcription mistakes. We used ATLAS.ti as our qualitative data analysis software. We used "structural coding" during the first cycle of coding and used "pattern coding" during the second cycle of coding [21]. We then used "thematic analysis" to identify themes based on the second cycle pattern codes [2].

3.3 Limitations

Despite reading the CC2PhD monthly timeline document to refresh their memory, participants' recall may be hindered by being interviewed two years after they completed the program. A second limitation is volunteer bias. Perhaps alumni who did not participate in the study had a more negative view of the program. Third, study participants may not have felt comfortable speaking frankly because of the lead author's positionality as CC2PhD's founder and director. Finally, our mentees may not be representative of the community college student body or other groups like freshmen-admit university students or STEM majors.

4 Findings

4.1 Improved Time-Related Issues

4.1.1 Saved Mentor and Mentee Time. The program saved mentors and mentees time from planning meeting agendas. MENTOR_3 said: *"[The prescribed meeting agenda] helps take some pressure off from me in determining what we're going to be talking about for an hour because otherwise, [the mentee] don't know what to ask me."* Similarly, MENTEE_1 said: *"Definitely [saved me time] with having to come up with topics."* MENTEE_4 stated the workshops and readings saved them time from finding their own resources: *"I didn't have to spend a lot of time looking for these materials. ... They were just given to us, which I thought was super helpful and a better use of time for us."* The program saved mentors time from the task of mentoring a beginner researcher without any help. MENTOR_3 stated:

> *Coding, analysis, and interview techniques these are all things that ... would be a whole class on methods. ... That would be a lot to ask one mentor to do by themselves. ... [Without CC2PhD] I probably would have met at least 10 to 15 hours a month [with the mentee] talking about things like "This is how you do research." And also [time outside of meetings] coming up with readings ... to help guide them.*

Reduced mentoring time is possible because CC2PhD provided foundational instruction on interview research. MENTEE_3 explains how they had less basic questions to ask their mentor:

> *If you really paid attention to the [workshops] you would see that, "Wow this is exactly what we're doing in our projects. I better pay attention or I'm going to be so lost." ... I learned so much from [workshops] that it definitely did decrease the amount of questions I asked my mentors. ... My [mentor] never had to clarify any of the assignments. ... All of our [meeting] time was spent diving into [feedback and revising] the assignments.*

In the survey, the six mentee alumni rated the extent to which various program components helped decrease the amount of mentoring they needed from their graduate mentor. In descending order: workshops (4.5), readings (3.83), faculty mentor (3.0), and peer mentor (3.0). Response options ranged from "Not at all" (1) to "A great deal" (5). This suggests that scaling up non-personalized aspects of apprentice-style research (e.g., workshops and readings) can still reduce a mentor's time burden even if the mentee has one mentor instead of a team of mentors.

4.1.2 Facilitated Mentee Time Management. MENTEE_1 speculated they would have procrastinated [25] without CC2PhD's monthly deadlines: "*If I hadn't been held accountable to the extent that I was, I definitely would have procrastinated a lot more [in CC2PhD]. ... It would have been much more stressful."* For context, the deadlines probably carried more weight because of the threat of program dismissal if they did not submit monthly assignments on time. MENTOR_3 states the curriculum's structure helped mentees with long term planning.

> *There were just step-by-step things for [the mentees] to be doing every single month ... and [the mentees] must do it by this [monthly deadline]. And [they] must figure it out before. Not the night before [the deadline] to do an interview. And so I think that the structure actually forced them to ... think about how a project might take a very long time, and they might have to do it in increments and stages.*

For example, meeting agendas helped with planning because the meetings focused on requesting feedback on assignment drafts before assignments were submitted. MENTEE_3 stated: *"The structure of those meeting agendas kind of set us to make goals like 'I should have this done by the meeting time so I can show them. Because the agenda says we need to talk about this.'"*

4.2 Influenced Meeting Content

4.2.1 Meetings were More Advanced/Mature. MENTOR_6 stated they didn't have to go over basics in meetings: *"[Workshops and readings] helped to provide students with a baseline knowledge [on] how to put together a project in its very basic form. ... We didn't have to rehash the basics of, 'Let's go through what a blank is.'"* Mentors used the workshops and readings as a baseline to impart new knowledge. MENTOR_1 said some meetings talked *"retroactively about a [workshop] presentation. And so it was easy for me to add on to that. We weren't starting off from zero."* MENTOR_1 also checked comprehension of prior content and provided clarifications:

> *Anything that he said he knew of, I would ask him a bit deeper ... just trying to really understand whether he knew what these things meant. ... We would even go back ... and [rewatch] some of the [in-person workshop recording] videos [or re-read the PowerPoint slides] ... [when the mentee] weren't sure about something.*

MENTOR_3 enjoyed how the program facilitated their meetings to focus on feedback instead of lecture-style instruction: *"[During meetings] they would come to me with like a pre-prepared*

assignment [draft] … [and ask] kinds of questions, where I just get to do course correction instead of like course writing."

4.2.2 Meetings for Holistic Mentoring. None of the prescribed meeting agendas had topics about holistic mentoring [13]. MENTOR_2, who strictly followed the prescribed meeting agendas, wished there was leeway to engage in holistic mentoring: *"Maybe even a half an hour of informal [meeting time per month for] just getting to know [my mentee] … I wish I could have been more of a resource to [my mentee] outside the formal [meeting] topic."* On the other hand, some mentor-mentee pairs treated the prescribed meeting agendas as optional. MENTOR_4 believed the workshops, readings, and other mentors provided mentees with enough support. This allowed the graduate mentor to use some of their limited meeting time to engage in holistic mentoring:

> *[CC2PhD] allowed me to be a sounding board for the research. … But it [also] allowed for the space to be like, "How are you doing? What's going on in your life?" kind of thing. So it was more of a multi-dimensional type of mentorship. And all the other types of support … allowed that to happen. Because I didn't have to spend an hour [in the meeting with basics] like, "This is what a research question is."*

4.3 Helped Beginner Mentors and Mentees

4.3.1 Helped Beginner Mentors. MENTOR_7 said the mentoring curriculum *"guided us through [my mentee's] project nicely. I think for folks that haven't mentored anyone [before] … it's like training in a sense of 'Here's the key things you should be thinking about when you're mentoring someone.'"* Without CC2PhD's curriculum, a new mentor may inadvertently not provide certain *"information my students need to successfully move forward on projects"* (MENTOR_7). MENTOR_2, who was new to mentoring, stated the meeting agendas "*made it very easy and made me confident in my [mentoring] ability. … [Without the agendas] I would have been more nervous because I wouldn't know what to expect going into the meetings."* Perhaps they were nervous about being caught off guard by questions they cannot adequately answer. Whereas if they know the meeting topic ahead of time, they can prepare for the meeting to ease their nerves.

4.3.2 Helped Beginner Mentees. MENTEE_4 stated CC2PhD provided resources and scaffolding necessary for beginners to conduct independent research: *"I probably would have had zero idea where to start or where to look for resources and how to build a project from the ground up if it wasn't spoon fed to us."* MENTEE_1 said meeting agendas helped her develop more thoughtful questions: *"You don't even know what to ask [as a beginner]. … [The agendas were] guiding topics that I could derive questions from. … So, I don't think the meetings would have been as fruitful [without] the prescribed meeting agenda."* MENTEE_2 states the curriculum helps to avoid rookie mistakes: *"The structure really kind of help keep people on the road instead of going off."* **MENTOR_1** agrees and reflects on their **past** as an undergrad in an unstructured research experience: *"I wasted a lot of time. Because some of [my mistakes] I could have [avoided] if somebody [preemptively] told me 'Hey when you do coding for an interview, this is how you do it.'"*

4.4 Increased Mentors' Willingness to Volunteer

The call for graduate mentor applications included descriptions of the predefined mentoring curriculum, support services mentees would receive, and mentor's 2.5-hour monthly time commitment. Unlike other interview questions, mentors had difficulty recalling if this application info impacted their willingness to volunteer years ago. So they speculated on what they may have thought at the time. MENTOR_7 said the predefined curriculum *"would be really positive because … with [teaching assistants], they're not really expected to create their own anything. And so it kind of fits in with what [graduate students] are already used to."* Creating their own mentoring curriculum for a beginner mentee would be a deal breaker for MENTOR_4: "*I would not have participated at all if that was required of me."* MENTOR_6 said the other support services (workshops, readings, faculty mentor, and peer mentor) were appealing *"because no one wants to be like, 'You are the only person [supporting the student].' … I really like the way that the program built out and spread out that [mentoring] burden."* MENTOR_5 found the low time commitment appealing "*because graduate students are so busy with their research or dissertation or whatever they have going on."*

5 Discussion

The CC2PhD evaluation data suggests scaling up non-personalized aspects of apprentice-style research may (1) save time and facilitate time management, (2) influence meeting content, (3) help beginner mentors and mentees, and (4) increase mentors' willingness to volunteer. Future research can address gaps within CC2PhD's scaled research-apprentice model. For example, future researchers can implement and evaluate scaled apprentice-style research that features: one mentor only (instead of a team of mentors), holistic mentoring (instead of research mentoring only), mentees with prior research experience (instead of beginners), a different research methodology (instead of interviews), MOOC-style instructional videos [8, 19] (instead of in-person workshops), and/or an apprentice-style research experience without a program director. To elaborate on the last point, would this scaled research-apprentice model still work if the mentoring curriculum (i.e., workshops, readings, assignments, meeting agendas) were posted online without a program director to oversee and incentivize mentees to complete their research project? For example, a standalone mentoring curriculum could be developed into a MOOC, or it could simply be posted on an undergraduate research center's website. From there, mentor-mentee pairs would reference the online standalone mentoring curriculum as they're completing their research project. Ideally, in the future, there will be a variety of MOOC mentoring curriculum courses that each focus on a different research methodology. This would provide mentor-mentee pairs with more options in their project's research methodology.

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