Mentoring in Informal Networks with Cognitive Apprenticeship

by

Curtiss Brouthers

A Thesis Presented in Partial Fulfillment
of the Requirements for the Degree
Master of Arts

Approved April 2021 by the
Graduate Supervisory Committee:

Leigh Graves Wolf, Chair
Scotty D. Craig
Steven J. Zuiker

ARIZONA STATE UNIVERSITY

May 2021

ABSTRACT

This design-based research study addressed whether cognitive apprenticeships mediated by informal mentor networks can expand, deepen, and transfer knowledge with and for Learning Sciences students. Three cohorts of Learning Sciences students were invited to participate with all three represented in surveys, co-designs, and interviews, with conjecture maps produced as artifacts for personal, professional, and education agendas. Survey and interview responses demonstrate that each participant found that it was a helpful tool for collaborative learning. Theoretically grounded in situated cognition, communities of practice, and legitimate peripheral participation, the conjecture predicted improved outcomes in students' perceptions, attitudes, and beliefs with informal mentor networks to support and encourage practice and engagement. Perceptions, attitudes, and beliefs did improve with confidence in conjecture mapping, however, through iterative co-design, the focus on informal mentor networks shifted from social media due to low usage among respondents to collaborative peer tutoring. Students expressed interest in expanding their networking and mentorship opportunities. Participatory co-design with conjecture mapping significantly improved recognition as a member in a community of practice for Learning Sciences students.

Keywords: situated cognition, community of practice, legitimate peripheral participation, conjecture mapping, cognitive apprenticeship, mentorship, more knowledge other (MKO)

DEDICATION

Dedicated to my family and loved ones. Always loyal, loving, and supportive. God Bless. Kids, this is for you. Thanks to my special and loving wife for being by my side, doing the best she can for us each and every day. I can’t say this enough, I love you. Thank you.

ACKNOWLEDGEMENTS

First and foremost, I have to thank my advisor and chair, Dr. Leigh Wolf for getting me to this point with support and encouragement throughout this journey. Thanks to Dr. Steven Zuiker for the last two years of professing the Learning Sciences and commitment to equity and education. Thanks to Dr. Scotty Craig for mentorship and contribution to my interdisciplinary curiosity. This committee has challenged me to my utmost and never let me down. I will be forever thankful. Thanks to Dr. Michelle Jordan for providing great experience, superb instruction, and commitment to the community. Thanks to Dr. Bryan Henderson for knowledge and insights into theory and learning strategies to improve my thinking and doing. Thanks to the MLFTC and the Learning Sciences Program for providing quality education and a culture of learning. Thanks to the students I have had the pleasure of learning with, across cohort, and degree program. Thanks to Linda DeFato for her dedication to supporting research for the program. Thanks to Darby Simpson, Zachary Reeves-Burton, Kimberly Scatton, Paul Signorelli, Library Services, Graduate College, ASU Mentor Network, Venture Devils Program, ChangeMaker, ShapingEDU, Talking About Design, Devil Invent, University Academic Success Program, and all the programs I was able to participate in and learn from. Thanks to Valarie Adams, Scott O'Neill, and my entire informal mentor network.

The U.S. Army Advanced Civil Schooling Scholarship for the opportunity and the Soldiers, Veterans, Retirees, and Civilians whom I have had the honor and privilege of serving with. For those wounded and above all, who have paid the ultimate sacrifice.

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CHAPTER 1

INTRODUCTION

OVERVIEW

Purpose. Learning Scientists in a master's degree program should be learning about how to learn with mastery. Having mastery in a domain or field brings with it expectations and responsibilities, not just from the department, but from the community of practice, the field of Learning Sciences. To define legitimate peripheral participation and a community of practice, Lave and Wenger state that, "learners inevitably participate in communities of practitioners and that the mastery of knowledge and skill requires newcomers to move toward full participation in the sociocultural practices of a community" (1991, p. 29). The Learning Sciences and design research is about theory and practice, which is covered well in curriculum, coursework, and research projects.

Problem. For students, ambiguity can be overwhelming and confusing as to what comes next after acceptance to a graduate program and what to do after receiving a degree. Professors are well-positioned to guide, advise, and even mentor in students' curiosities, inquiries, and interests; however, faculty are outnumbered by students, limiting further time and one-on-one consistent development. Clubs and other organizations in domain-specific fields and interests are common for some disciplines, but they are also specialized and bounded. There is room for networking and mentorship for Learning Scientists who want to explore opportunities in informal environments. Social media could be a catalyst to connecting students with mentors not just outside of their formal settings, but also within the community of Learning Sciences students.

RATIONALE

"Live as if you were to die tomorrow. Learn as if you were to live forever." - Mahatma Gandhi

Introduction. The Learning Sciences is a relatively new interdisciplinary field in higher education, which has potential to be innovative and transformative (Sandoval, 2014, p. 18). Looking at the field from multiple perspectives with various theories on learning, the Learning Sciences have evolved along a trajectory of inquiry, theoretical insights, practice, and distributed cognition within a community of practice (Evans et al., 2016). Learning can occur around communities of interest and discipline-based learning. Learning can also be flexible with multi/interdisciplinary associations and interactions, connecting "just-in-time" mentors to inquiry-based or interest-based learners (Bransford et al., 2000; Collins & Halverson, 2018).

Building on the theories of learning and the learning strategies in the Learning Sciences, it is important to see how students might benefit from networking and social media platforms with mentors and peers using Cognitive Apprenticeship Models (CAM; Collins et al, 1988). Taking it one step further, this study intends to observe how benefits of such networks expand, deepen, and facilitate transfer of knowledge with self-efficacy for learning as a skill with usable knowledge.

Learning and development are important throughout our lives, inside and outside of the classroom. Learning is improved by 1) exposure to learning opportunities and 2) learning in a social context (Bransford, et al., 2000, pp. 80-82, pp. 190-242; National Academies of Sciences, Engineering, and Medicine, 2018, pp. 1-9, pp. 197-223). The first point of opportunity is related to lifelong learning, "learning that occurs outside of compulsory educational environments is a

function of the learner's motivation, interests, and opportunities" (National Academies of Sciences, Engineering, and Medicine, 2018, p. 223). An example of the second point is in a "community of practice also provides direct cognitive and social support for the efforts of the group's individual members" (Bransford et al., 2000 p. 184). Relationally there is the student or learner, the professor or expert, and the mentor, who could be considered a More Knowledgeable Other (MKO). In many cases, an MKO could also be a peer, someone with more experience or knowledge of something (Vygotsky, 1980). Ultimately, if the Zone of Proximal Development (ZPD) is the optimal locus for learning, CAM can help find and maintain it. Then, CAM could be applied to informal learning in an authentically designed context, given the appropriate relationships, content, and goal alignment. The interplay of ZPD, social networks, personal and professional goals, competence, challenges, motivation, interest, and access are all important. Formal education has the structure to facilitate and support achievement. A network of mentors may provide additional or complementary content and domain knowledge, perspectives, and experience. Additionally, these relationships and connections may be beneficial at different times and as desires, circumstances, and interests change. The right mentor or expert at the right time could be pivotal to establishing identity in a community of practice with legitimate peripheral participation or toward a community of interest. This study therefore examines how a mentor network can provide support structures.

ASU Mentor Network. Arizona State University (ASU) has a networking social media platform dedicated to providing students with access to alumni in various fields. It is comparable to LinkedIn, in that it is oriented towards professional networking, however, it is specifically focused on mentorship for students.

Support Structures. Cognitive Apprenticeship, Professional Learning Communities (PLCs), and Personal Learning Networks (PLNs), offer support for adult learners (Chandler, 2012; O'Byrne et al., 2021). These supports can reduce anxiety in students who are unsure about what they want to do and how to get there. It can be taken for granted that things will take care of themselves or, on the other hand, things are going to be extremely difficult, if not impossible. Cognitive Apprenticeship Models and mentor networks are ways to help students navigate uncertainty and enhance learning with the assistance of MKOs. Students could even benefit from participating as mentors themselves for peers and newer cohorts (Roscoe & Chi, 2007; Roscoe & Chi, 2008). Exploration and encouragement lead to learner-centered outcomes, where "knowing not only captures the world and individual participation as it is but stresses the opportunities for learners to reveal their ability and talent" (Barab & Plucker, 2002).

RESEARCH QUESTIONS

Social media increasingly pervades our lives and is evolving in unpredictable ways. As technology grows and expands, one genre of applications caters to the social networks in real life and the real world. It is quite simple to virtually expand a network without ever actually meeting someone but rather connecting them through common connections and interests. Applying this context to learning, is it possible to extend formal connections between educators and learners to informal mentorships?

Popular social media sites where one might connect with a mentor, includes sites such as LinkedIn, Slack, Discord, Facebook, and Twitter. This can be used to interact with established mentors or connect with a new one. Social media sites that specifically offer a mentor-type relationship and expert guidance in an area of interest are ASU Mentor Network

(https://mentorship.asu.edu/) and ASU Startup Tree (https://asu.startuptree.co/). This idea of mentorship can be viewed as "something that takes place between a professionally active person and a student. A central factor is that the mentor does not have any evaluating or appraising function" (Arnesson & Albinsson, 2017, p. 202). Being professionally active in an area that interests the learner corresponds well with identity and motivation. Giving the right context and motivation is a step toward connections with mentors who are in positions to guide learners to their personal, professional, and educational goals. To learn about student interactions, experience, and perceptions in cognitive apprenticeships supported by mentor networks, this study's research questions are:

RQ1: What are Learning Sciences students' experiences with social media platforms to organize informal mentorship learning opportunities during the application and acceptance process, during graduate studies, and/or post-graduation?

RQ2: How have these experiences influenced their personal and professional goals?

RQ3: How might identity play a role in Learning Sciences student communities of practice and mentorship?

RQ4: What are the key systems and structures in informal learning and mentoring networks?

Questions are designed to understand identity, motivation, and build upon personal experiences students have had, with the goal of future mentoring in a community of practice.

CHAPTER 2

LITERATURE REVIEW

THEORETICAL GROUNDING

This study's thesis, 'cognitive apprenticeships mediated by informal mentor networks can expand, deepen, and transfer knowledge with and for Learning Sciences students is grounded in situated cognition and cognitive apprenticeship in communities of practice as how learning happens socially, contextually, and interactively (Brown et al., 1989). Lave and Wenger note a potential drawback for formal education and classroom teaching where, "a training program that consists of instructional settings separated from actual performance would tend to split the learner's ability to manage the learning situation from his ability" (p. 21).

In a chapter titled, "Situating Learning in Communities of Practice", Lave (1991) states that, "I propose to consider learning not as a process of socially shared cognition that results in the end in the internalization of knowledge by individuals, but as a process of becoming a member of a sustained community of practice" (p. 65). This is important because it integrates practice into learning. Identity and membership also make learning an active process and, with the support of a mentor, guides the learner in their community of practice. Lave continues, "this theoretical view emphasizes the relational interdependency of agent and world, activity, meaning, cognition, learning, and knowing. It emphasizes the inherently socially negotiated quality of meaning and the interested, concerned character of the thought and action of persons engaged in activity" (p. 67). This view represents a step toward opportunities for learning where practice becomes more meaningful and valuable to the learner and the community.

Attempts to design for authentic contexts and experiences with cognitive apprenticeship as a method could close the knowledge and practice gap of instructional settings in formal education. This study's argument is similar, except instead of using cognitive apprenticeship in a formal setting to make school more authentic, it proposes using cognitive apprenticeship models, techniques, and methods in informal environments, with mentors, networks, and social media to augment and supplement formal education outside of the classroom, predominantly virtual with pandemic precautions. Situated cognition is about content and context, and having opportunities to engineer or design them (Barab & Plucker, 2002). This flip-flop of cognitive apprenticeship would take interest and desire, assuming coursework and education is in the realm of interest and desire already, to motivate and inspire connections with MKOs, experts, peers, and others within communities of practice related to personal and professional goals, or within "affinity spaces" to broaden knowledge, seek enjoyment, and engage in nontraditional learning experiences (Collins & Halverson, 2018, p. 76; Gee & Hayes, 2009). This theoretical framework concludes that participating in informal mentoring networks, with reciprocal teaching, and social media to access and connect with mentors is a way for students to achieve personal, professional, and academic goals.

CONCEPTUAL FRAMEWORK

Introduction. Through literature review, cognitive apprenticeship has been defined, characterized, and implemented into familiar forms to improve practice and for analytical purposes. The Cognitive Apprenticeship Model (CAM) used by Garcia et al. "describes six learning-centered instructional methods: modeling expert performance, coaching to give learners feedback, scaffolding to guide learners, fading assistance once learners externalize their

understanding through appropriate articulation, reflection activities where learners compare their understanding with others, and exploration to apply what they have learned" (García-Cabrero et al., 2018, p. 815). This review will break down each component and characterize how they foster effective communities of practice in the Learning Sciences.

Modeling. With modeling, an apprentice observes correct or desired performance of a task which can then be conducted by the apprentice. Ideally, this would occur in an authentic setting with authentic tools for situated cognition where, "the apprentice repeatedly observes the master executing (or modelling) the target process, which usually involves a number of different but interrelated subskills" (Collins et al., 1988, p. 3). An example of modelling in a classroom environment would be through the demonstration of a task, or even the presentation of a conceptual model. This is where the "expert", or MKO, makes visible the cognitive representation of knowledge and practice for observation and reproduction. A learner moves from novice to expert with the aid of models which "by acquiring greater competence appears to be the increased ability to segment the perceptual field (learning how to see)" (Bransford et al., 2000, p. 36; NAS, 2018, p. 46). The idea of "seeing" through the use of modeling is not a complete way of teaching and learning on its own, but as a tool it is complementary to gaining expertise. Online tools offer many opportunities for modeling, anywhere and anytime, but coaching is the next topic that provides a necessary feedback loop for effective modeling and practice.

Coaching. The expert, or MKO, now observes the demonstration of the learner and coaches accordingly. In the constructivist tradition, the MKO can "see" the learners' prior knowledge in the present through the enactment of tacit cognitive representation. Constructivism

and Cultural Historical Activity Theory proposes that learners come with a "range of prior knowledge, skills, beliefs, and concepts that significantly influence what they notice about the environment and how they organize and interpret it. This, in-turn, affects their abilities to remember, reason, solve problems, and acquire new knowledge" (Bransford et al., 2000, p. 10). It is important to consider an MKO not as an instructor or "sage on a stage", but as a participant involved in actively guiding a learner through usable knowledge into practice. The term coaching is not synonymous with strict disciplinarian; it is more closely related to mentoring, as someone trusted that coaches, listens, and understands.

Scaffolding. The Zone of Proximal Development becomes more salient when discussing the concepts of scaffolding and fading. References to ZPD locate the zone between an axis of competence and challenge that an MKO uses to guide the learner to mastery. Collins et al. state "a key aspect of coaching is the provision of scaffolding, which is the support, in the form of reminders and help that the apprentice requires to approximate the execution of the entire composite of skills" (Collins et al., 1988, p. 3). One useful analogy is learning to ride a bike, the scaffolding is like training wheels.

Fading. The analogy of riding a bike holds true for fading, except unlike scaffolding, the learner has reached a level of mastery where the challenge has shifted, and the expert may remove the training wheels to progress to higher levels of competence. In other words, "once the learner has a grasp of the target skill, the master reduces his participation (fades) providing only limited hints, refinements, and feedback to the learner, who practices by successively approximating smooth execution of the whole skills" (Collins et al., 1988, p. 3). This level of

guidance and direction seems important, especially when it comes to intrinsic motivation and confidence.

Reflection. Collins et al. define reflection as "the process that underlies the ability of learners to compare their own performance, at both micro and macro levels, to the performance of an expert" (Collins et al., 1988, p. 4). Garcia, et al. state "it is essential that students be given opportunities to reflect on their own knowledge and performance, and compare them to those of other students and experts" (García-Cabrero et al., 2018, p. 826). The National Academy of Sciences recommends "the integration of metacognitive instruction with discipline-based learning can enhance student achievement and develop in students the ability to learn independently. It should be consciously incorporated into curriculum across disciplines and age levels" (Bransford et al., 2000, p. 21; NAS, 2018). Reflection expands formal curriculum to informal environments, "affinity spaces", domains, and communities of practice. Collins et al. continue to elaborate that reflection "involves enabling students to compare their own problem-solving processes with that of an expert, other students, and ultimately, an internal cognitive model of expertise" (Collins et al., 1988, p. 24). The benefits of reflection are metacognitive, which feed into other processes that facilitate learning, such as articulation.

Articulation. The articulation of knowledge is important for multiple reasons which support learning and the activity of learning. Collins et al. state that "articulation includes any method of getting students to articulate their knowledge, reasoning. or problem-solving process in a domain" (Collins et al., 1988, p. 23). The learner states what they already know, informing the MKO where pre-existing knowledge is and to what degree the learner understands. Cognitive Apprenticeship "refers to the fact that the focus of the learning-through-guided experience is on

cognitive and metacognitive, rather than on physical, skills and processes" (Collins et al., 1988, p. 5). The metacognitive role of articulation reinforces existing knowledge and identifies gaps in knowledge, placing self-control and regulation as a key component to mastery, not just of knowledge, but on learning. Garcia et al. explain that "students need opportunities to verbalize their understanding to consolidate and expand their mental representations" (García-Cabrero et al., 2018, p. 826). Articulation allows for the co-construction of knowledge between a community or network of MKO(s), challenging the learner further across domains and communities of practice. The role of reciprocal teaching is an excellent example of a method of practice that is used in the Learning Sciences program across most courses throughout the semester. This could be extended informally to other contexts, given the appropriate connections between learners and MKOs, peers, and communities formed through these networks. For example, a study group of peers formed through Slack where students who are motivated and available conduct tutoring and mentoring informally to support their formal curriculum and course objectives, co-constructing and reinforcing knowledge.

Exploration. The inspiration or motivation to explore can be greatly influenced by others, particularly MKOs, peers, and influencers. This guidance of exploration is defined as " a method of teaching involves setting general goals for students, but encouraging them to focus on particular subgoals of interest to them or even to revise the general goals as they come upon something more interesting to pursue" (Collins et al., 1988, p. 24). This is likely to resonate with anyone who has had a teacher or mentor nudge or push them to do something that made an impact on them. The idea of exploration can have meaning within a domain or body of knowledge, and also to extend out into other domains.

Exploring broadly and deeply may seem counterintuitive, as they appear to move in different directions, but being able to swim out to sea is similar to swimming down into the deep, and situations may call for the ability to do both. Arguably, swimming deep is more important and valuable, as a master has a deep understanding and ability for transfer of knowledge broadly. Collins, et al. remark the "difference between cognitive apprenticeship and traditional apprenticeship is the emphasis in cognitive apprenticeship on decontextualizing knowledge so that it can be used in many different settings. Traditional apprenticeship emphasizes teaching skills in the context of their use. We propose that cognitive apprenticeship should extend situated learning to diverse settings so that students learn how to apply their skills in different contexts" (1988, p. 6). This claim is supported by research from the National Academy of Sciences, which describes findings for effective transfer, "initial learning is necessary for transfer, and a considerable amount is known about the kinds of learning experiences that support transfer. Knowledge that is overly contextualized can reduce transfer; abstract representations of knowledge can help promote transfer. Transfer is best viewed as an active, dynamic process rather than a passive end-product of a particular set of learning experiences. All new learning involves transfer based on previous learning" (Bransford et al., 2000, p. 53). To play with the analogy, whether swimming out and deep, or hiking far and high, the Zone of Proximal Development is a continuously sought-after time and space that doesn't linger for long.

Authentic Tasks. The notion of situated learning is prominent in theory and practice for the method of Authentic Tasks. Collins et al. state that "a critical element for learning is that students are carrying out tasks and solving problems in an environment that reflects the multiple uses to which their knowledge will be put in the future" (Collins et al., 1988, p. 6). If this is the

case, in some ways, formal education is well-equipped to provide most of the elements. What social media and informal networking offer are entrances into a new form of learning and authenticity, primarily as legitimate peripheral participation. In the context of "The Knowledge Age" and "Knowledge Economy", for example, authentic learning is something that has been in virtual and online environments for quite some time and has been mentioned in the future of work (Bereiter & Scardamalia, 2006; Collins & Halverson, 2018). The construction and production of work in the future may well be done in virtual and online environments where Cognitive Apprenticeship will be well positioned with the support of mentorship that is accessible, flexible, iterative, scalable, relevant, and personalized.

HISTORICAL GROUNDING

In communities of practice, particularly the Learning Sciences, effective practices that can be characterized in relation to the theories and methods already described and further explained by Collins et al. (1988, pp. 28-30) are:

1. Situated Learning
2. Culture of expert practice
3. Intrinsic motivation
4. Exploiting collaboration
5. Exploiting competition

Group dynamics, communities of learning networks, and personal learning networks can be leveraged by students informally, given the productive mixture of interest, motivation, confidence, opportunity, and encouragement. Prior work in ethnography and participant co-design are helpful in research work. Making thinking visible in mediating processes, a design

researcher is “interested in designing artifacts that will support the activities of these communities” (Blomberg et al., 1993, p. 123). Using two contexts where learning CAM can be implemented and effectively measured in this study are Professional Learning Communities (PLCs) and Personal Learning Networks (PLNs).

Professional Learning Communities. “Professional learning communities have been embraced in the scholarship of teaching and learning, as well as in practice. PLCs help to understand how students learn and how educators can help them learn more effectively” (O’Byrne et al., 2021). The term “cognitive apprenticeship” is widely used yet there was limited research conducted that implements CAM in terms of professional learning communities or, more specifically, informal environments for mentorship with social media. However, there are insights from the research that ground the need for further research in this area.

Students who informally self-organize themselves may not be considered to be a professional community of practice. Therefore, for personal learning, a network study may be more suitable. With an educational influence and large community of educators in the Learning Sciences, PLCs may resonate with familiarity and experience for professional development. There are examples of proposed practical implementations of cognitive apprenticeship for personal or professional learning. An example of this is named similarly to CAM, the “Community of practice (CoP) apprenticeship model” (Khousa et al., 2015). The authors seek to enhance formal learning toward career preparation with social learning analytics to “augment formal schooling with the process of becoming a member of a mentored CoP that supports a successful career, immediately upon graduation. This process involves developing an identity as a member of a community” (p. 9). Another study looked at a professional development program

for teachers-in-training with online collaborative space and social media. The aims are consistent with mentorship aims of PLNs which aim for "use of the technologies always utilised the linguistic and practical skills of the participant, symbiotically in order to develop teachers of the future with a social network and way of learning" (Chandler, 2012, p. 8).

Professional development with technology expands the network, community, and accessibility for connections that a learner can build based on a problem or opportunity. Career preparation or professional development with CAM are slightly different in their aims, however, the amount of interest and engagement by participants can be judged similarly within a community of practice. For career preparation, participation is largely determined by choice. Professional development is sometimes mandatory, but if it is self-organized then choice would make it more consistent with CAM, as the mentor is more receptive to how to support the learner, without being in an officially formal capacity or obligation.

Personal Learning Networks. Richardson and Mancabelli describe a PLN as "unique, created and developed to our personal learning goals", (2011, p. 3). Having a sense of personal learning goals can be an important support for and influence on them, including projects associated with university graduate degree programs. These goals can be unique to students' identities previously explored and experienced by MKOs and experts in a community of practice. By building upon the collaborative learning and social interaction, personal interest extends to pathways unique to the learner and social identity toward legitimate peripheral participation beyond and unbounded to one community of practice, even enhancing professional learning opportunities (Oddone et al., 2019).

There is research that supports networking and collaboration where learning is improved when it is co-constructed and learning is deeper when participants interact socially and informally (Rienties & Tempelaar, 2018; Smirnov et al., 2018; Zhang et al., 2018). In an informal network, such as self-organized student study groups, collaboration is part of the learning process. Ensuring that the study is content-driven, the task of study can be focused with clear goals and outcomes. As for networking opportunities, Moore adds, "social media provides an increasingly viable platform for peer networking and mentoring" (2019, p. 6). A viable option does not mean that social media networking is desirable, however feasible.

Using social media as a context for networks, in a case study of K-12 teacher Twitter use, Pollard states that "many of the chat participants expressed that they find inspiration through their Twitter connections and others equate the relationships they have built through Twitter as coaching or mentoring" (Pollard, 2015, pp. 84-85). Two points from this statement are consistent with CAM, coaching and exploration, applying learning to diverse settings through social media and connections within it. In another research study, Twitter was found to be an opportunity for PLNs and cognitive apprenticeship, which the author describes how "teachers use Twitter to plan field trips, chat with industry professionals, connect classrooms, facilitate research, post supplementary materials, to engage students in the classroom, parents outside the school, and colleagues and administrators in networks they can design according to need and interest… Successful networks start with a vision, create trust and build consensus" (Fouchaux, 2013, p. 19). In medication education research, a study of surgeon mentoring finds that "social media brings a new dimension to mentorship, reinventing the way we communicate with others, such that interactions may be asynchronous and with individuals who are geographically remote. Our

study shows that social media serves as a valuable tool to enhance the networking and mentorship… Longitudinal studies surrounding the effectiveness of this emerging method of mentorship are warranted" (Luc et al., 2018, p. 759). The authors found that social media promotes learning outside of the classroom, improves knowledge and skills from engagement, collaboration, and feedback. In another study using design research conducted in a formal mentorship program found that "social media capabilities are able to facilitate mentorship activities, therefore while social media cannot independently transfer tacit knowledge, it is an effective mechanism in the tacit knowledge transfer process as it helps facilitate mentorship activities, which are best ways to transfer tacit knowledge" (Mahlangu, 2014, p. 100).

There is a lot of commonality and crossover between PLNs and PLCs. The difference seems to be that PLCs in my research are more structured toward more pedagogical contexts, such as teachers and educators, while PLCs are more like "affinity spaces" (Gee & Hayes, 2009). Career preparation and a network of experienced and knowledgeable mentors to guide learners is a valuable asset for communities of practice. Social media is a modality that is being explored although the barrier may be more of choice than of access. A support system that successfully utilizes social media will require design for participants to identify with and mentors who can engage with CAM principles.

From the extant literature, the conclusion is that social media can help learners connect with and engage mentors, and the space is underutilized. A sense of identity and membership that is inherent in CAM through communities of practice is complicated in technological terms and literacies, which are tough to find extensive research on methodologically and in practice.

CHAPTER 3

METHODS

Design-based Research is the standard methodology for the Learning Sciences. This study used Educational Design Research as a framework, based upon McKenney and Reeves (2012). Specific to DBR is the iterative approach and implementation of an intervention while conducting research. The high-level conjecture was interested in what Barab and Squire refer to as "a conception of design-based research that includes research on innovations in the context of systemic reform and that explores usability in terms of 'gaps' between the culture, capability, and policy/management structures" (Barab & Squire, 2004, pp. 11-12). The gap chosen here in this study looked to improve learning through informal communities of practice as legitimate peripheral participants. Culture relates to identity and membership in the Learning Sciences, as well as context, co-constructed by participants and designed for in this study. The method of cognitive apprenticeship, facilitated as CAM, invites members to collaborate on conjecture maps with participatory co-design in a community of practice toward artifacts that have meaning for the participants (Collins et al., 1988; Lave, 1991; Lave & Wenger, 1991; Sandoval, 2014). The structures that are represented in conjecture maps, or elements, are also components that illuminate and make visible context and content that allows participants, researchers, and the community to make sense of DBR and make design decisions with and for them.

PARTICIPANTS

Learning Sciences students from three separate master's degree cohorts, specifically the graduating classes of 2020, 2021, and 2022, were recruited to participate. Each annual cohort represents an additional year of experience and membership in the Learning Sciences. Students

often informally self-organize study groups to prepare for assignments, projects, and exams. This study was an effort for students to take advantage of knowledge and practice with conjecture maps (Sandoval, 2014), an authentic and valuable DBR tool with implications for future work. As a participant observer, the author employs ethnographic methods of mediating processes.

DESIGN

In accordance with the educational design research framework (McKenney & Reeves, 2012), this research was conducted over three phases, Analysis and Exploration, Design and Construction, and Evaluation and Reflection. Analysis and Exploration included the proposal and literature review. As an example of design-based research, this study uses design to bring about a new approach to learning and teaching in order to understand and improve it. The initial design guiding this study concentrates on "just in time" opportunities between time, mentor, and place or space. This place or space was to uncover social media usage as potential contexts where informal connections and mentorship could occur. The content was focused on conjecture mapping delivered with CAM (Figure 3).

The design further wanted to find out perceptions, attitudes, and beliefs from the learner's perspective to reveal information about mentorship, informal mentorship, and social media networks. The relevance of conjecture maps as content embodied situativity and authentic tasks to help frame the design around students' own High-Level Conjectures (Thesis Statement), Design Conjectures (Tools & Materials, Task Structures, Participant Structures, and Discourse Practices), Theoretical Conjectures and Mediating Processes (Observable Interactions and Participant Artifacts), and Outcomes (Sandoval, 2014). An example of the initial conjecture map for this study demonstrates how the study tool was designed (Figure 1).

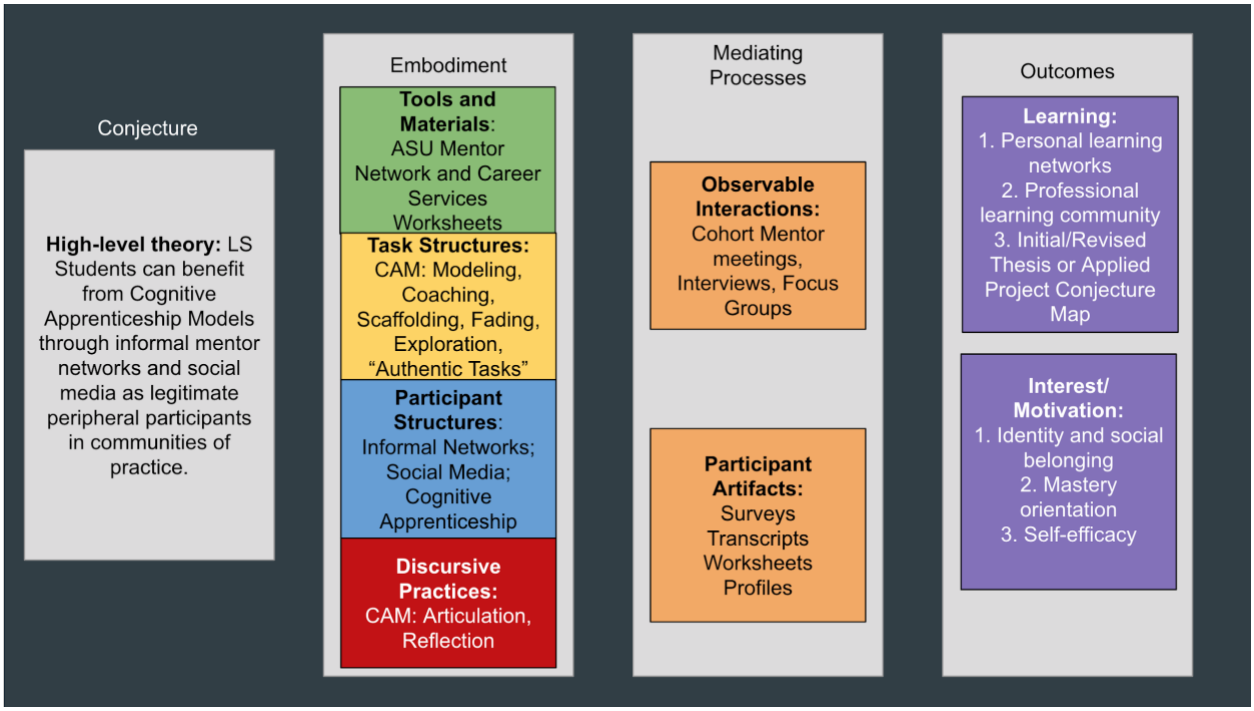

Figure 1. Initial Study Conjecture Map

The community of practice locally for students has a centrality and focus, where the design hopes to build expansively toward learner-centered opportunities at the periphery to new contexts (Engle et al., 2012). Context is the "Sphere of Influence" and the content is disciplinary, and interest based (Figure 2).

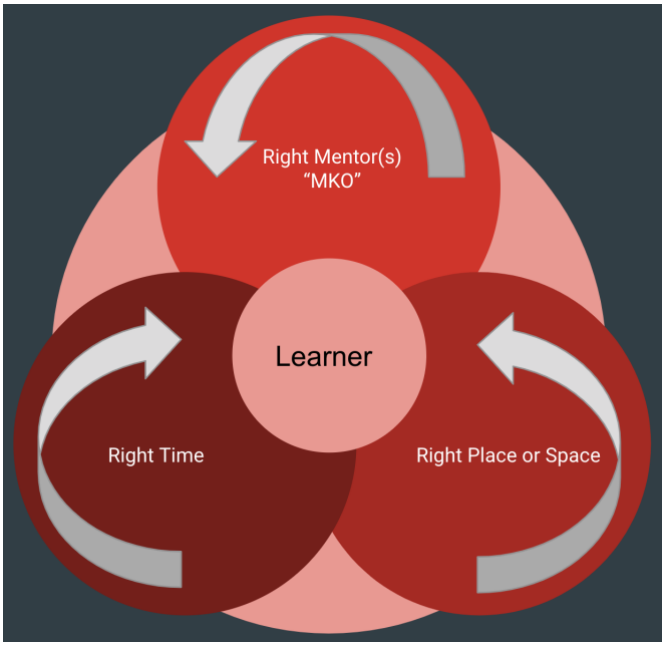

Figure 2. Design Sketch "Sphere of Influence" for Learner-centered Mentorship

Design and Construction included the proposal's design sketch and conjecture map. Key to this phase are the micro-cycles of design iteration to be implemented and analyzed for future iterations. The primary tools for iteration included a CAM Facilitator's Guide (Appendix H) designed for this study that went through each process from modeling to exploration. Resources in the form of presentation slides with example conjecture maps for scaffolding and templates for collaborative artifacts were distributed along with a "power introduction" tool to help with networking and connecting to prospective mentors/mentees (Appendices D and E). Among the other resources are a competency worksheet that can be used in conjunction with already established goals and objectives as opportunistic areas for development, and a "career story worksheet" which allows the students to self-author their story and encourage continued or improved self-regulated learning (Arizona State University, 2020; see Appendix E). As already stated, the Facilitator's Guide (see Appendix H) served as the iterative tool that was improved

upon from co-design to co-design with assistance from participant feedback and observation. Notes and changes were documented within the document itself after hand transcription to the digital file. To underscore the role of iteration, not only between studies, but within studies, Figures 13-15 in the results chapter and Appendix H depict the collaborative changes implemented with participatory co-design, where participants are modelled and scaffolded with CAM sequencing. A presurvey and postsurvey and interviews bookend the co-designs to evaluate for change in perceptions, attitudes, and beliefs. Evaluation and Reflection begins with the interviews of participants and ends on submission, with the goal of this research to inform theory and practice, into a "maturing intervention" and "theoretical understanding" (McKenney & Reeves, 2012).

MEASURES AND PROTOCOLS

To examine perceptions, attitudes, and beliefs related to informal mentorship and networking with social media, a survey, questionnaire, and interview protocol were developed to illuminate identity constructs, situated cognition, and emergence of mediating processes or outcomes not intentionally designed for.

Surveys and Questionnaires.

Surveys. For the survey, questions were designed to identify and later compare cohort, track, comfort level with conjecture mapping, whether the respondent identified as a mentor and/or mentee, how important mentorship is in the Learning Sciences and in pursuing personal, professional, and educational goals, what modalities of social media or otherwise respondents use to connect and communicate with mentors and mentees, whether they would like to see more mentorship opportunities. The survey was developed by familiarity with Likert scales and

assessments and intended to achieve descriptive measures for the existing systems and participant data. Cohort and track serve as independent variables, although for 1st year students, they have most of the first year to decide which track they want to take, thesis or applied project. Thesis does take more planning and preparation, as proposals are due before the 2nd year semester registrations begin. Conjecture mapping and having an idea of what to plan and prepare for could make a difference. Identifying as a mentor and/or mentee are compared with a yes/no/not sure answer option. The last survey measure is whether respondents would like to see more mentorship opportunities to determine any change and to what extent.

Questionnaire. A questionnaire was adapted from Godwin's "Identity Constructs" of recognition, interest, and performance/competence as an index for compared means for repeated measures of pre intervention (pretest) and post intervention (posttest) defined in Table 1 (Godwin, 2016).

Table 1. Identity Construct Factors for Paired Sample t-Test

Factor 1	Factor 2	Factor 3	Factors 1 and 3
Recognition	Interest	Performance/ Competence	Oblique
My family and friends outside of school circles see me as a Learning Scientist	I am interested in learning more about the Learning Sciences	I am confident that I can understand Learning Sciences theories in class	Others ask me for help in the Learning Sciences
My instructors see me as a Learning Scientist	I enjoy the Learning Sciences	I am confident that I can understand Learning Sciences theories outside of class	

My peers see me as a Learning Scientist	I find fulfillment in the Learning Sciences	I am confident that I can do well on exams or my career in the Learning Sciences
Others ask me for help in the Learning Sciences		I understand concepts I have studied in the Learning Sciences
		Others ask me for help in the Learning Sciences

[a] Oblique includes Recognition (Factor 1) and Performance/Competence (Factor 3) Indexes

Interview Protocol. Each participant who participated in a conjecture mapping co-design was asked to be interviewed with ten predetermined questions, aligned with research questions for coding and analysis based upon their perceptions, attitudes, and beliefs about the Learning Sciences, informal mentor networks, and the intervention activity of co-design with CAM and conjecture mapping (see Appendix B). Interviews were recorded over Zoom and transcribed for coding and content analysis.

Data Collection. This study involved multiple forms of data that were collected before, during, and after the design intervention described above. Pre-post surveys were administered within one week of the intervention. During the three co-design sessions, I captured audio and video recordings of social interaction and collected digital files of all participants artifacts including conjecture maps (see Appendix G). I also assumed the role of participant-observer in order to provide support when needed and to take field notes when possible. Between sessions, design features were revised in order to better realize design intentions. Finally, 8 students participated in 45 minutes to over an hour, semi-structured interviews following the completion

of the final co-design sessions. Table 1 disaggregates participation by cohort year and track (i.e., two-semester research thesis or one-semester applied project).

Table 2. Respondent and Participant Data

Group	*Data Collection Activity*				
	Presurvey	Co-design 1	Co-design 2	Co-design 3	Postsurvey
Cohort					
2020	1		1	1	2
2021	7	1	2	4	6
2022	3		1		2
Total	11	1	4	5	10
Track					
Thesis	3	1	3		4
Project	8		1	5	6
Total	11	1	4	5	10

Data Analysis. This section reports the analytical strategies utilized for the multiple forms of data in relation to the design conjecture. For ethnographic participant observation, the approach is "to interpret and give meaning to those activities", in natural, yet informal settings through observable actions and artifacts, and from a "members' point-of-view" (Blomberg et al., 1993, p. 125; Blomberg & Burrel, 2012, p. 1028). As "unobtrusive observer" through the co-design, facilitated by emergent mentors, peer mentorship, and shared discussion, descriptive analysis of qualitative and quantitative data (p. 1031). For interviews, transcripts were reviewed

using an adapted approach to content analysis in order to illuminate mediating processes for two primary measures: (a) explaining and feedback and (b) questioning, which provides descriptive verbal data (Chi, 1997; Zhang et al., 2018). Using a theory-driven coding system compatible with situated cognition, Greeno provides "levels" of situated cognition that is also applied to the codebook for analysis in Table 3 (DeCuir-Gunby et al., 2011; Greeno, 2011). The connection between the codes is rooted in cognitive descriptions of interaction that help make meaning about the participants and what is taking place. Greeno refers to explaining, however, Chi, and Roscoe and Chi have work specifically influential regarding peer tutoring and explaining (Roscoe & Chi, 2007; Roscoe & Chi, 2008).

Table 3. Codebook Adapted from Chi (1997), Greeno (2011, p. 42), and Zhang et al. (2018)

Code	Description	Defined
Level 1	Routine comprehension, conceptual understanding, problem solving, including performing procedures, search in problem spaces, reasoning, planning, skill acquisition	Conversational contributions, mutual attention, understanding propositions and reference
		Conceptual common ground, patterns of reasoning in practice
		Shared repertoire of schemata and procedures
		Negotiating different interpretations for mutual understanding
Level 2	Emergent understanding	Problematizing, resolving, and positioning in interaction
		Explaining
Level 3	Adopting tasks, expending effort toward accomplishing goals	Practices that encourage problematizing and resolving and that position students in disciplinary discourse with competence, authority, and accountability in participation structures

		Changes in discourse practice; legitimate peripheral participation
Level 4	Conceptual growth, commitment to learning goals, sustained, persistent participation in learning practices	Intellective identities regarding learning, academic learning, and learning in specific school subjects; positional identities in school and classrooms with mutual engagement and productive agency in relation to a community's joint enterprise of learning
Explaining	● Elaborated explanations ● Elaborated facts ● Theorizing topical terms only ● Unelaborated facts	
Questioning	● Explanation-seeking ● Fact-seeking ● Idea-deepening ● Initial wondering	

CHAPTER 4

RESULTS

INTRODUCTION.

The research conducted produced a large amount of video, audio, transcripts, artifacts, and results that indicate a high level of interest and research questions that were highly insightful. Research Question 1 presupposed social media use and modalities, as a non-finding indicates it is underutilized. Research Question 2 built off the previous question and was less effective because of how closely bonded it was to the first, although one student indicated a desire to start a Facebook group for Learning sciences Students. Research Question 3 provided the richest data set, grounded in identity and communities of practice in the Learning Sciences, consistent with the quantitative identity index for interest and significance in recognition. Research Question 4 was also insightful for identity as a mentor and supportive of recognition index. The rest of the chapter will go into greater detail by specific methods, tests, and measures.

FINDINGS.

Educational Design Research. The first significant finding, involving a mediating process, is how students feel regarding comfort levels with conjecture mapping (Table 4). How helpful the co-design was is mentioned repeatedly by students in the field notes and interview data (Table 10). The iteration from beginning to end with thesis co-design conjecture maps is "exploiting collaboration" as Collins et al. (1988) refers to as a principal for cognitive apprenticeship (pp 28-30; Figures 1, 10-13). Students gain usable knowledge in an authentic setting, although informal. This better prepares students for wrestling with Learning Sciences theory and practice with DBR and conjecture mapping.

An insight from conjecture mapping about recognition in a community of practice, relates directly to RQ 3, "How might identity play a role in Learning Sciences student communities of practice and mentorship?" Significance was found in the recognition of index, indicating how Learning Sciences students' perceptions of themselves as Learning Scientists as a positive outcome (Table 4). Table 9 demonstrates how often identity was coded, far outweighing other verbal data, descriptively important to recognition. A related example of conceptual growth with conjecture mapping is demonstrated in Table 8. The student says, "I will say that the more that I engage with them, the more comfortable I feel just kind of being comfortable with that ambiguousness. And working with that ambiguousness. And just letting myself kind of try it out. It definitely makes me feel a lot more comfortable with my project" (Table 8). Interestingly, the student mentions comfort with conjecture mapping and with their project. Greeno calls this level of legitimate participation "less focused on what we want learners to know and know how to do, and more sharply focused on what it is that we want learners to become and be" (2017, p. 46). The meaning of identity and membership is also complemented by the already high level of interest in the Learning Sciences (Figures 8 and 9). This finding contributes support to the theories of cognitive apprenticeship and legitimate peripheral participation through CAM and the value of conjecture mapping as a tool, but also a mediating process for conceptual growth.

Lastly, to refer back to the application of cognitive apprenticeship to different contexts, such as PLCs and PLNs, and social media, we can look at the use of Slack, but this is where the design failed from the initial conjecture. The use of social media did not change and was rarely mentioned in field notes, observations, or interviews. Zero respondents use social media to keep in touch with a mentor presurvey and changes slightly by one in the postsurvey. This may have

been an effect of the co-design, and if, by chance, it is a small one. Interviews did have more utterances, particularly in reference to Slack, so the option is still viable (Table 9). One student in an interview stated, “Oh yeah I like Slack”. Another student in an interview had an interest in Facebook, “I think it will be cool... we could have a Facebook group and then have like an email list or like a newsletter”. This student was interested in being comfortable with peers and “if you came don't worry about it it's informal let's talk about what we're doing let's talk about successes opportunities failures... I'm gonna get on that when I have time”. This shows interest and potential that perhaps can be explored in future iterations, or could be enacted without the need for research, but good practice. The design fell short of the initial intended design, but the contribution was still beneficial toward the support of a PLC or PLN, but perhaps more emergent self-organized study groups until a better design comes along (Chandler, 2012; O’Byrne et al., 2021). The question remains, whether CAM applied to informal mentor networks with social media can expand, deepen, and transfer knowledge.

Surveys. A primary focus of this study was to support CAM using social media. In spite of the analysis and exploration phase of educational design research, social media use as a modality for mentorship, or even contact with a mentor was low. Of the 13 respondents who took the survey, none had checked neither Facebook, LinkedIn, Instagram, nor ASU Mentor Network. One had responded with Facebook and Instagram for staying connected with a mentee. Based on low social media usage in the responses, the relationships participants have with professors and peers are closer recognized from a networking perspective.

The primary task within the CAM co-design is conjecture mapping, and the presurvey analysis showed an opportunity with a familiar and authentic task with relevant material. When

asked, “How comfortable are you with conjecture mapping?” (Figure 3), six of eight participants had increased their comfort rating. A repeated measures t-test was conducted on participants pretest to posttest “How comfortable are you with conjecture mapping?” responses. This test indicated significant change over time, t(7) = 2.99, p = 0.02; Cohen’s d = 1.30. This indicated that the mean posttest score (M = 1.38) was significantly higher than participants’ initial pretest score. Table 4 provides the means and standard deviations.

Table 4. Repeated Measures Paired Samples Summary by Test

Test	Pre Mean (SD)	Post Mean (SD)	t(7)	Sig. (p)	Effect (Cohen’s d)
How comfortable are you in conjecture mapping?	6.13 (1.55)	7.50 (0.76)	2.99	0.02*	1.30
How important is mentorship in the Learning Sciences?	4.13 (0.84)	4.5 (0.54)	1.43	0.20	0.74
How important is mentorship in pursuing your personal, professional, and educational goals?	4.38 (0.92)	4.50 (0.76)	1.00	0.35	0.35
Recognition Index	0.38 (0.74)	0.75 (0.56)	2.18	0.07	0.49
Interest Index	1.46 (0.43)	1.5 (0.47)	0.31	0.76	0.38
Competence/Performance Index	0.93 (0.59)	1.10 (0.43)	1.59	0.16	0.31
Oblique	0.60 (0.53)	0.87 (0.45)	3.26	0.01**	0.23

*$p < .1$, one-tailed t(7)= 2.183, p= 0.065, Cohen’s d= 0.486

**$p < .1$, one-tailed t(7)= 3.257, p= 0.014, Cohen’s d= 0.232

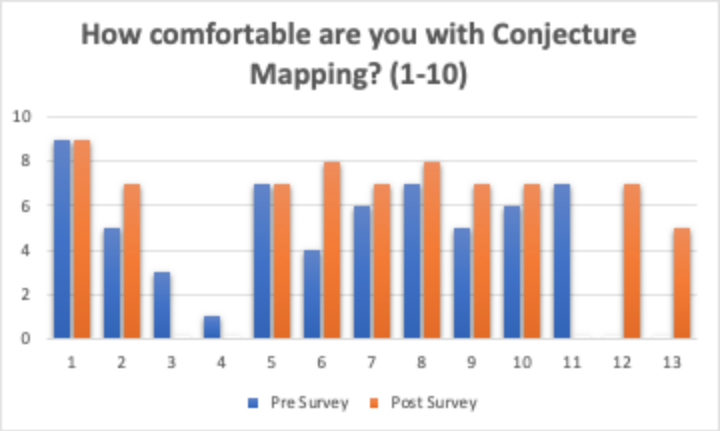

Figure 3. Comfort Level with Conjecture Mapping

The results on comfort level of conjecture mapping from presurvey and postsurvey in Figures 4 and 5 show a change that other analytics have not - a pattern visible in a small sample, but a clear perception change in students. This intervention was only a complement of what is taught and explained very well in formal program courses. This was an informal invitation to get more practice that contributed to participants and their confidence in an authentic task as legitimate peripheral participants.

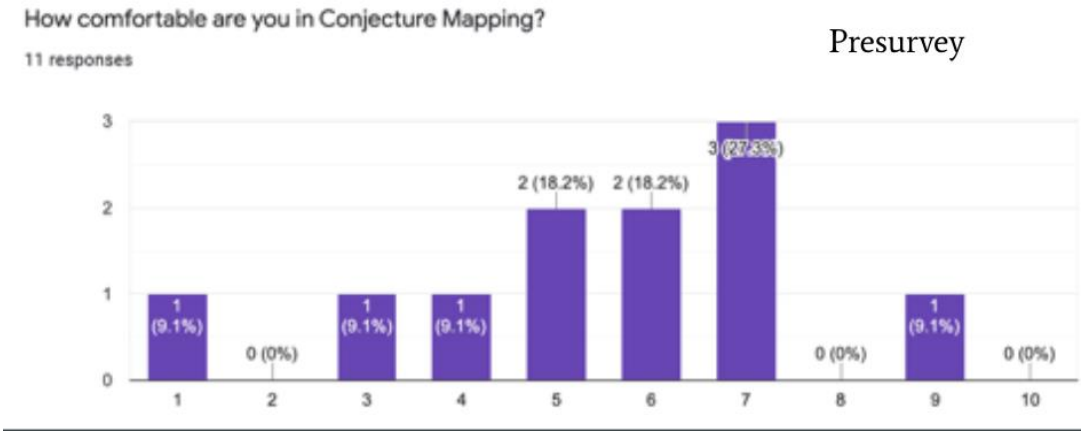

Figure 4. Presurvey Comfort Level with Conjecture Mapping

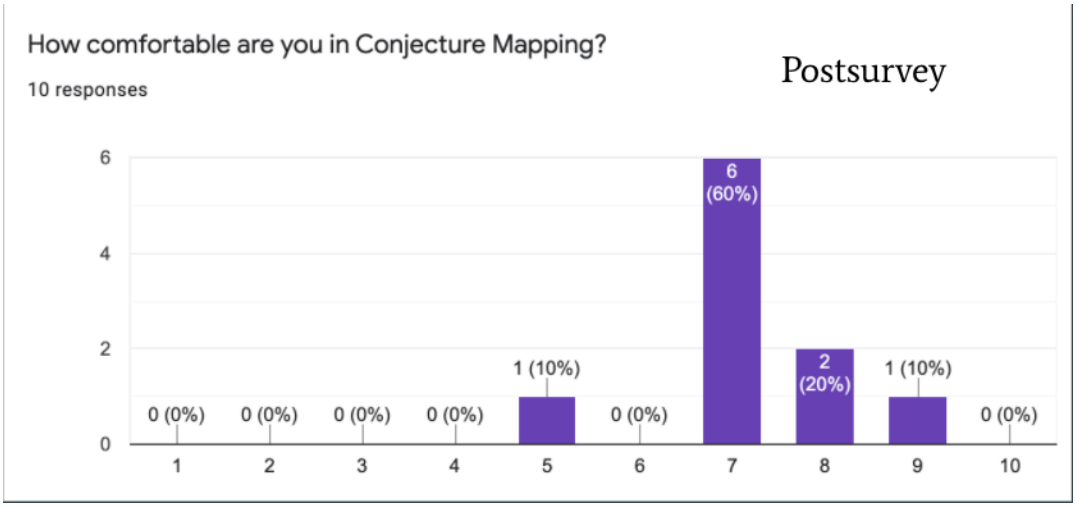

Figure 5. Postsurvey Comfort Level with Conjecture Mapping

When asked on a scale of 1-5, "How important is mentorship as a Learning Sciences Student?" (Figure 6), the lowest rating in both surveys was a 3. From Presurvey to Postsurvey, the number of 3 ratings went from four to one. All Co-design participants rated 4 or greater for this variable, three with no change, one going down from 5 to 4, and four increasing by a rating respectively. The importance for a mentor network with 9 of 13 participants is confirmed based on these results, increasing in the majority of participants from presurvey to postsurvey.

A repeated measures t-test was conducted on participants pretest to posttest "How important is mentorship as a Learning Sciences Student?" responses. This test indicated non-significant change between tests, $t(7) = 1.43$, $p = 0.20$; Cohen's $d = 0.74$. This indicated that the participants' mean posttest score ($M = 0.38$) was not different from participants' initial pretest score. Table 4 provides the means and standard deviations.

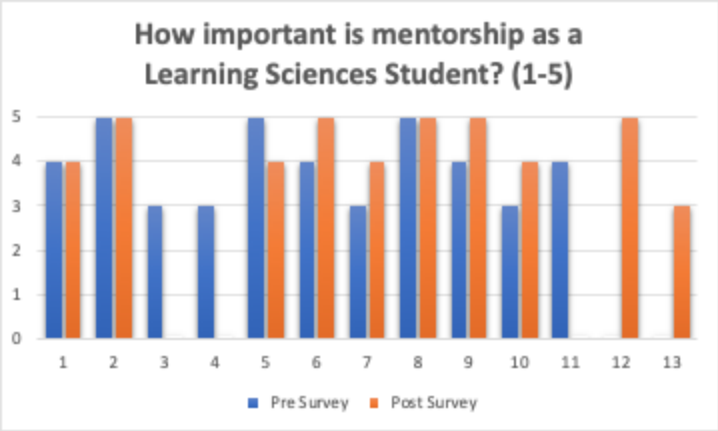

Figure 6. Importance of Mentorship in the Learning Sciences

Differentiating contexts from the Learning Sciences specifically, to broader goals in general, many respondents put the same or more importance on the latter. When asked on a scale of 1-5, "How important is, and/or was, mentorship in pursuing your personal, professional, and educational goals?" (Figure 7), the differences between Presurvey and Postsurvey are not as remarkable but indicate a high degree of importance to broader goals outside of the Learning Sciences. This probably has to do with the significance placed on "big picture" goals that encompass their formal education in the Learning Sciences and how it fits into the rest of their personal, professional, and educational goals. This also makes mentorship even more important in these cases.

A repeated measures t-test was conducted on participants pretest to posttest "How important is, and/or was, mentorship in pursuing your personal, professional, and educational goals?" responses. This test indicated non-significant change between tests, $t(7) = 1.00$, $p = 0.35$; Cohen's $d = 0.35$. This indicated that the participants' mean posttest score ($M = 0.13$) was not different from participants' initial pretest score. Table 4 provides the means and standard deviations.

Figure 7. Importance of Mentorship for Personal, Professional, and Educational Goals

The Likert scale for Identity Constructs seemed like a good opportunity to test whether there was an effect from the intervention, but when asked on a scale of 1-5 Likert scale for Identity Constructs, with only a slight shift in Confidence Index, but generally consistent patterns on the affirmative position (Figures 8 and 9). One thing to note is the recognition of "friends and family outside of school circles" straddling the Neutral position for both Presurvey (Figure 8) and Postsurvey (Figure 9). This may suggest a lack of familiarity with the field, as it is relatively young and not as popular as other professional disciplines, even within education. It does reflect an opportunity for continuing to build an identity as Learning Scientists, for Learning Scientists, and being active, engaged, participants, and sharing research with friends, families, and communities to influence positive change.

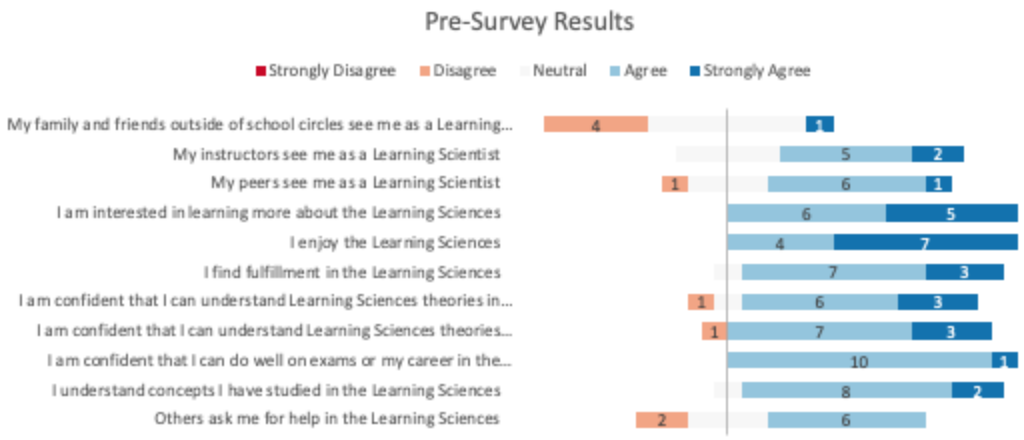

Figure 8. Presurvey Identity Constructs Likert Scale

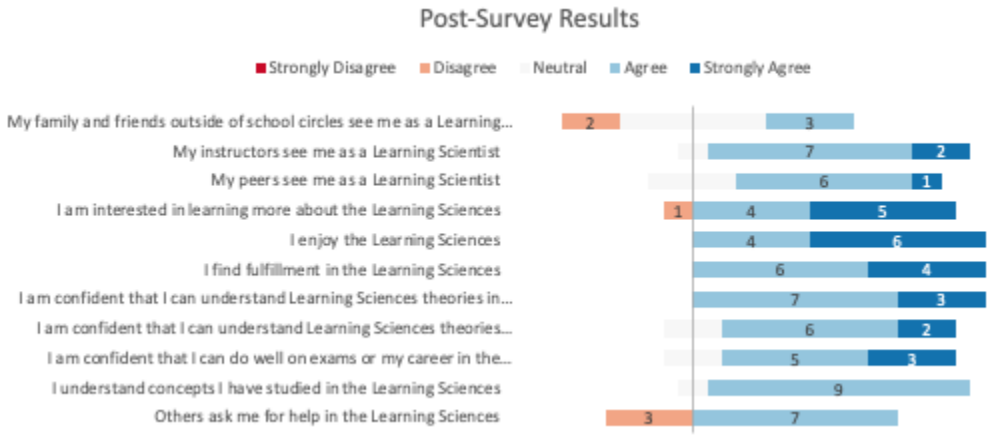

Figure 9. Postsurvey Identity Constructs Likert Scale

It was valuable implementing quantitative analysis methods, though not with the significance level hoped for, nonetheless, the results and method could be used in the future as an example. When compared using a Paired Sample t-test for Identity Constructs of "Interest", and "Confidence", the results are not significant for a difference that the intervention changed perceptions related to identity, which compares means of the averages for factors related to each index from Presurvey and Postsurvey (Table 4). The significant measure for Oblique applied to one question, "Others ask me for help in the Learning Sciences", has a recognition and

confidence factor calculated from the means. Results of the Paired Sample t-Test were calculated in SPSS.

The means for indexes is depicted in Figure 9. Recognition Index indicated a significant change between tests, $t(7)= 2.18$, $p= 0.07$, $d= 0.49$. This indicated that the participants' mean posttest score ($M=0.375$) was significantly higher than the participants' initial pretest score. Interest Index indicated a non-significant change between tests, $t(7)= 0.31$, $p= 0.76$, $d= 0.38$. This indicated that the participants' mean posttest score ($M=0.04$) was not different from the participants' initial pretest score. The Competence/Performance Index indicated a non-significant change between tests, $t(7)= 1.59$, $p= 0.16$, $d= 0.31$. Lastly, Oblique indicated a significant change between tests, $t(7)= 3.26$, $p= 0.01$, $d= 0.23$. This indicated that the participants' mean posttest score ($M=0.27$) was significantly higher than the participants' initial pretest score.

All factors for identity constructs increased, in order of significance recognition, performance/competence, and interest. The data for identity factors showing a high level of interest pretest and posttest could be an indicator of high interest in the field and program, and also respondent motivation. Students who chose not to participate may have had an impact on the testing, particularly in medium power results ($d < 0.5$) present in all factors, more so in performance/competence ($d = 0.3$). Considering the significant changes in comfort with conjecture mapping and identity factor of recognition, the role of identity seems to be correlated and perhaps the high level of interest is a causal process, addressing research questions 3 and 4. Highly engaged respondents and participants were the sample that provided data, but providing data does not mean that nonparticipants and non-findings are significantly different.

The last question for the survey was “Would you like to see more mentorship opportunities in the Learning Sciences?” with the majority from both tests responding “Yes”, a smaller percentage responding “Maybe”, and zero “No” responses (Table 5). In discussion, part of the intervention was providing resources for mentorship opportunities which are available but may be underutilized or not explored yet for some. The “takeaway artifacts” are equipped with these resources, in the hopes that they may be useful for others and shared with peers.

Table 5. Would You Like to See More Mentorship Opportunities in the Learning Sciences?

Answer	Presurvey	Postsurvey	Change
Yes	7	8	+1
	63%	80%	+17%
No	0	0	0
	0%	0%	0%
Maybe	4	2	-2
	36%	20%	-16%

Situated Cognition Codebook. The codebook developed from Greeno’s levels of cognition in activity was oriented toward situated cognition for the co-design sessions and later, the interviews with individual participants (Table 8, Table 9, Table 10, & Appendix H). The intervention was conducted over three iterative sessions, which took into account participant feedback and researcher field notes and observations through a Facilitator’s Guide (Appendix D). The first session had one participant, which resulted in a revised thesis conjecture map and co-design for future iterations, in which the participant was involved in a second iteration. The

second session had four participants, two of whom were working collaboratively on a seminar group project, resulting in a tentatively improvised template for future use and implementation. The second session was also the only session to have all three cohorts represented at one time. The final session had five participants, with four participants who were able to conduct a draft or revise a conjecture map for their Applied Project.

Table 6. Levels of Cognition

Co-design Session	Level 1 Achievement	Level 2 Achievement	Level 3 Achievement	Level 4 Achievement
	Routine Comprehension	Emergent Understanding	Adoption and Effort	Conceptual Growth/ LPP
Iteration 1	37	9	7	7
Iteration 2	28	6	3	0
Iteration 3	20	7	9	4

The most common code across measures for each co-design was explaining and feedback (Table 7). This is an important metric because it encompasses different levels of explaining, including elaborated feedback, unelaborated feedback, unelaborated facts, and topical terms only. The codes for explaining and questioning have potential for additional weighting, however, for this study method only frequency for each item was quantified (Zhang et al, 2018). Questioning was less than half of all utterances and excerpts. Noteworthy is the frequency of elaborated explanations which are similar to Roscoe and Chi's "reflective knowledge-building", which are "intermingled processes of knowledge construction and metacognition... that support tutor learning" (2008, p. 322). Collaborative learning allowed peers to exercise in engaged

learning activities surrounding content material and systemic processes at a high level intercontextually.

Table 7. Feedback and Questioning

Co-design	Explaining and Feedback	Questioning	Explanation-seeking	Fact-seeking	Idea-deepening	Initial Wondering
1	47	26	6	4	11	5
2	44	16	1	5	5	5
3	34	12	0	6	5	1
Totals	125[a]	54	7	15	21	11

[a] 76 elaborated explanations, or 61% of all explaining and feedback utterances

Table 8. Codebook Examples

Code	Description	Example
Level 1	Routine comprehension, conceptual understanding, problem solving, including performing procedures, search in problem spaces, reasoning, planning, skill acquisition	"And just to clarify, you said that in my breakout room, I can just continue working on mine, I guess in combination with... Okay, cool"
Level 2	Emergent understanding	"Yeah, I agree the more I do this the more I mean there's so many nuances but it's also it really you know seeing other peoples' research through these tools really, really provides insights that are sometimes hard to follow even in a narrative"
Level 3	Adopting tasks, expending effort toward accomplishing goals	"This is the first time and, this is, this is partially why, a big reason why, I wanted to come because I figured it'd help me kind of formulate this, but now we're just doing it. So that's even better"

Level 4	Conceptual growth, commitment to learning goals, sustained, persistent participation in learning practices	"I will say that the more that I engage with them, the more comfortable I feel just kind of being comfortable with that ambiguousness. And working with that ambiguousness. And just letting myself kind of try it out. It definitely makes me feel a lot more comfortable with my project"
Explaining	● Elaborated explanations ● Elaborated facts ● Theorizing topical terms only ● Unelaborated facts	"Well, that's it's an interesting question, because it kind of kind of underlies the fact that every environment is out of our control, right. There's no environment that 100% control. And so, when you think about doing a conjecture map in a learning environment in which things are constantly shaping and shifting, then getting that multitudinous sense of perspective and shift is important. But you also have to remember that a conjecture map is a point of view, right? You're conjecturing that something is going to cause something else. If I, if I have cooking classes for my students, it will increase engagement, which will cause them to turn in more homework. Right? And so that conjecture then is shaped and formed by the context that you talked about in the embodiments. And in the mediating processes. You've got your beginning and ending, but you have a reason why you think something's going to happen. And that's where you back it up. Like Latour would say, you back it up with your research and everybody else's citations."
Questioning	● Explanation-seeking ● Fact-seeking ● Idea-deepening ● Initial wondering	"OK it seems like for us it was the same thing. Co-designing 'cause we talked through my conjecture I mean my thesis and didn't change it, does that sound right to you? Tell me which part was co-design? I feel like we did the conjecture mapping together which has been excellent and helpful but since we were already dealing with a design that I've created did we do a co-design or what part counts is co-design?"

Interviews. The focused interviews were coded based on social media, identity, and informal networks to triangulate toward research question alignment and relevance (Table 9). The pivot toward a community of practice and the importance of identity became more evident through iteration, but the interviews being conducted following the final co-design reinforce the degree of discourse focused on it. The support for peer tutoring and informal mentorships is exhibited in the coding of co-design also, where systems and structures play an important role. One participant added "When you touch a piece of knowledge or when you, you know receive a piece of knowledge is part of relationships' push-pull, give-get, and so, in a way, going to the study groups is actually mentoring me in, you know, what are the kinds of problems that people are facing what are people thinking about what's this community relationship". Positioning and authority relate to identity and structures, as one student puts it, "I don't know if I would really think about that experience in terms of myself being a mentor more of myself being a mentee perhaps, but maybe that's a better positioning right maybe that's more of like a 'we're all here to learn from each other'". Participant co-design and CAM have a strong influence on situated cognition and resonate frequently in the analysis.

Table 9. Interview Identity and Informal Network Coding

Interview	Social Media	Mentor Networks	Identity	Systems Structures
J10	0	2	13	8
I9	0	0	14	4
H8	0	0	18	13
G7	0	4	22	8
F6	1	1	10	13

E5	5	7	10	6
B2	2	0	11	12
A1	2	4	8	5
Totals	10[a]	18	106	69

Note. Participant IDs are listed under the interview column for all 8 participants. Survey respondents were not interviewed and did not participate in co-design.

[a] 6 of 10 Social Media references were attributed to Slack. Slack was mentioned by 4 participants separately. LinkedIn was mentioned once by one participant and Facebook was mentioned three times by another.

Table 10. Interview Question Analysis with Examples

Question	Level	Construct(s)	Example
How did the study group change your perceptions of the Learning Sciences?	4	Recognition	"It enacted it, what I haven't experienced yet which is this group of people coming together doing collaborative research collaborative design… I'd heard of and read through the literature, but I actually experienced it and I was actually a part of it, so it made the Learning Sciences real to me."
How did the study group change your perceptions of mentorship?	4	Recognition	"When you touch a piece of knowledge or when you... receive a piece of knowledge is part of relationships' push-pull, give-get, and so, in a way, going to the study groups is actually mentoring me… what are the kinds of problems that people are facing, what are people thinking about, what's this community relationship"
How did the study group change your perceptions and behaviors with networking?	4	Confidence	"Before the group that we did, I saw networking as people who I directly interact with. I see them in a close network, and I feel comfortable with them… I didn't really think think of it as people that I can interact with I thought of them

			as networks of other persons that I could be affiliated with by being affiliated with someone in my network, but I guess in summary, it expanded my network and allows me to think of anybody in that system to be someone I can communicate with and work with and… gain mentorship from… it brought awareness to how substantial my network actually is, and it built confidence for reaching out too… I perceive my network as in two levels, and so… it provided and built confidence with reaching out to my second level network persons"
Do you see any benefits to building a mentor network?	3	Recognition Competence	"Having more people like different people to reach out to that you feel comfortable like asking for their help, or their advice, or just like, even to just talk about talk through some things. I think it's great"
Do you see any risks to building a mentor network?	3	Recognition Competence	"When you think about a mentor network, you also have to think about the the match of, generally thinking about resources and the resources that people have, including their time, their expertise, and their humanity in a way, one of the other problems with mentoring networks is that if you come up with a mentor is a really successful person. That can lead to the idea that they've always been successful and so transparency in failure is another really important part of a mentor network and mentor relationship"
How might you use the study group as a way of becoming a Learning Scientist?	4	Recognition Interest	"I think anytime you study, something that is central to the Learning Sciences like conjecture maps and you're studying it with people who are also interested in doing Learning Sciences, then I think that increases your identity as a Learning Scientist"
Is there something you really liked about the study group?	4	Recognition	"I really liked that we were all in the same, we're all working kind of on the same project and in the same course, so we were all able to like, use our own applied projects and actually work through real things that we needed to work through. Like, it wasn't a scenario, is really,

			really real, meaningful work. I think on all sides”
Is there something you didn’t really like about the study group?	4	Interest	“If I'm being honest, the only thing I didn't like was that our time was limited, because I think just maybe, just who we are, but we like to talk and talk and like, not just talk about talking about what we're doing you know, like the fact that we just had to limit it because, like you're collecting information and data and stuff it's like we can't just like drag it on you'll have hours and hours to parse through. But I think if we had more time, we might have had more… things could have gone better too. I don't know, but again everybody's got different schedules, too, so. But if we ever had like a very long time to talk about things I wouldn't mind”
How might students improve the study group in the future?	4	Interest	“You were in there with us and kept us very well on, like time you know, going through an appropriate time which I appreciated. Just from experience with getting together in groups in general, that does not always happen. So, making sure that that continues to happen would be good”
Will this experience make you a better mentor or mentee in the Learning Sciences or in general? How and why?	4	Recognition Interest	“I don't know if I would really think about that experience in terms of myself being a mentor more of myself being a mentee perhaps but maybe that's a better positioning right maybe that's more of like a we're all here to learn from each other”

The second iteration development of the conjecture map for the study had done away with the original tools and materials as part of a design conjecture for embodiment, as well as the social media participant structure (Figure 10).

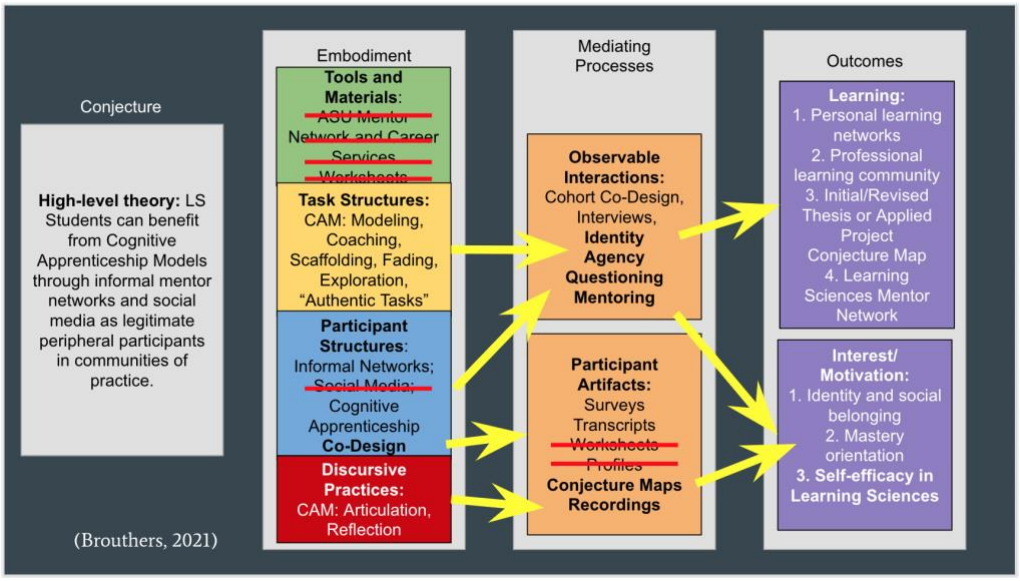

Figure 10. Conjecture Map 2 Iteration 2

Iteration 3 has revisions to tools and materials, the Facilitator's Guide and "takeaway items" which were already in use but codified in a better depiction of the study's enactment. (Figure 11).

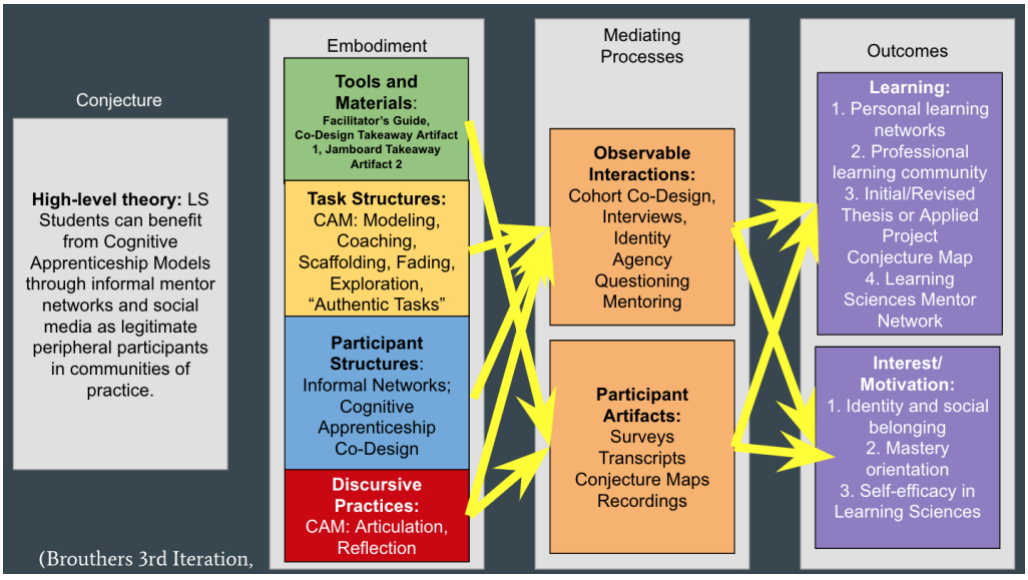

Figure 11. Conjecture Map 3 Iteration 3

The final version of the study's conjecture map better depicts outcomes in terms of the codebook and coding system, as well as the identity constructs being used for analysis (Figure 12).

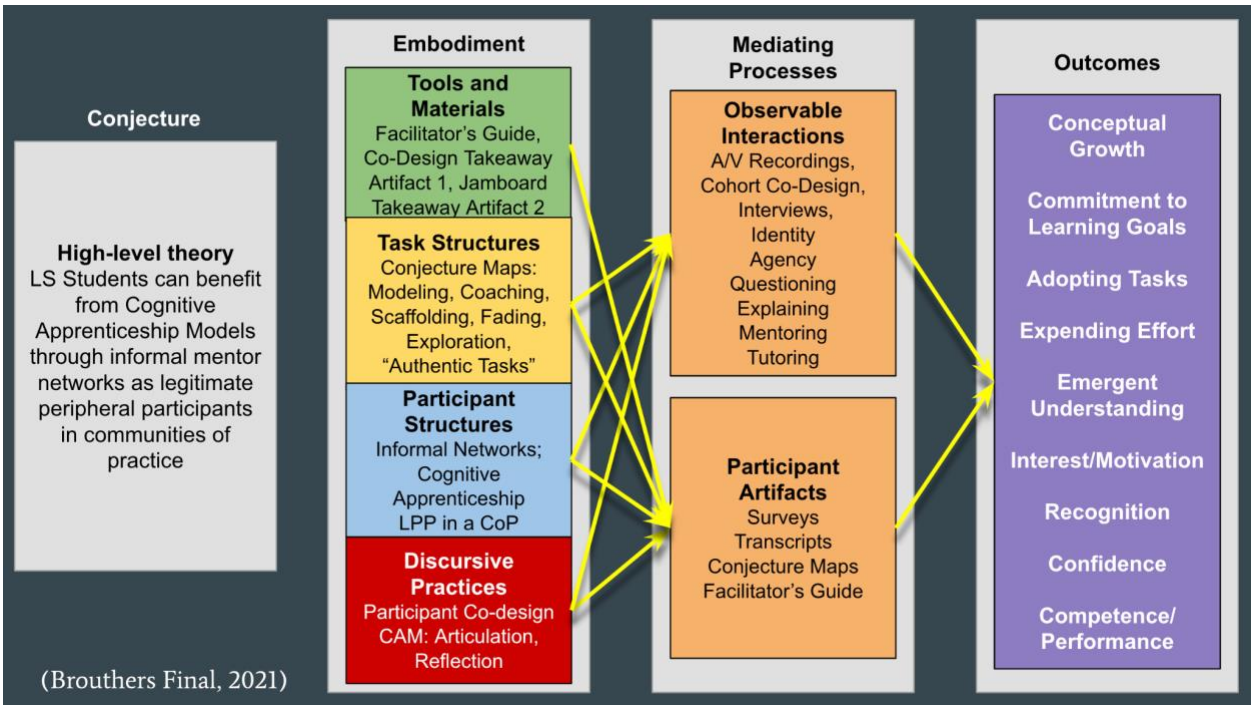

Figure 12. Conjecture Map Final

Looking at interview data, survey results, content analysis of conjecture maps, what wasn't displayed in the co-design coding is better explained in the embodiment and for expending effort and conceptual growth with legitimate peripheral participation. For a first-year student to go from a 4 to an 8 in comfort level with conjecture mapping, express Level 4 legitimate peripheral participation in an interview, then demonstrate it with a collaborative conjecture map for conceptual change and application in a community of practice demonstrates the promise of study groups or informal mentor networks with cognitive apprenticeship. When asked "How did the study group change your perceptions of the Learning Sciences?", one

student responded, “It enacted what I haven't experienced yet which is this group of people coming together doing collaborative research collaborative design, even in the initial stages that I'd heard of and read through the literature, but I actually experienced it and I was actually a part of it, so it made the Learning Sciences real to me” (Table 10). This was Legitimate Peripheral Participation, where theory and practice were connected and enacted, grounded in formal classroom settings, enacted and embodied in an informal environment, though we could argue that a recorded study somewhat formalizes the situation. As a comparison artifact for content to further illustrate this conceptual change and expended effort, a conjecture map was shared that was used in Seminar collaboratory with other students, one of which made the suggestion that we use their group agenda as a case for an example in Co-design Session 2 (Figures 13 and 14).

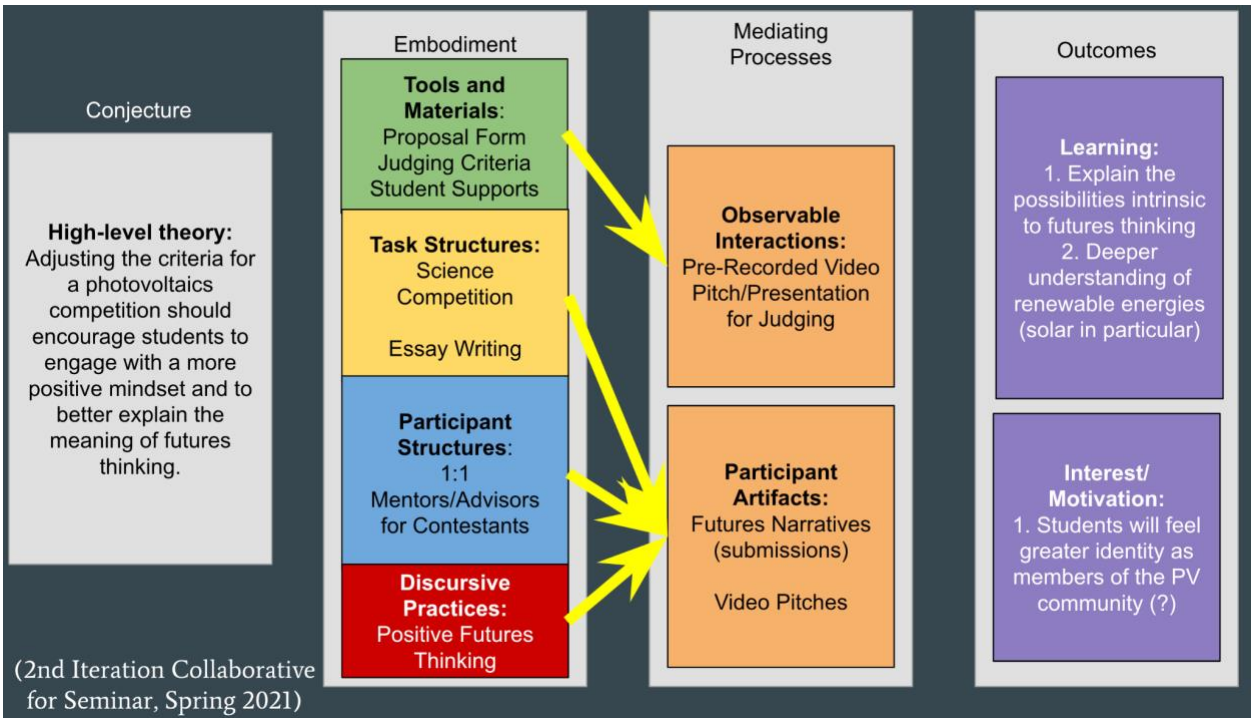

Figure 13. Co-Design Session 2 Collaborative Coaching and Scaffolding

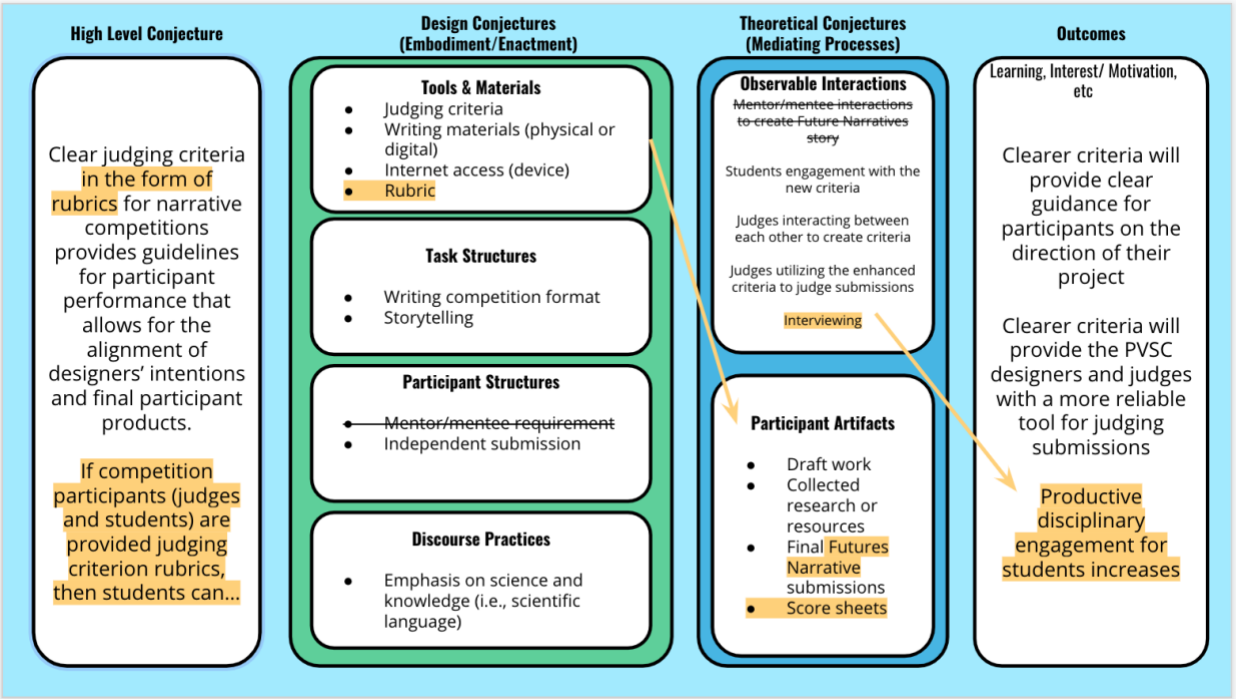

Figure 14. Co-design Session 2 Level 3 and Level 4 Artifact

One final item that was taken into comparison, unlike paired samples, are participants to respondents, cohorts, and tracks. For comparison of averages, this table will not show statistical significance, but changes in averages with calculations for basic points across independent variables (Table 11). From the changes in average, the groups that benefited most by points were 2022 cohort and thesis track. Given the amount of time and experience with the content and working within the context as Learning Scientists, the analysis makes sense. Thesis and project tracks have small changes and little difference by points. The expectation for knowledge in theory and practice is the same for both tracks.

Table 11. Respondent vs. Participant Comfort with Conjecture Mapping by Cohort and Track

Cohort	Presurvey	n	Postsurvey	n	Change
All Respondents					

2020	9	1	8	2	-1.0
2021	6.1	7	7.2	6	1.0
2022	2.7	3	6.5	2	3.8
Only Participants					
2020	9	1	9	1	0.0
2021	6.0	6	7.5	6	1.5
2022	4.0	1	8	1	4.0

Track	Presurvey	n	Postsurvey	n	Change
All Respondents					
Project	5.4	8	7	6	1.6
Thesis	5.7	3	7.5	4	1.8
Only Participants					
Project	6.4	5	7.4	5	1.0
Thesis	5.7	3	7.7	3	2.0

Participant Observation. The iterative and participatory nature of the study was important for evolving from a social media context with online presence and exploration, to a focused student group that was closer to a community of practice that students were comfortable with. From the first iteration, field notes were difficult, as it was one to one, with one participant, but it was helpful in that the co-design improved the Facilitator's Guide. A good example of explaining and metacognitive reflection, gaps in the guide were made visible in the enactment is

in Appendix H and Figure 13. At this point, co-design had identified the design conjectures shift from social media oriented tools to the Facilitator's Guide and collaborative artifacts embedded in the presentation. The identity constructs and situated cognition played a more significant role than the original design goal of expanding out into communities of interest with ASU Mentor Network profiles and worksheets from Career and Professional Development Services. Further observations were made in the usefulness of CAM and conjecture mapping. Exploration into PLC and PLN resources and references, courtesy of ASU Graduate College and Career and Professional Development Services for informal mentorship (Arizona State University, 2020). The resources were there and provided as "takeaway items" through shared Google Slides and Jamboard. The time for exploration was reduced to make more time for collaborative activities after the first and second iterations (Appendix H). According to field notes, "second iteration went long, adjusted to group and opportunity" and one student remarking, "I don't think I'm great at doing it, but I love it". There is recognition and performance/competence in this statement. There is both commitment to learning goals and interest, on one hand, and a humble performance/competence. This particular student made a level 4 leap in conceptual growth with the conjecture map (Figure 17). Students' interest is and was already in the Learning Sciences. Conjecture mapping resonated and participant co-design was important to increasing student recognition from peers toward membership in a community of practice. Participant interest in the Learning Sciences is the highest among identity constructs and indexes, and mentorship is something that most students place a high importance on, more so for personal, professional, and broader educational goals. The initial proposal for informal mentorship with social media had an intended methodology that could use social network analysis to understand the existing systems

students used and potential insights and impacts on those systems. It was discovered early on that social media had low usage for mentorship which didn't change over the course of the study. One observation that was repeated over and over was that the intervention was helpful, and the participant co-design, being multigenerational, was demonstrative of peer mentoring. Design-based research and iterative participant co-design allowed for the study to focus on identity within a community of practice, and potential for structures and systems of mentorship and informal networks to better understand why some resources might be underutilized.

LIMITATIONS

Methods. The method and coding used would be stronger with Inter-Rater Reliability. There was systematic coding of data, but it would be interesting to see the similarities and differences in comparisons with other researchers (Collins et al., 2004, p. 40). Interrogation using this coding system and how it might change and improve through rigorous critique and implementation of multiple users would refine the descriptive quality and perhaps change the findings and analysis from them.

One failure was that the methodology for the intended research of informal mentor networks was disproportionately angled toward social media. In the initial stages for exploration and analysis, some of the signs of a mismatch in literature review might have hinted towards a better initial design and construction. The research questions could have been altered early on to account for the changes in early iterations, though may not have changed early enough for more thorough research methods. The urge to do more was a constraint to smaller more focused research and caused a considerable amount of work to adjust, taking time away from later stages in the research process for ongoing review and adjustment of methods.

Data. Having more participants could have changed the results and confidence ratings. When it began, there was some concern that there could be limited size for collection. Interest in the study was high enough, that a baseline was reached and could be repeated with a larger sample to test results for theory and practice. The worksheets in Appendix H and resources were not provided a process or time to know whether they were useful to any of the participants.

CHAPTER 5

DISCUSSION AND CONCLUSIONS

DISCUSSION

Referring back to the literature review, social media can help learners connect with and engage mentors. Most people use social media, and some use it for mentorship with desirable outcomes. This study did not reach a point or result in much for findings related to the first research question. Apparent from the presurvey, the space is underutilized for ASU Learning Sciences students, however, the survey missed one social media platform, Slack. Through interviews, Slack did come up and is noted in Table 9. This study was not prepared or interested in collecting data from Slack, but through interviews, questions could have highlighted many insights from students directly from what they wanted to share. Slack is not underutilized, but to what extent was not analyzed, but there could be an opportunity to conduct a less complicated study from participants related to peer mentoring and social media. Building off the results of this study, another iteration could be conducted with a better design prepared and focused in advance.

All participants had a conjecture map considered useful by the members who provided them. The identity of the participants and that of the group was shared, reciprocal, and appreciated with recognition for those considered "mentors" from current and previous courses, but also from those considered to be in a position to mentor themselves by being present, supportive, and encouraging. Being a part of the community of practice was beneficial, whether from a questioning standpoint or an explaining perspective, engaging in the exchange was constructive. Learning about others' research interests, conjectures, and elements of their

conjecture maps was an activity that provided relational agency and productive disciplinary engagement (Engle & Conant, 2002).

An informal setting with recognized peers who see each other as Learning Scientists conducting authentic tasks, questioning and explaining collaboratively is an opportunity that supports MKOs and content knowledge for co-construction (Roscoe & Chi, 2007; Roscoe & Chi, 2008) . The benefits of peer tutoring have been shown to improve outcomes when performed with elaborated explanations, a strong reason for continuing the practice as students to self-organize into study groups and pursue content in different contexts with multigenerational peers. A trajectory toward exposure to learning opportunities and social contexts was a likely contributor to the conceptual growth and legitimate peripheral participation.

Research Question 1: What are Learning Sciences students' experiences with social media platforms to create informal mentorship learning opportunities during the application and acceptance process, during graduate studies, and/or post-graduation? Few students initially recognized that social media was an option, and one mentioned Facebook as having potential for future use and with intention. A few students were receptive to the idea of ASU Mentor Network, but what was a primary focus initially, became an opportunity for exploration with CAM. Most students are interested in personal connections and meaningful relationships. Considering COVID-19 Pandemic, in-person relationships have been changed for the foreseeable future, but the desire has probably only grown. Virtual and online opportunities have been there, yet it is yet to be seen whether the adoption will increase out of will or necessity.

Research Question 2: How have these experiences influenced their personal and professional goals? This is not entirely moot, based on the previous overarching question, yet what was discovered were examples of mentorship in general, as well as communication through Slack, which is a tool that is often used between cohorts and courses for a variety of purposes. Slack has emerged as a great connection tool which offers opportunities to share insights and interests, as well as ask questions and provide feedback. Staying connected to an active exchange of past, present, and future allows all members to participate as members in the Learning Sciences community of practice under various themes and channels, including "Random". Data from Slack is beyond the scope of this research. What was mentioned in interviews was that informal mentor networks are usually formed through personal connections with people they already know and trust. Most are reluctant to "connect" with a stranger.

Research Question 3: How might identity play a role in LS student communities of practice and mentorship? Membership in a community of practice makes a big difference, as evidenced by the strong agreement in presurvey and postsurvey comparisons. The agency is already there for Learning Sciences students. What was not as obvious or recognized, was the significance and appreciation for the ambiguous and roles of mentor and mentee, which are not designated or appointed, but interchanging and fluctuating, informally in interaction. As members in a community of practice, peers can and should play both roles. One identity inhibitor that was mentioned by a few participants was impostor syndrome. The amount of support and encouragement, carried over from professors and the culture, do well formally and are part of the community of practice, in the field of Learning Sciences, but also the University and program specifically. It is the hope of this study to support identity and its constructs, to make expansive

framing and exploration possible for all students. This was the richest of research questions from a data and findings perspective. Between PLCs and PLNs, members as a community of practice are key. Learners need to identify, connect, and be recognized as legitimate peripheral participants who have agency.

Research Question 4: What are the key systems and structures in informal learning and mentoring networks? Similar to the previous question, the keys were related to the theory and methods, and from those found that context, activity, identity, and content, per the analysis already mentioned. Two structures introduced in this thesis were CAM and conjecture mapping. Participant co-design is closely aligned with CAM, as a participant structure, the positioning helps participants progress from the periphery to the ZPD, in a community of practice. The co-design was helpful for students, but the key system is what exists in the Learning Sciences program at ASU, and perhaps central to that system is the university itself and the field of Learning Sciences. The intermingling of communities, contexts, and cultures of learning are inextricably linked. The principles of CAM and situated cognition are sewn together for members of these communities, connecting students with faculty, researchers, and educators. Students self-organizing and putting theory to practice and practice to theory is consistent with DBR. Equating a study group to a PLC or PLN only goes so far. Exploring these opportunities is something that is where CAM fosters expanding, deepening, and transfer of knowledge.

Time. Time was one of the most recurring themes in the interviews and in the articulations of each co-design. Participants wanted more time with the activity over a longer period of time. This has led to more self-organizations of study groups on the topic (Level 3 and 4). This isn't the first time a study group was self-organized, but the framework may have been a

productive option, or at least a facilitating tool for scaffolding. Time also came up as a risk or concern that students had in a mentor relationship. Feeling burdened or responsible for not wasting the time of someone else, faculty and advisors particularly. A peer-to-peer mentor network or study group helps students wrestle with a topic and gain multiple perspectives before presenting to a formal mentor. Most formal mentors may be aware of this perception already and mitigate it by being open, accessible, and inviting, but the identity and influence of previous experiences or culture may still be difficult to navigate.

Future Research. Building on the limitations with data and theorizing with practice about context, it would be interesting to see Social Network Analysis applied to answer the following questions in a study (de Laat et al., 2007):

- Who learns from whom?
- What do they learn from each other?
- What kind of interaction happens between learners?
- Which direction do resources flow?
- How frequently do interactions happen?

Local Context. The program and existing design within the program, between administration, faculty, and students, allows for emergence and is designed with agency with and for a community of learners and community partners in education and innovation. Study groups will always exist. Formalizing study groups was not the goal of this study, improving attitudes, perceptions and beliefs was, but the program already does an outstanding job with that. The pivot was in addressing recognition and confidence in members of the community of practice to perform authentic tasks as professed in coursework as legitimate peripheral participants. Going

forward, students will continue to self-organize around the demands and desires of their prerogative. It would be interesting to see whether cognitive apprenticeship models are implemented and improved, but conjecture mapping is indeed a focus that should persist. Future surveys can take into account more design-related ideas in advance, and more time, if not per session, definitely over a span longer than one or two weeks and with more than 3 sessions.

CONCLUSION

The purpose of this research is to help Learning Sciences students and improve ways of learning in informal environments while advancing theory and practice to contribute something meaningful to the field and its participants, in essence, the community as a whole. Social media is influential, but not when it comes to mentorship. Students want personal connections and relationships that have meaning. Students often self-organize into study groups. The Cognitive Apprenticeship Model provides a framework for accomplishing the tasks, skills, and content areas for conceptual growth, emergent understanding, adoption and effort, along with routine comprehension and problem-solving, but for situated learning with deeper understanding as legitimate peripheral participants in a community of practice.

Mentorship is a co-design. In “traditional” mentorships, not unlike traditional apprenticeships, there is a relationship where both parties have some agreed upon terms or expectations, but the choice of role models and mentors is often done by the mentee. In some cases, a “mentor” may see a mentee as needing some guidance and make a decision to intervene or establish a relationship. In informal mentor networks, particularly in a study group, the participants choose whether or not they want to be involved or engaged, and they choose the content, whether what is interesting, important, applicable, and accessible. Opportunities do

exist, and it takes a nudge or an invitation sometimes. The relationship and equitable practice make it meaningful, supporting and encouraging confidence, recognition, and interest for all learners and levels, by meeting them where they are.

For the Learning Sciences Program at ASU, there is an incredible amount of interest among students, past and present. The program should continue to develop mentorship opportunities locally and conduct research that advances theory and practice with legitimate peripheral participation. It is clear that conjecture mapping will be relevant content and the mentorship opportunities exist, and students should co-create them, in addition to share the opportunities and resources that already exist. Slack could be the main platform or modality for social media-like mentorship. Others like ASU Mentor Network could become valuable alternatives to some students. For the field of Learning Sciences, LinkedIn and Twitter seem to have the most potential for social media informal mentor networks, be it PLCs or PLNs, a community of practice with legitimate peripheral participants who are interested and identify as members can learn from each other in meaningful ways. Conjecture mapping and exposure to contrasting cases and examples could be one of the more helpful artifacts for critique and sharing with and for the community.

Social media is a great way to boost membership and engage with participants. Spreading knowledge and experience through local resources or events such as Talking About Design, Grad Webinars, Shaping EDU, or larger events like the International Conference of the Learning Sciences (ICLS) and International Society of the Learning Sciences (ISLS) community events could be a small move smartly made. Integrating with other colleges, programs, and community

partners is another way to expand and participate in ever-growing opportunities for learning and development.

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APPENDIX A

IRB APPROVAL DOCUMENT

ASU Knowledge Enterprise Development

EXEMPTION GRANTED

Leigh Wolf
Division of Educational Leadership and Innovation - Tempe
-
Leigh.Wolf@asu.edu

Dear Leigh Wolf:

On 2/2/2021 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Cognitive Apprenticeship in Informal Mentor Networks
Investigator:	Leigh Wolf
IRB ID:	STUDY00013300
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Brouthers-approval.pdf, Category: Off-site authorizations (school permission, other IRB approvals, Tribal permission etc); • Final IRB Social Behavioral - Spring 2021 (1) (1).docx, Category: IRB Protocol; • IRB Supporting Docs 29JAN2021 (1) (1).pdf, Category: Consent Form; • Survey, Interview, and Mapping Activity, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions);

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 2/2/2021.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

If any changes are made to the study, the IRB must be notified at research.integrity@asu.edu to determine if additional reviews/approvals are required. Changes may include but not limited to revisions to data collection, survey and/or interview questions, and vulnerable populations, etc.

Sincerely,

IRB Administrator

cc: Curtiss Brouthers
Curtiss Brouthers

APPENDIX B

INTERVIEW PROTOCOL

1. How did the study group change your perceptions of the Learning Sciences?
2. How did the study group change your perceptions of mentorship?
3. How did the study group change your perceptions and behaviors with networking?
4. Do you see any benefits to building a mentor network?
5. Do you see any risks to building a mentor network?
6. How might you use the study group as a way of becoming a Learning Scientist?
7. Is there something you really liked about the study group?
8. Is there something you didn't really like about the study group?
9. How might students improve the study group in the future?
10. Will this experience make you a better mentor or mentee in the Learning Sciences or in general? How and why?

APPENDIX C

QUESTIONNAIRE INSTRUMENTS (PRESURVEY + POSTSURVEY)

Pre-survey Questions

1. When did you graduate or expect to?
2. How comfortable are you in Conjecture Mapping?
3. For 2020 Cohort, were you in the Applied Project or Thesis track?
4. For 2021 Cohort, are you in the Applied Project or Thesis track?
5. For 2022 Cohort, are you most interested in Applied Project or Thesis track?
6. Are you a mentor? (You are currently mentor or have mentored recently)
7. Are you a mentee? (You are currently being mentored or had mentorship recently)
8. How important is mentorship as a Learning Sciences student?
9. How important is, and/or was, mentorship in pursuing your personal, professional, and educational goals?
10. How do you connect and stay in touch with your mentor(s)? Check all that apply
11. How do you connect and stay in touch with your mentee(s)? Check all that apply
12. My parents see me as a learning scientist
13. My instructors see me as a learning scientist
14. My peers see me as a learning scientist
15. I am interested in learning more about the learning sciences
16. I enjoy the learning sciences
17. I find fulfillment in the learning sciences
18. I am confident that I can understand LS theory in class
19. I am confident that I can understand LS theory outside of class
20. I am confident that I can do well on exams or my career in the learning sciences
21. I understand concepts I have studied in the learning sciences
22. Others ask me for help in the learning sciences
23. Would you like to see more mentorship opportunities offered to you?
24. Would you be willing to participate in further research on mentorship?
25. If you answered "Yes" or "Maybe" to the previous question, please leave an email so we can reach you in the near future. This concludes the survey. Thanks again!

Post-Survey Questions

1. When did you graduate or expect to?
2. How comfortable are you in Conjecture Mapping?
3. For 2020 Cohort, were you in the Applied Project or Thesis track?
4. For 2021 Cohort, are you in the Applied Project or Thesis track?
5. For 2022 Cohort, are you most interested in Applied Project or Thesis track?
6. Are you a mentor? (You are currently mentor or have mentored recently)
7. Are you a mentee? (You are currently being mentored or had mentorship recently)
8. How important is mentorship as a Learning Sciences student?
9. How important is, and/or was, mentorship in pursuing your personal, professional, and educational goals?
10. How do you connect and stay in touch with your mentor(s)? Check all that apply
11. How do you connect and stay in touch with your mentee(s)? Check all that apply
12. My parents see me as a learning scientist
13. My instructors see me as a learning scientist
14. My peers see me as a learning scientist
15. I am interested in learning more about the learning sciences
16. I enjoy the learning sciences
17. I find fulfillment in the learning sciences
18. I am confident that I can understand LS theory in class
19. I am confident that I can understand LS theory outside of class
20. I am confident that I can do well on exams or my career in the learning sciences
21. I understand concepts I have studied in the learning sciences
22. Others ask me for help in the learning sciences
23. Would you like to see more mentorship opportunities offered to you?
24. Which parts of the study did you participate in? (check all that apply)

APPENDIX D

FACILITATOR'S GUIDE

Introduction *Conjecture Mapping* *Cognitive Apprenticeship* *Mentor networks*	**Task and Purpose** *Conjecture Mapping is a tool to organize and communicate design research. Cognitive Apprenticeship is a way to teach and learn knowledge work. An informal mentor network is a relationship between a learner and the people they go to for support and guidance. My focus is on informal contexts and opportunities.*	
Modeling Big Idea: Demonstration Participants Will: Observe and Ask Questions	**Materials/Resources:** Presentation Sandoval (2014) Conjecture Map	**Notes:**
Coaching Big Idea: Professional Vision Mentor(s) observe task(s) performance assessment. Participants Will: Example Collaborative "White Board" for Mapping, Apprenticeship, or Mentorship Questions	**Materials/Resources:** Sandoval (2014) Conjecture Map Template	**Notes:**
Scaffolding Big Idea: Support concepts where needed and produce examples Participants Will: Find Productive Failure and Desirable Difficulty	**Materials/Resources:** Artifact 1 Reference materials and definitions	**Notes:**
Fading Big Idea: Mentors and MKOs assume roles and allow mentees "hands-on" Participants Will: Continue Collaborative "Jam	**Materials/Resources:** Jamboard Artifact 2	**Notes:**

Board" for Mapping, Apprenticeship, or Mentorship Mentees take lead		
Reflection Big Idea: Pair and share Participants Will: Reflect on own knowledge and performance Pair and share switch	**Materials/Resources:** Artifact 1 Jamboard Artifact 2 Reference materials and definitions	**Notes:**
Articulation Big Idea: Designated articulation for participant co-design Participants Will: Open turn-taking Reciprocal teaching	**Materials/Resources:** Artifact 1 Jamboard Artifact 2 Reference materials and definitions	**Notes:**
Exploration Big Idea: Agency, Identity, and Futures Thinking Participants Will: Goal-setting: Personal Research Conjecture Map Sub-goals: Thesis or Applied Project, Establishment of Mentor Network Contextualized goals	**Materials/Resources:** Artifact 1 Jamboard Artifact 2 Reference materials and definitions	**Notes:**
Introduction/Hook: **(5 mins)** 1. Thank you everyone for coming. The intention for this co-design is to help all of us as Learning Sciences students from different cohorts reach personal, professional, and		

educational goals through Cognitive Apprenticeship in an informal mentor network, or Community of Practice through a Conjecture Mapping activity. We will use the Cognitive Apprenticeship Model and Participatory Co-Design to co-construct clear and specific DBR practice and goals for Thesis and Applied Projects, and future career ambitions as a group, then individually. Whether you have something you are already working on or want to get started, this is about practice and advancing theory, so we all have something to gain.

2. My thesis states: "*Cognitive Apprenticeship Models Applied to Informal Mentor Networks:* Cognitive apprenticeships mediated by informal mentor networks can expand, deepen, and transfer knowledge with and for Learning Sciences students.

3. To begin, the Cognitive Apprenticeship Model may not be familiar, but as we go over the exercise, each method will be addressed as specified on this slide. This stems from cognition theory and the work of Lave and Wenger, and introduced as CAM by Collins, et al.

4. This is the timeline to keep us at an hour, we will be moving quickly, the first 30 minutes, then the last 30 minutes will be dedicated to unpacking the first 30 minutes and exploring future application toward individual research, personal goals, and professional agendas.

5. To situate ourselves as Learning Scientists, we conduct DBR and Conjecture Mapping is an authentic task for what we do and how we do it. We should all be familiar with this, but let's review the elements. This is slightly decontextualized, so consider your personal culture, contexts, and stance toward teaching and learning for application.

Modeling:
(5 mins)

1. *** Share Artifact Google Slides link in Zoom (Link)

2. To get started I am sharing a set of slides to model Conjecture Mapping and Guide us through the activity. We will begin with refreshing ourselves with Elements of Conjecture Mapping. A high-level conjecture, embodiment and design conjectures, mediating processes and theoretical conjectures, and desired outcomes.

3. Figure 1 illustrates these elements in relation to each other. Is this the first time anyone here has seen a conjecture map? (all should have, if not, welcome to the crash-course, but I will show you, and we will co-design together).

4. Slide 6 is the Conjecture Map I made for this research and will model. I know this slide is busy, but if you follow the crumbs, it makes more sense. Feel free to come back to any of this if any of it is unclear or lacking. Notice the thesis, I already talked about as the first element. I left some revisions, so you can see that this is not the first version, and this is also, likely not the last. All additions are in **BOLD** and deletions are Strikethrough. I began with a design for social media. I realized the scale and scope would be enormous and with the recommendations of the panel and my advisor, I

decided it wasn't feasible and would be too much to tackle. As you may notice, CAM is the task structure, Co-design is the participant structure, and Discourse practice refers back to CAM and the Co-Design as "ways of talking".

I later realized there were more observable interactions than I originally considered as mediating processes. I got more specific, instead of "what", I dug deeper to "specifically what". And that is something conjecture mapping helps you with, diving deeper into details systematically. Notice I removed worksheets and profiles, which were part of the original social media component. The desired outcomes are as mentioned already, and related to communities, networks, and identity, which you may have noticed as a theme in the surveys.

We are tight on time and have more to do, but are there any questions thus far?

Coaching:

(5 mins)

Now that I modeled the Conjecture Map for this co-design, let's do just that, Co-Design.

ADD: We will be using a blank Conjecture Map Template. All participants are invited to edit this as we go, though you do not have to, but it is helpful for someone to record as ideas are being discussed, as well as asynchronous "jigsaw" edits are also welcome.

Would someone like to suggest their own research? (One each for time)

What is the conjecture? If none, a theory we would like to work with?

Tools and Materials?

Task Structures?

Participant Structures?

Discursive Practices?

Observable Interactions?

Participant Artifacts?

Desired Outcomes?

Scaffolding:

(10 mins) ~~(5 mins)~~

Provide examples from Sandoval ***and previous iterations (ADDED 2nd and 3rd iteration)***

What did we get right?

What did we get wrong?

Have you noticed anything helpful from the examples?

Fading:

(10 mins) ~~(5 mins)~~

ADD: ***Share Jamboard Link
https://jamboard.google.com/d/19WZoYpZ9GqjZ8UXQekeILnsJ4dDuH-0buGgUGbatW_U/viewer?f=0

Go to the Jamboard Co-Design and continue the exercise but in random pairs, fading from support for activity unless requested but observe. We will not record, I would like everyone to focus on the activity and not the technicals. Discuss and I will tell you when to switch.

Reflection:

(5 mins)

ADD: Change groups for reflection. Reassign breakout rooms

The next 5 minutes you will be paired randomly to reflect on your knowledge about Conjecture Mapping for 2 minutes, then switch. We will not record, I would like everyone to focus on the activity and not the technicals.

Articulation:

(15 mins)

Group share on knowledge and perceptions Conjecture Mapping Co-Design and reflections.

What about the Co-design was good?

What about the Co-design could be better?

What about the Conjecture Mapping could be better?

What about the Conjecture Mapping was good?

What would make this activity/research better?

Exploration:

(5 minutes) ~~(15 mins)~~

The Final portion of this is to take theory and practice and apply it to your personal, professional, and educational agendas.

Goal-setting: Personal Research Conjecture Map (submitted for content analysis, not grading)

Sub-goals: Thesis or Applied Project, Establishment of Mentor Network(s)

Contextualized goals

I have compiled a list of resources and references available to all ASU Students, and particularly Graduate Students. I left out the Graduate Writing and Statistics Tutoring information but that is easy to find and if you need/want it, I highly recommend that as well.

Who would like to share what they have in mind, or where they might go with this?

Interviews and questions are all predetermined.

Post Survey is nearly identical to the first.

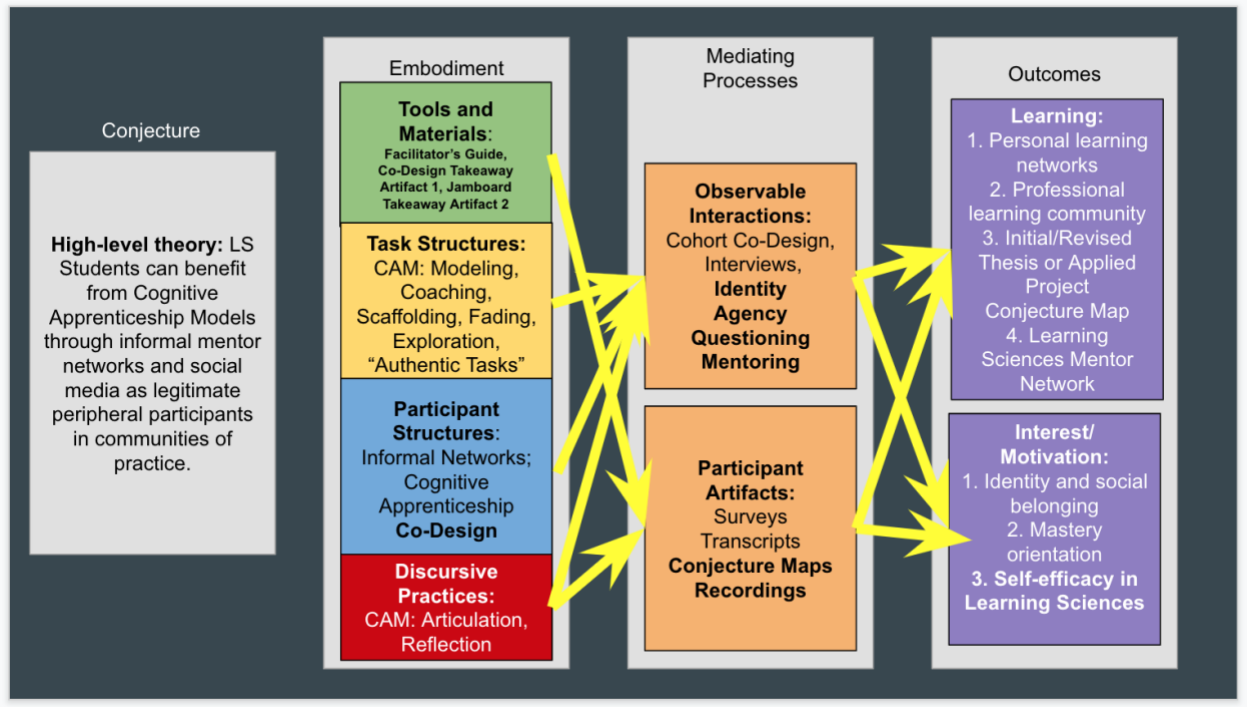
Lastly, thank you all. I will email each of you to schedule a short interview, I would like if you could send me your conjecture map in an email, and a final post enactment survey. This has been extremely helpful and I hope you will be able to use the takeaway materials, the Google Sheets artifact from this activity. I really appreciate your time and participation.

Field Notes:		
Interest/Motivation (i.e., Personal feelings, Questioning, Satisfaction, Purpose, Goals, etc.):	**Performance/Competence (How they see themselves, Confidence, Perceived Understanding):**	**Recognition (How they think others see them):**

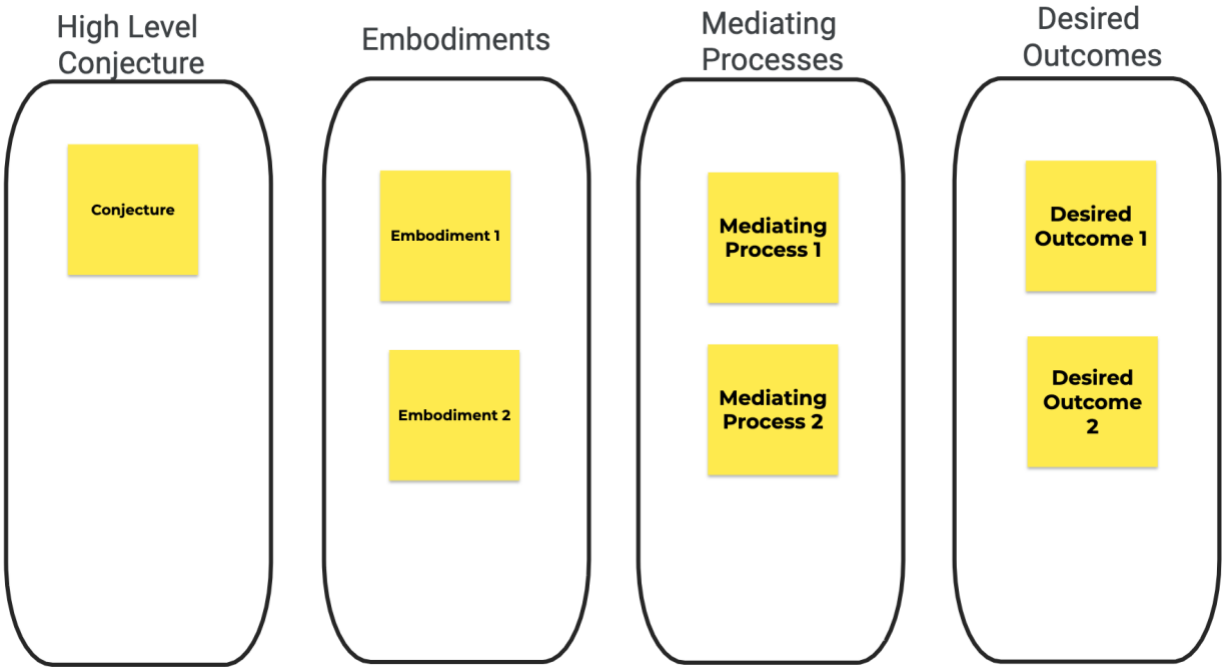
Identity Construct Questionnaire:

Construct	Questionnaire Statement
Recognition	My parents see me as a Learning Scientist
	My instructors see me as a Learning Scientist
	My peers see me as a Learning Scientist
Interest	I am interested in learning more about the Learning Sciences
	I enjoy the Learning Sciences
	I find fulfillment in the Learning Sciences
Performance/ Competence	I am confident that I can understand LS theory in class
	I am confident that I can understand LS theory outside of class
	I am confident that I can do well on exams in the Learning Sciences
	I understand concepts I have studied in the Learning Sciences
	Others ask me for help in the Learning Sciences

Artifact 1:


Conjecture
High-level theory: LS Students can benefit from Cognitive Apprenticeship Models through informal mentor networks and social media as legitimate peripheral participants in communities of practice.
Embodiment
Tools and Materials: Facilitator's Guide, Co-Design Takeaway Artifact 1, Jamboard Takeaway Artifact 2
Task Structures: CAM: Modeling, Coaching, Scaffolding, Fading, Exploration, "Authentic Tasks"
Participant Structures: Informal Networks; Cognitive Apprenticeship Co-Design
Discursive Practices: CAM: Articulation, Reflection
Mediating Processes
Observable Interactions: Cohort Co-Design, Interviews, Identity Agency Questioning Mentoring
Participant Artifacts: Surveys Transcripts Conjecture Maps Recordings
Outcomes
Learning: 1. Personal learning networks 2. Professional learning community 3. Initial/Revised Thesis or Applied Project Conjecture Map 4. Learning Sciences Mentor Network
Interest/ Motivation: 1. Identity and social belonging 2. Mastery orientation 3. Self-efficacy in Learning Sciences

Artifact 2:


High Level Conjecture
Conjecture
Embodiments
Embodiment 1
Embodiment 2
Mediating Processes
Mediating Process 1
Mediating Process 2
Desired Outcomes
Desired Outcome 1
Desired Outcome 2

APPENDIX E

EXAMPLE ASU CAREER AND PROFESSIONAL DEVELOPMENT SERVICES WORKSHEETS

Powerful introductions

Create a powerful introduction to use at career and internship fairs or professional networking opportunities and to respond to interview questions like "Tell me about yourself," and "Why should we hire you?" It's important to have a powerful introduction to connect with potential employers whether on the phone, email or in person. **Remember, this is a conversation starter, not a memorized speech** and should be used to help market your career competencies in a very short time. You may need to adjust this template depending on who you are speaking with.

Example:

Hello, my name is Jennifer and I'm interested in Human Resources. I have experience as the Vice President of a student organization where I interviewed and onboarded new members. My strengths in communication, problem solving, and working as a team member come into plan on a daily basis working in food service. Additional business courses have supplemented my communication degree and attributed to my interest and growing knowledge in Human Resources. I'm looking for more information about what your organization looks for when hiring HR coordinators.

Hello, my name is: _____

I am interested in: _____

I have experience or coursework in: _____

My strengths are: _____

I am looking for information about opportunities in: _____

Skills employers are seeking in candidates

As a student at ASU, you are constantly building new skills, experiences and competencies that contribute to your overall personal growth and professional development. Many of these skills and experiences can be used to help you be career ready even before graduation. Below are eight career competences that employers are seeking, and highly qualified candidates often possess. Career competencies were developed by the National Association of Colleges and Employers (NACE) that works to promote career readiness in students. Career and Professional Development Services has made it easy for you to ensure you are making strides in each of these areas.

Critical thinking/problem solving

Exercise sound reasoning to analyze issues, make decisions and overcome problems. The individual is able to obtain, interpret and use knowledge, facts and data in process and may demonstrate originality and innovation.

Professionalism/work ethic

Demonstrate personal accountability and effective work habits, e.g., punctuality, working productively with others, and time management, and understand the impact of non-verbal communication on professional work image. The individual demonstrates integrity and ethical behavior, acts responsibly with the interests of the larger community in mind, and is able to learn from their mistakes.

Teamwork/collaboration

Build collaborative relationships with colleagues and customers representing diverse cultures, races, ages, genders, religions, lifestyles and viewpoints. The individual is able to work within a team structure, and can negotiate and manage conflict.

Digital technology

Leverage existing digital technologies ethically and efficiently to solve problems, complete tasks and accomplish goals. The individual demonstrates effective adaptability to new emerging technologies.

Global/intercultural fluency

Value, respect and learn from diverse cultures, races, ages, genders, sexual orientations and religions. The individual demonstrates, openness, inclusiveness, sensitivity and the ability to interact respectfully with all people and understand individuals' differences.

Career management

Identify and articulate one's skills, strengths, knowledge and experiences relevant to the position desired and career goals, and identify areas necessary for professional growth. The individual is able to navigate and explore job options, understands and can take the steps necessary to pursue opportunities and understand how to self-advocate for opportunities in the workplace.

Oral/written communication

Articulate thoughts and ideas clearly and effectively in written and oral forms to persons inside and outside the organization. The individual has public speaking skills; is able to express ideas to others; and can write and edit memos, letters and complex technical reports clearly and effectively. Individual is adaptable to all forms of communication, or advocates for resources to effectively communicate their ideas.

Leadership

Leverage the strengths of others to achieve common goals, and use interpersonal skills to coach and develop others. The individual is able to asses and manage their emotions and those of others; use empathetic skills to guide and motivate; and organize, prioritize and delegate work.

Career readiness means that you have **experience and skills** in each of the career competencies and are capable of navigating the **job search and interview process** and have the skills and knowledge to be **successful** in the career of your choosing.

Adapted from NACE Career Readiness for the New College Graduates

Putting career competencies in action

Now that you are familiar with these career competencies, let's take a look at which ones you have most developed and which you would like to develop further. Employers are going to not only seek out these competences, but want to see evidence on how you apply them. Fill in the section below to summaries your most developed competencies.

Skills developed:	Comments: (What activities have I engaged in that prove my proficiency in this skill)
1.	
2.	
3.	
4.	

Now that we have looked at what competencies you are strong in, what about the ones that you would like to develop further? Employers are going to want to address a variety of different competencies and might hit on ones that you are not so strong in. Why not work on developing some strategies to strengthen them? Start with listing four competencies you would like to get more experience with and what activities and steps you can take to develop them. You can ask for suggestions from friends, mentors, advisors f you can't think of activities yourself.

Skills developed:	Comments: (What activities can I engage in that will increase my proficiency in this skill)
1.	
2.	
3.	
4.	

Career tip:

Want to learn more about career competencies? Check out the YouTube videos at: **links.asu.edu/CPDSYouTube** or schedule an appointment on Handshake.

ASU Career and Professional Development Services
Arizona State University

asu.joinhandshake.com
@sundevilcareers

480-965-2350
career.asu.edu
careerservices@asu.edu

Crafting your career story

Tell your story. Market yourself. Ace that interview.

Being able to sell recent stories that showcase your skills and career readiness is invaluable when interviewing or interacting with other professionals. Prior to an interview or interaction, reflect and develop stories that relate to career competencies and industry-specific skills. Use varied examples to cover aspects of your education, work experiences and other involvement. This worksheet provides a blueprint with example questions to create stories that highlight your past experiences. Utilize the STAR method to tell a story about your development in each one of the eight competencies.

S	T	A	R
Situation	**Task**	**Action**	**Result**
Set the scenario for your example.	Describe the specific challenge or task that relates to the question.	Talk about the actions that you took to accomplish the task.	Present the results that followed because of the chosen action.

NACE Career Competencies Icons

These icons represent eight career competencies that students should have experience with in order to be career ready at graduation. Look for these symbols next to the interview questions on this handout that highlight these career competencies.

Career management | Leadership | Global/intercultural fluency | Digital technology | Critical thinking/ problem solving | Oral/written communication | Professionalism/ work ethic | Teamwork/ collaboration

Leadership

Tell me about a time when something went wrong at work and you took charge.

Situation: Ice cream machine at work broke.
Task: Figure out protocol to get the machine fixed.
Action: Talked with management to replace the machine or get a repair man to fix the problem.
Result: The ice cream machine was fixed and sales improved.

Teamwork

Have you had to convince a team to work on a project they weren't thrilled about? How did you do it?

Situation: _____
Task: _____
Action: _____
Result: _____

Conflict resolution

Tell me about a time in which you handled a difficult situation with a coworker.

Situation: _____
Task: _____
Action: _____
Result: _____

ASU Career and Professional Development Services
Arizona State University

asu.joinhandshake.com
@sundevilcareers

480-965-2350
career.asu.edu
careerservices@asu.edu

Perserverance

Tell me about a time in which you overcame an obstical to reach a goal. Be specific.

Situation: _____
Task: _____
Action: _____
Result: _____

Time management

When you worked on multiple projects, how did you prioritize?

Situation: _____
Task: _____
Action: _____
Result: _____

Goal setting

Give an example of how you set goals and achieve them.

Situation: _____
Task: _____
Action: _____
Result: _____

Problem solving

Give us an example of a situation when you realized that you wont be able to meet the set deadline. What did you do?

Situation: _____
Task: _____
Action: _____
Result: _____

Organization

Tell me about a time when your organization skills helped you succeed.

Situation: _____
Task: _____
Action: _____
Result: _____

Adjusting to change

Provide me with an example of how you handle change in the workplace.

Situation: _____
Task: _____
Action: _____
Result: _____

Learning a new technology

Describe a time where you had to implement a new technology based program or tool in your work.

Situation: _____
Task: _____
Action: _____
Result: _____

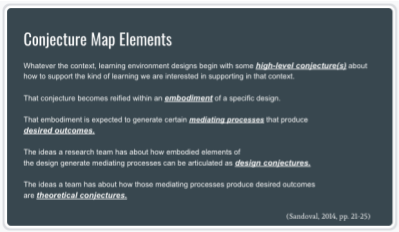
Working with diverse populations

Describe a time where you had to implement a new technology based program or tool in your work.

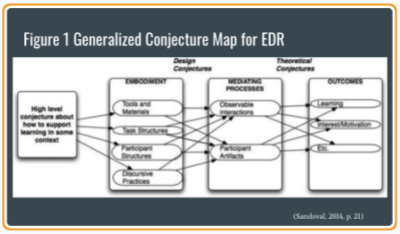
Situation: _____
Task: _____
Action: _____
Result: _____

APPENDIX F

ARTIFACT 1 SLIDES



1



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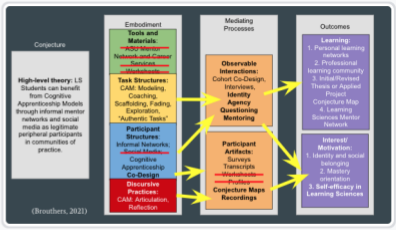

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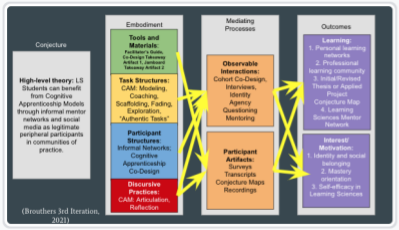

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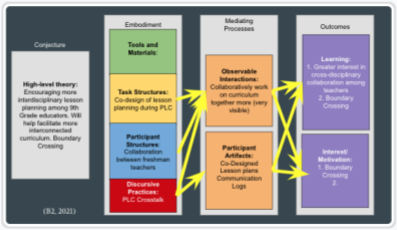

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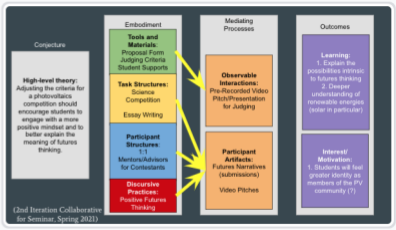

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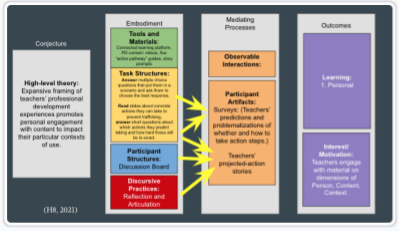

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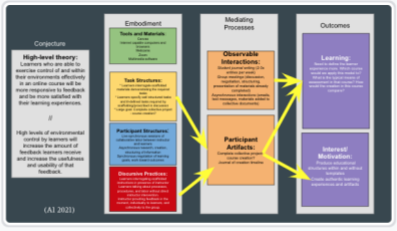

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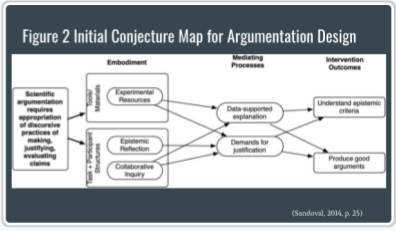

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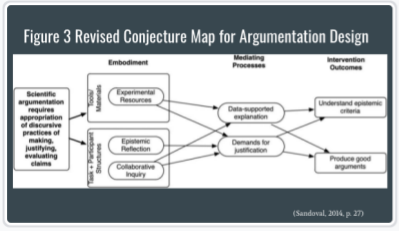

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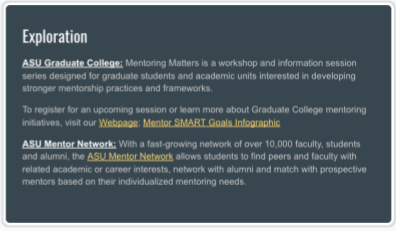

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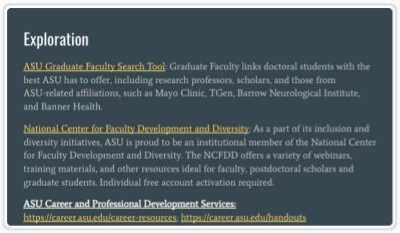

Exploration
ASU Graduate Faculty Search Tool: Graduate Faculty links doctoral students with the best ASU has to offer, including research professors, scholars, and those from ASU-related affiliations, such as Mayo Clinic, TGen, Barrow Neurological Institute, and Banner Health.
National Center for Faculty Development and Diversity: As a part of its inclusion and diversity initiatives, ASU is proud to be an institutional member of the National Center for Faculty Development and Diversity. The NCFDD offers a variety of webinars, training materials, and other resources ideal for faculty, postdoctoral scholars and graduate students. Individual free account activation required.
ASU Career and Professional Development Services:
https://career.asu.edu/career-resources; https://career.asu.edu/handouts

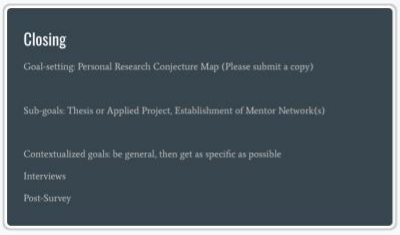
13


Mentor Network Invitation - Power Intro Template
Powerful Introductions

14


Mentorship Tools from ASU Career Development Services

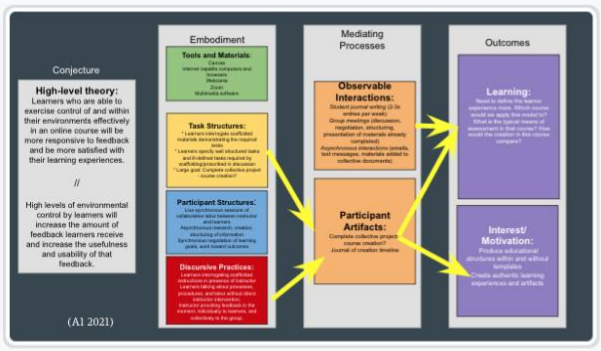
15


Closing
Goal-setting: Personal Research Conjecture Map (Please submit a copy)
Sub-goals: Thesis or Applied Project, Establishment of Mentor Network(s)
Contextualized goals: be general, then get as specific as possible
Interviews
Post-Survey

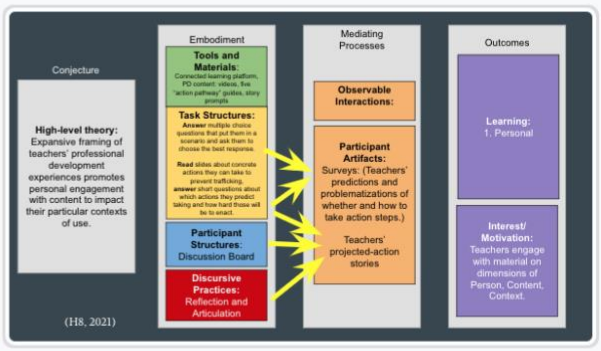
16

APPENDIX G

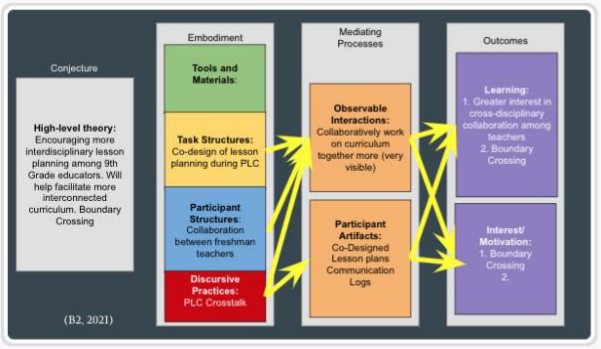
CONSOLIDATED CONJECTURE MAPS


Conjecture
High-level theory:
Learners who are able to exercise control of and within their environments effectively in an online course will be more responsive to feedback and be more satisfied with their learning experiences.
//
High levels of environmental control by learners will increase the amount of feedback learners receive and increase the usefulness and usability of that feedback.
Embodiment
Tools and Materials:
Task Structures:
Participant Structures:
Discursive Practices:
Mediating Processes
Observable Interactions:
Participant Artifacts:
Outcomes
Learning:
Interest/ Motivation:
(A1 2021)

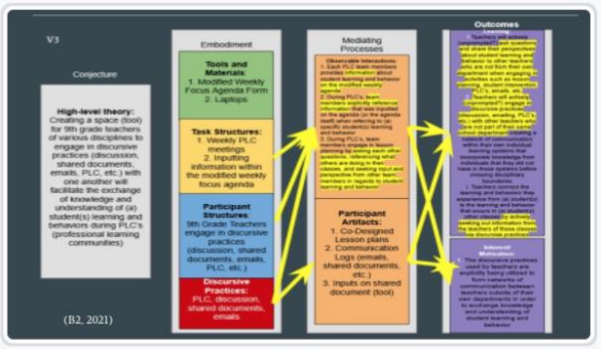
1


Conjecture
High-level theory:
Expansive framing of teachers' professional development experiences promotes personal engagement with content to impact their particular contexts of use.
Embodiment
Tools and Materials:
Task Structures:
Answer multiple choice questions that put them in a scenario and ask them to choose the best response.
Read slides about concrete actions they can take to prevent trafficking.
answer short questions about which actions they predict taking and how hard those will be to enact.
Participant Structures:
Discussion Board
Discursive Practices:
Reflection and Articulation
Mediating Processes
Observable Interactions:
Participant Artifacts:
Surveys: (Teachers' predictions and problematizations of whether and how to take action steps.)
Teachers' projected-action stories
Outcomes
Learning:
1. Personal
Interest/ Motivation:
Teachers engage with material on dimensions of Person, Content, Context.
(H8, 2021)

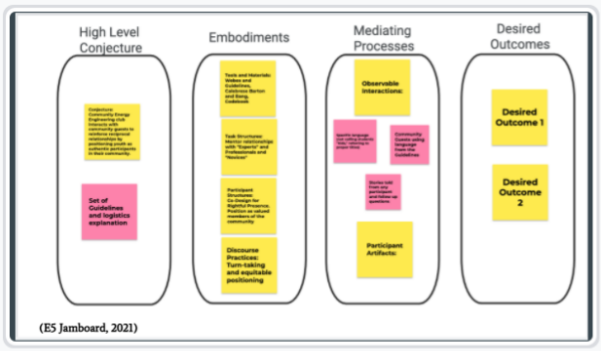
2


Conjecture
High-level theory:
Encouraging more interdisciplinary lesson planning among 9th Grade educators. Will help facilitate more interconnected curriculum. Boundary Crossing
Embodiment
Tools and Materials:
Task Structures:
Co-design of lesson planning during PLC
Participant Structures:
Collaboration between freshman teachers
Discursive Practices:
PLC Crosstalk
Mediating Processes
Observable Interactions:
Collaboratively work on curriculum together more (very visible)
Participant Artifacts:
Co-Designed Lesson plans
Communication Logs
Outcomes
Learning:
1. Greater interest in cross-disciplinary collaboration among teachers
2. Boundary Crossing
Interest/ Motivation:
1. Boundary Crossing
2.
(B2, 2021)

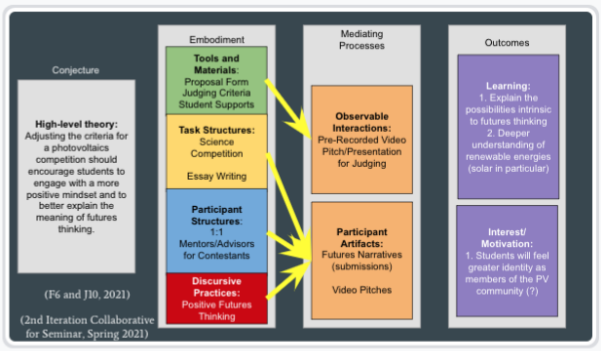
3


V3
Conjecture
High-level theory:
Creating a space (tool) for 9th grade teachers of various disciplines to engage in discursive practices (discussion, shared documents, emails, PLC, etc.) with one another will facilitate the exchange of knowledge and understanding of (a) student(s) learning and behaviors during PLC's (professional learning communities)
Embodiment
Tools and Materials:
1. Modified Weekly Focus Agenda Form
2. Laptops
Task Structures:
1. Weekly PLC meetings
2. Inputting information within the modified weekly focus agenda
Participant Structures:
9th Grade Teachers engage in discursive practices (discussion, shared documents, emails, PLC, etc.)
Discursive Practices:
PLC, discussion, shared documents, emails
Mediating Processes
Participant Artifacts:
1. Co-Designed Lesson plans
2. Communication Logs (emails, shared documents, etc.)
3. inputs on shared document (tool)
Outcomes
(B2, 2021)

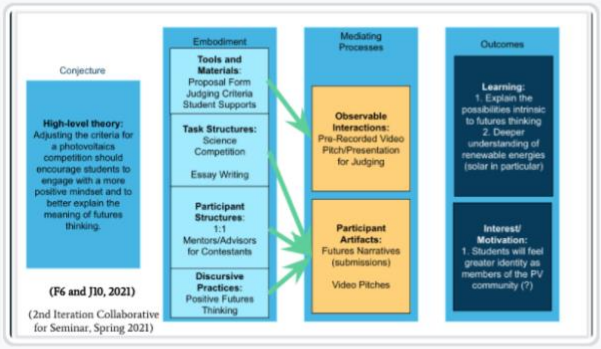
4


High Level Conjecture
Embodiments
Mediating Processes
Desired Outcomes
Desired Outcome 1
Desired Outcome 2
(E5 Jamboard, 2021)

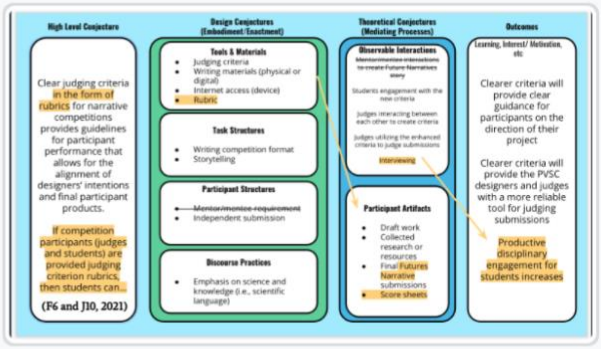
5


Conjecture
High-level theory:
Adjusting the criteria for a photovoltaics competition should encourage students to engage with a more positive mindset and to better explain the meaning of futures thinking.
Embodiment
Tools and Materials:
Proposal Form
Judging Criteria
Student Supports
Task Structures:
Science Competition
Essay Writing
Participant Structures:
1:1 Mentors/Advisors for Contestants
Discursive Practices:
Positive Futures Thinking
Mediating Processes
Observable Interactions:
Pre-Recorded Video Pitch/Presentation for Judging
Participant Artifacts:
Futures Narratives (submissions)
Video Pitches
Outcomes
Learning:
1. Explain the possibilities intrinsic to futures thinking
2. Deeper understanding of renewable energies (solar in particular)
Interest/ Motivation:
1. Students will feel greater identity as members of the PV community (?)
(F6 and J10, 2021)
(2nd Iteration Collaborative for Seminar, Spring 2021)

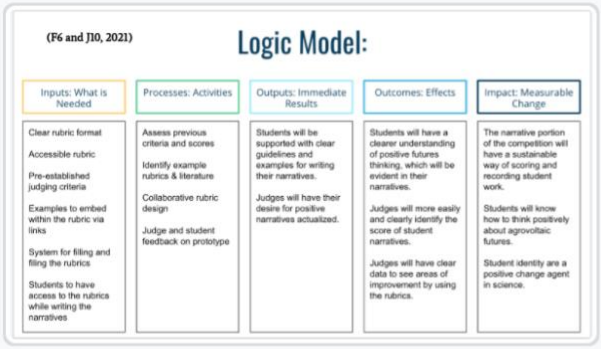
6


Conjecture
High-level theory: Adjusting the criteria for a photovoltaics competition should encourage students to engage with a more positive mindset and to better explain the meaning of futures thinking.
(F6 and J10, 2021)
(2nd Iteration Collaborative for Seminar, Spring 2021)
Embodiment
Tools and Materials: Proposal Form Judging Criteria Student Supports
Task Structures: Science Competition
Essay Writing
Participant Structures: 1:1 Mentors/Advisors for Contestants
Discursive Practices: Positive Futures Thinking
Mediating Processes
Observable Interactions: Pre-Recorded Video Pitch/Presentation for Judging
Participant Artifacts: Futures Narratives (submissions)
Video Pitches
Outcomes
Learning: 1. Explain the possibilities intrinsic to futures thinking 2. Deeper understanding of renewable energies (solar in particular)
Interest/ Motivation: 1. Students will feel greater identify as members of the PV community (?)

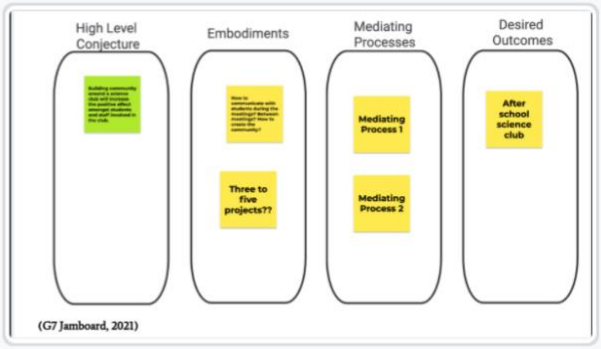
7


High Level Conjecture
Clear judging criteria in the form of rubrics for narrative competitions provides guidelines for participant performance that allows for the alignment of designers' intentions and final participant products.
If competition participants (judges and students) are provided judging criterion rubrics, then students can...
(F6 and J10, 2021)
Design Conjectures (Embodiment/ Enactment)
Tools & Materials
Judging criteria
Writing materials (physical or digital)
Internet access (device)
Rubric
Task Structures
Writing competition format
Storytelling
Participant Structures
Mentor/mentee requirement
Independent submission
Discourse Practices
Emphasis on science and knowledge (i.e., scientific language)
Theoretical Conjectures (Mediating Processes)
Observable Interactions
Mentor/mentee interactions to create Future Narratives entry
Students engagement with the new criteria
Judges interacting between each other to create criteria
Judges utilizing the enhanced criteria to judge submissions
Interviewing
Participant Artifacts
Draft work
Collected research or resources
Final Futures Narrative submissions
Score sheets
Outcomes
Learning, Interest/ Motivation, etc
Clearer criteria will provide clear guidance for participants on the direction of their project
Clearer criteria will provide the PVSC designers and judges with a more reliable tool for judging submissions
Productive disciplinary engagement for students increases

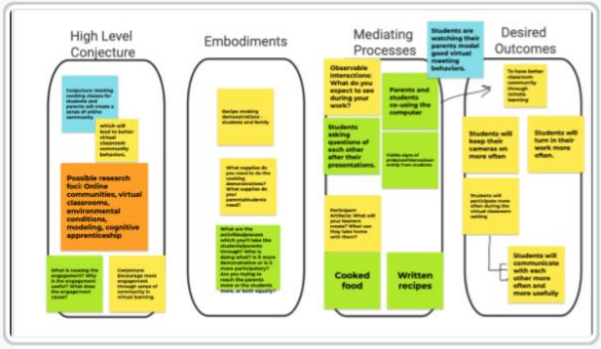
8


(F6 and J10, 2021)
Logic Model:
Inputs: What is Needed
Clear rubric format
Accessible rubric
Pre-established judging criteria
Examples to embed within the rubric via links
System for filing and filing the rubrics
Students to have access to the rubrics while writing the narratives
Processes: Activities
Assess previous criteria and scores
Identify example rubrics & literature
Collaborative rubric design
Judge and student feedback on prototype
Outputs: Immediate Results
Students will be supported with clear guidelines and examples for writing their narratives.
Judges will have their desire for positive narratives actualized.
Outcomes: Effects
Students will have a clearer understanding of positive futures thinking, which will be evident in their narratives.
Judges will more easily and clearly identify the score of student narratives.
Judges will have clear data to see areas of improvement by using the rubrics.
Impact: Measurable Change
The narrative portion of the competition will have a sustainable way of scoring and recording student work.
Students will know how to think positively about agrovoltaic futures.
Student identity are a positive change agent in science.

9


High Level Conjecture
Embodiments
Mediating Processes
Desired Outcomes
Mediating Process 1
Mediating Process 2
After school science club
Three to five projects??
(G7 Jamboard, 2021)

10


High Level Conjecture
Embodiments
Mediating Processes
Desired Outcomes
Possible research foci: Online communities, virtual classrooms, environmental conditions, modeling, cognitive apprenticeship
Students are watching their parents model good virtual meeting behaviors.
Observable interactions: What do you expect to see during your work?
Parents and students co-using the computer
Students asking questions of each other after their presentations.
Cooked food
Written recipes
Students will keep their cameras on more often
Students will turn in their work more often.
Students will communicate with each other more often and more usefully

11

APPENDIX H

CODEBOOK

Title	Description
Level 1 Achievement	**(1) Routine comprehension, conceptual understanding, problem solving, including performing procedures, search in problem spaces, reasoning, planning, skill acquisition**
Conceptual Understanding	• Conversational contributions, mutual attention, understanding propositions and reference • Conceptual common ground, patterns of reasoning in practice • Shared repertoire of schemata and procedures
Problem Solving-Performing Procedures	• Conversational contributions, mutual attention, understanding propositions and reference • Conceptual common ground, patterns of reasoning in practice • Shared repertoire of schemata and procedures
Problem Solving-Planning	• Conversational contributions, mutual attention, understanding propositions and reference • Conceptual common ground, patterns of reasoning in practice • Shared repertoire of schemata and procedures
Problem Solving-Reasoning	• Conversational contributions, mutual attention, understanding propositions and reference • Conceptual common ground, patterns of reasoning in practice • Shared repertoire of schemata and procedures
Problem Solving-Search in problem spaces	• Conversational contributions, mutual attention, understanding propositions and reference • Conceptual common ground, patterns of reasoning in practice • Shared repertoire of schemata and procedures

Problem Solving-Skill acquisition	• Conversational contributions, mutual attention, understanding propositions and reference • Conceptual common ground, patterns of reasoning in practice • Shared repertoire of schemata and procedures
Routine Comprehension	• Conversational contributions, mutual attention, understanding propositions and reference • Conceptual common ground, patterns of reasoning in practice • Shared repertoire of schemata and procedures
Level 2 Achievement	**(2) Emergent understanding**
Emergent Understanding	• Negotiating different interpretations for mutual understanding • Problematizing, resolving, and positioning in interaction • Explaining
Level 3 Achievement	**(3) Adopting tasks, expending effort toward accomplishing goals**
Adoption	Practices that encourage problematizing and resolving and that position students in disciplinary discourse with competence, authority, and accountability in participation structures
Expending Effort	Practices that encourage problematizing and resolving and that position students in disciplinary discourse with competence, authority, and accountability in participation structures
Level 4 Achievement	**(4) Conceptual growth, commitment to learning goals, sustained, persistent participation in learning practices**

Commitment to Learning Goals	• Changes in discourse practice; legitimate peripheral participation • Intellective identities regarding learning, academic learning, and learning in specific school subjects; positional identities in school and classrooms with mutual engagement and productive agency in relation to a community's joint enterprise of learning
Conceptual Growth	• Changes in discourse practice; legitimate peripheral participation • Intellective identities regarding learning, academic learning, and learning in specific school subjects; positional identities in school and classrooms with mutual engagement and productive agency in relation to a community's joint enterprise of learning
Sustained, Persistent Participation in Learning Goals	• Changes in discourse practice; legitimate peripheral participation • Intellective identities regarding learning, academic learning, and learning in specific school subjects; positional identities in school and classrooms with mutual engagement and productive agency in relation to a community's joint enterprise of learning
Explaining and Feedback	
Elaborated Explanations	Epistemic complexity: 4= elaborated explanations
Elaborated Facts	Epistemic complexity: 3= elaborated facts
Unelaborated Facts	Epistemic complexity: 2= unelaborated facts
Theorizing Topical Terms Only	Epistemic complexity: 1= topical terms only
Questioning	
Explanation-seeking	Explanation-seeking: about reasons and mechanisms
Fact-seeking	Fact-seeking: about factual information and definitions

Idea-deepening	Idea-deepening: searching for deeper understanding on the basis of the existing information
Initial wondering	Initial wondering: seeking general information about a topic