Teacher Professional Vision in the Work of Co-Design

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Abstract: This design-based research study explores how one instructor constructed and refined her professional vision (PV) (noticing, interpreting, and responding to classroom interactions) as she worked alongside a researcher to design and facilitate a human-centered robotics curriculum. This co-design case considers how PV is dynamically constructed in co-design that occurs throughout a curriculum implementation. Using a PV framework and discourse analysis methodology, this study explores how video viewing and analysis collaboratively done by design partners can support iterative curriculum refinement. Findings inform how we might better support teachers in the important work of creating learning experiences for students that extend beyond the classroom.

Introduction

To bring problems and practices into the classroom that resonate with students, teachers must cultivate nuanced facilitation practices and creatively design curricula that adapt to fit learners' emerging interests and pursuits. This process requires professional vision (PV)—noticing, interpretation, and response to student actions that takes time to develop and refine (Sherin & van Es, 2005). In creating powerful student-centered learning environments, it is essential to study teachers' PV to understand how curricula are enacted over time. This allows us to learn how to better recognize, support, and teach ambitious pedagogy (van Es, Cashen, Barnhart, & Auger, 2017).

This study aims to better understand how one instructor (pseudonym Brenda) constructed and refined her PV as she worked alongside a researcher (the first author) to co-design and facilitate a human-centered robotics curriculum that asked students to design and build robots that could address needs in their school community. Co-design is considered here as work between teachers and researchers to design innovative educational experiences, implement and evaluate these experiences, and continue to refine them in order to fill local educational needs (Penuel, Roschelle, & Shechtman, 2007). Further, co-design is a collaborative space where teachers are empowered "as agents of change…and engaged as co-creators of curriculum that directly addresses problems of practice in their own contexts in response to their own students" (Goldman et al., 2019, p. 1). We attend to the work of co-design throughout this study as an interactional context where teacher PV is fluidly constructed. This study extends current research centered on teacher PV—considering how PV is dynamically constructed in co-design that occurs before and throughout a problem-based learning curriculum implementation.

Problem-based learning (PBL) and co-design

PBL is a pedagogical approach that begins with an ill-structured and authentic problem and offers support to student groups throughout the problem-solving process. With its student-centered approach, PBL supports learner agency and engages students in authentic disciplinary practices (Hmelo-Silver, 2004; Kolodner, 2003). However, PBL is not easy to implement. As teachers adopt and enact PBL, they navigate several tensions (e.g., how to assess, when to ask a probing question, how to set group norms) (Savin-Badin, 2003). In PBL, the instructor acts as a facilitator—scaffolding student learning by asking guiding questions, providing just-in-time information, and supporting students' evaluation of the problem-solving process (Hmelo-Silver, 2004).

Though facilitation is well studied in the PBL literature, research often focuses on the complex work of scaffolding, student outcomes, and the design of effective problem statements (Walker, Leary, Hmelo-Silver, & Ertmer, 2015). Further research is needed to consider the trajectory instructors take as they refine their understanding of themselves as PBL designers and facilitators and adjust what they attend to in the classroom environment—working to embrace a student-centered approach that is not the norm in US classroom environments (Sedova, Sedlacek, & Svaricek, 2016). Studying how teachers' reflective practices are constructed in the design and implementation of PBL is necessary as we work to understand how to support teachers in their design of these complex experiences. Here, we consider how co-design experiences between researchers and practitioners can be structured and analyzed to make visible how teacher reflections unfold in the work of PBL design and facilitation. We attend to the ways in which one teacher's PV in co-design shaped the design and implementation of a culturally situated problem-based STEM experience.

Professional vision (PV) and video-based reflection

As teachers reflectively observe and interpret classroom interactions, they consider how their actions are taken up and use this understanding to adapt facilitation practices (Loughran, 2002). This research explores teacher reflective practices through the lens of PV—organized ways of interpreting an environment that are informed by particular communities of practice (Goodwin, 1994). For teachers to develop robust facilitation practices, they need to develop rich PV—the ability to see and respond to nuanced issues of teaching and learning in their (Borko, 2004).

Given the pressure teachers face to constantly integrate new technology and practices into their instruction, co-design partnerships between researchers and practitioners can support the development of rich PV and curricula that meaningfully integrate technology and address authentic problems (Svihla et al., 2015). For example, reflective sessions can scaffold the development of teacher PV. Carefully organized viewing of classroom video can make PV visible and inspire action. Reflective use of classroom video over time can lead to changes in observational skills (Sherin & van Es, 2005), and video analysis has been found to be a useful tool for understanding what a teacher knows and how they reason in classroom scenarios (van Es et al., 2017). Further research is needed to understand how reflective video viewing of an instructor's own teaching in collaboration with a research partner can inspire change in senses of self and in the design of a curriculum.

This study considers classroom video as a boundary object—an artifact that helps participants in an interaction to move across individual perspectives and come to a shared understanding (Akkerman & Bakker, 2011). The co-design experiences analyzed in this study were organized with PV articulation in mind—incorporating shared video viewing and construction of design artifacts by researcher and practitioner partners. These shared artifacts and the conversation that happened around them are analyzed in order to make clear how noticing, interpretation, and response were interactionally accomplished in co-design.

Contribution and research question

In sum, this study explores one teacher's evolving PV as she worked to design and enact a PBL robotics curriculum centered on using technology to address local needs in students' local communities. We examine how Brenda, a science instructor, refined her PV in the process of co-designing and facilitating a human-centered robotics curriculum. This focus on the evolution of PV informs how to best support the iterative design and implementation of locally meaningful PBL experiences. We ask: *How is teacher PV constructed in reflective co-design?*

Methods

Human-centered robotics (HCR) context

This study builds on several iterations of a problem-based curriculum designed to engage underrepresented populations in STEM via HCR. Brenda taught five iterations of the HCR curriculum in her applied science course and an afterschool club at her Junior High School in the rural Midwest US. Brenda identifies herself as a PBL science instructor with 15+ years of experience. These HCR experiences are the first she had teaching robotics. The analysis presented in this study centers on the most recent implementation of our HCR unit. HCR, a field that focuses on the use of robotic technology to address human needs and challenges (Schaal, 2007), can help students understand how robots can help humans in their everyday lives. Students were presented with a design challenge to create robots that serve a need in their local communities. The most recent iteration was inspired by lessons learned from four prior implementations of the HCR experience. As we prepared to implement a five-week unit in Brenda's elective science course, we worked with school stakeholders to provide an authentic design experience for students. We asked the community to serve as design clients for students in an upcoming classroom implementation of the robotics unit. Four community members created HCR design proposals, and we compiled these responses for student teams to review. Student design teams of 3-4, reviewed client design proposals and selected clients to work with. They worked together to design and build robots that addressed the needs established by their clients, integrating their own experiences as members of the school community. Students received formative feedback from their clients at multiple time points. This robotics experience required students to grapple with a complex problem and to collect information and apply design practices as they worked to solve it.

Discourse Analysis (DA) methodological approach

DA, which considers talk as social action, can be used to identify discursive patterns and norms that both shape and are shaped by participants (Gee & Green, 1998). DA works to understand how discursive actions (e.g., pointing, repetition) function in interactions. In the work of iteratively viewing and interpreting discourse, patterns are uncovered that speak to how meaning is being constructed in interaction (Potter & Wetherell, 1987). DA was selected as a methodological approach for this study because it can be used to examine what Brenda oriented to in co-design experiences and how this orientation shifted over time. We use DA methodologies to frame both

study design (capturing co-design interactions through the collection of video and artifact data) and analysis (iteratively reviewing data sources to identify and unpack patterns related to PV construction in interaction).

Demographics and data collection

The classroom implementation examined here included 21 students (ages 13 - 14). These participants enrolled in an eight-week elective science class. The HCR unit was enacted over the course of the first five weeks, with sessions held daily for twenty-two 40- to 50-minute class periods. Students were placed into 6 collaborative groups. These selections were made by the instructor who worked to include an even mix of male and female students in each group.

Co-design sessions

Nine structured co-design sessions and 13 informal co-design sessions were held to support the design and implementation of this unit. "Structured" co-design sessions were those that included a formal agenda, incorporated joint video viewing and work with design scaffolds (e.g., planning artifacts and conjecture maps). "Informal" co-design sessions included just-in-time planning and reflection by co-designers. Informal sessions were organized by co-designers when it was determined that further conversation and planning were needed. Across informal sessions, co-design partners discussed what they noticed during class that day and made real time decisions about planning for the next class period. These reflections incorporated video viewing when requested (e.g., reviewing group presentations recorded that same day).

Structured co-design sessions included goal setting, video analysis, and co-design of activities supported by lesson plan documentation. Video clips were carefully selected to include 1) examples of instructor facilitation 2) examples of student groups working without the instructor present 3) examples of both high- and low-quality group engagement (Rogat et al., 2019). Video clips were selected from class periods that occurred in the 1-2 days before each co-design session. Clips were initially selected by the first author, but after the first few structured co-design sessions, clips requested by the instructor were incorporated. The following prompts were used to guide each video viewing experience: "Watch each clip once through, with initial reflections at the end of the clip. Then watch each clip and pause, noticing how and when students are engaging with engineering design and how this is supported by facilitators. Ask: What do I notice about the ways that students are interacting and engaging? How are facilitators and/or the design of the activity supporting this engagement? How do we see PBL in this clip? What improvements could be made? What new goals come to mind after watching this clip?"

Data sources

We video recorded 17 hours of structured co-design sessions and 13 hours of informal co-design sessions. Co-design sessions were held at the end of the school day and the co-designers sat side by side. A screen capture of shared video viewing was recorded. Agendas used in structured co-design sessions included additional scaffolds. For example, planning artifacts inspired by conjecture mapping (Sandoval, 2014), rubrics for student engagement, and consistent questions to guide video viewing. Agendas were crafted by the first author, but they were adjusted in real time as Brenda identified specific areas where she wanted to focus. In addition, we recorded a pre- and post- teacher interview that included reflections on the co-design.

Two focus groups, selected by the instructor, were video recorded throughout the robotics unit implementation. All student presentations throughout the unit were also video recorded and all student artifacts were collected. An additional camera followed the teacher throughout each class period.

Data analysis procedure

Video logging of co-design sessions captured social activities in interactions of interest (Potter, 2012). In this logging process, the first author created memos that highlighted interactional moves related to PV construction. These memos included early "codes" that labeled the function of these moves (as seen in the ways that they were taken up in the interaction by participants).

Memoing and coding led to the selection of extracts that were transcribed and referenced in a series of data sessions. Data sessions with members of the research team and colleagues were used to provide a check on interpretations of data and to guide subsequent finer grained rounds transcription (e.g., nonverbal layers), coding, and line-by-line analysis. Across data sessions, a specific pattern in PV construction emerged (noticing, interpreting and designing, and reflecting on design enactment). This "cycle" became a means of organizing a corpus of examples.

Tracing co-design cycles revealed how PV construction occurred across related events—moving from video viewing and interpretation to real-time dialogue and decision making in the classroom informed by these interpretations. We compiled a corpus of extracts that showcased this trajectory—presenting initial co-design

decisions made about classroom enactment using shared video viewing as a starting point with subsequent reflections on these video recordings in co-design. This three-part trajectory moved from 1) noticing to 2) design proposals, to 3) classroom enactment and reflection on enactment and became a template for findings presentation.

Findings

Here, we present one of the three analyzed co-design cycles. In this cycle, joint analysis of student artifacts and video supported the consideration of 1) breakdowns in student group coordination 2) what productive group coordination looks like and 3) how to support students' presentation of design ideas to clients. As co-design partners, Brenda and the first author navigated the challenge of using noticing and interpretation to inform design together—co-constructing observations and responses to student activity as we make decisions about how to best serve students in real time. This co-construction of PV built on what occurred in the previous co-design cycle and laid a foundation for the co-design cycles that followed. Throughout these findings, line-by-line analysis is used to show how PV was constructed and make one full co-design cycle visible.

Extract 1: Initial analysis of student artifacts

Extract one begins with a shared orientation to student artifacts. This extract is pulled from an impromptu informal afterschool reflection session held two weeks into the unit. In this brief interaction, design partners jointly reconstruct what occurred for one student group. In the class period that occurred on this date, students worked to finalize design artifacts and a presentation script for communicating early robot design ideas to their clients. Group 1, referenced throughout this extract, designed a robot to meet needs articulated by the school counselor. This client's design proposal asked students to design a robot that could help students experiencing escalated emotions to calm down by leaving the classroom and walking around the school. Group 1 considered this function for their robot and incorporated their own life experiences, proposing that the robot might also serve as a listener and reporter. One student proposed that the robot could record student reports and share them with appropriate adults. This first extract, in which instructor and researcher reflect on Group 1's evolving ideas about robot function, highlights a tension that emerged for this group.

In the following early lines of the first extract, a discrepancy is noticed between Group 1's storyboard artifact (depicting the social problem that their robot design works to address) and their presentation script artifact (created to support the communication of early design ideas to their client in an upcoming meeting). Here, the real time noticing that occurred during facilitation is articulated in co-design. This first extract of the co-design cycle provides context for the subsequent extracts. Throughout the extracts presented here, is used to denote interaction in the context of co-design, while is used to denote interaction that occurs in video being viewed during co-design. = Symbols note latched speech, and *italics* note nonverbal action.

Line	Speaker	Verbal Transcript	Nonverbal Transcript (Brenda)	Nonverbal transcript (First author; Andi)
1	**First Author (A)**	Well it seems like there's a little bit of disagreement within the group about =	*Gaze directed at own computer screen; typing.*	
2	**Brenda (B)**	=The topic.		*A reaches for student artifacts on table across from her (group scripts).*
3	**A**	Mmhm. 'Cause he was saying he still wants it to be a robot that…plays calming music and walks the kids around and has stress balls. Then their storyboard is all about this abuse situation.	*Gaze directed at student artifacts*	*Gaze directed at student artifacts. Points to students' script as she speaks.*
4	**B**	Yeah.	*Gaze directed at student artifacts*	
5	**A**	…So I think trying to figure out [if] it has a dual purpose. It can be used to report if students need to and it's also a calming down robot. But I	*Gaze directed forward. Nods as A speaks*	*Directs gaze at Brenda, uses hands for emphasis*

		think they just need to make that clear.

In Lines 1 to 3, the first author (A) refers to student artifacts to highlight a disconnect between students' storyboard and presentation script. In Line 3, A describes an observed classroom interaction. This move to reconstruct student interactions was used frequently by co-designers to highlight challenges that arose in the daily work of the unit. This reconstruction aligned our noticing of student group dynamics as we co-constructed interpretations and design decisions. Thus, it was important for the construction of PV in co-design.

Both Brenda and A directed gaze to the group's script artifact, and A pointed to the script as they spoke. The student artifact functioned to make the noted disconnect in the group's work even more visible.

Though this interaction was dominated by A's conversational turns, events that unfolded in the class period on the following day suggest that the conversation was taken up by Brenda as significant and was reflected in how she facilitated Group 1's work. Furthermore, Brenda articulated a desire to look more closely at student artifacts in the future. In the post-interview extract below, it appears that our experiences exploring student artifacts and using them to inform subsequent design decisions were seen as valuable.

Line	Speaker	Verbal Transcript
1	**Interviewer**	If you were to deliver this unit again, is there anything you would do differently?
2	**Brenda (B)**	What I think was so great about us working together was that we made those changes along the way.
3	**B**	…One of those things was having a client. In the past when we had done this we didn't have students choosing a client…they didn't have a certain person or group for which they were designing…that was a major piece that was missing previously that really gave focus to these students.
4	**B**	…Again, going through and making sure that we are…scaffolding and hitting the benchmarks when the kids need them.
5	**B**	…So that might be just keeping up more on checking the artifacts maybe…so we could see exactly where they were.

In Lines 2 to 3, Brenda highlights the benefit of engaging in co-design *throughout* the implementation of a curriculum (and the real time changes that this affords). This attention articulates the ways that we looked backward and forward in our co-design and denotes this movement and reflection as meaningful for Brenda as an instructor. In lines 4 and 5, Brenda identifies "checking on artifacts" as something to pay even further attention to in the future as a way to make student thinking even more visible. This reflection can be tied to our work together (as seen in Extract 1) exploring student artifacts and using them to inform design decisions.

Extract 2: Video viewing and interpretation informs design

In the following extract, selected from a structured co-design session later in the week, Brenda reflects on a clip of Group 1 working to develop their client script. This clip was selected because of our shared interest in this group's progress and how the multiple robot functions may have emerged in their interaction.

Line	Speaker	Verbal Transcript
1	**Student Mary (M)**	What do you guys want to start talking about in the script?...So like we want to introduce our robot so what do you want to say?
2	**Student Aaron (A)**	What's up guys
3	**M**	Welcome to my YouTube channel
4	**Student Nola (N)**	((*quietly, head down)*) I think ((*trails off)*)
5	**M**	So [Aaron] you're going to introduce the robot
6	**Brenda (B)**	What= ((*First Author pauses the video as Brenda begins to speak)*)

7	**A**	She said "I think" and then they kept talking and so she just went back
8	**B**	That is what she was feeling the other day…When she was struggling I think that's what…They didn't hear her…She was very quiet…I mean I don't think I would have…noticed it.

In Lines 1-3, students self-organize their activity. In Line 4, groupmate Nola attempted to make a contribution, but it did not appear to be heard by the group and was not taken up. In Line 6, Brenda begins to comment as she says "What." At this point A pauses the video—noting that Nola said "I think…"and did not get a response from her groupmates. Brenda builds on this observation in Line 8 with a conjecture about Nola. In previous class periods, Nola expressed that she felt like her voice wasn't being heard in her group. Brenda noted that this particular interaction, where her attempted contribution was not noticed by the group, might be part of why Nola felt this way. Brenda goes on to reflect that though Nola's contribution was not taken up by the group, it doesn't appear to be because the rest of the group mates were actively shutting Nola out. Rather, it seems most likely that they simply did not hear Nola's "I think…"

This reflection, joint noticing and interpretation led by Brenda, highlights the affordance of video viewing for better understanding group dynamics and how they are constructed during collaborative work. Here, closely viewing video made a tension in this group visible that was not recognized in the classroom. This, noticing and interpretation elements of PV were augmented by joint video viewing—supporting eventual design decisions.

Extract 3: Design enactment and reflection

In the final extract presented from the same co-design session, we reflect upon video of ourselves intervening with Group 1 in the classroom. Here, we review a video clip of our co-facilitation. This clip was selected because it showcased our work to translate our observation of Group 1's coordination challenges and disconnect between design artifacts into action. As we view this clip or our interaction with Group 1, we consider how our decision to intervene was taken up by students.

Line	Speaker	Verbal Transcript
1	**B**	(*Brenda stands at Group 1's table alongside A in the video clip)* One thing that…A and I were looking at…was the storyboard…We're not sure that it matches up with your full script.
2	**Aaron (A)**	…We are going to have one person talking about the storyboard…we were going to have [Nola] talking about the storyboard.
3	**Nola (N)**	No, I'm doing the storyboard.
4	**B**	Okay, if you're reading this though (*points to handwritten script in Aaron's hand)* it doesn't mention anything about um the abuse. But your storyboard is completely about abuse.

In Line 1, Brenda explicitly brings our co-design work into the classroom. This facilitation move makes Brenda's PV visible to students—highlighting that she is noticing and interpreting students' work not only in class, but also after students leave school for the day. In Line 4 of the video recorded interaction, recognizing that her Line 1 comment has been misinterpreted, Brenda rephrases. Pointing to the group's handwritten client meeting script as a shared reference point, she highlights that there is a focus on abuse in the storyboard that does not come through in the script. A jumps in to build on and support Brenda's observations. Sstudent (Aaron) states that his understanding was that the storyboard could zoom in on just *one* part of the design idea. In this video clip, noticing of students' misalignment is turned into classroom action—the third part of a PV cycle that includes noticing, interpretation, and response. Here, the video is paused as Brenda begins to speak.

Line	Speaker	Verbatim Transcript
5	**B**	I like the fact that we were able to have that conversation with them…And they were able to explain it…they had already thought of that…before we had mentioned anything to them. …[They] had already decided that that was one aspect that they were going to um highlight in the storyboard but it wasn't the only thing that their robot was going to do. And they were able to explain that away as soon as it was in question.
6	**A**	So do you feel like that questioning helped them to think through?

7 **B** …I'm wondering if they were thinking the day that [Nola] was really struggling … And so they were able to say "well that's one thing that it can do, but we think the client also wants this." And they did that before we got there.

In Lines 5 and 7, Brenda emphasizes that this interaction cued her into understanding how students were thinking about their design artifacts. She was impressed that students were able to "explain away" the questions and discrepancies that we raised as co-facilitators. In Line 5, Brenda also highlights that as facilitators we weren't fully understanding students' process—validating this intervention as necessary. Here, Brenda explains that the students "had already decided that this was one aspect they needed to highlight" before we raised anything. This seems to suggest that this conversation served to make student understanding visible to facilitators.

In the co-design exchange that followed, we agreed that this conversation did more than make students' understanding visible, it also supported refinement in how students were communicating their design ideas. Here, we co-constructed a shared understanding of how our co-facilitated intervention played out and was taken up. The first author noted that the presentation of evolving design ideas was something "that we need to keep scaffolding."

In many ways, the integration of storyboard artifacts and formative design client presentations in this iteration of the robotics unit was inspired by the challenges we identified in students' work to make their design ideas clear to community stakeholders. Despite these hard scaffolds and curricular re-design, additional just-in-time support was also needed. In a post-interview, Brenda articulated the importance of formative assessment:

1 [Co-design with video reflection during an implementation was] something that we had not done in the three years past that we had done the unit…To go through that assessment of "what are we seeing, what are we hearing, what do we want them to get out of this, and what should we go back to the next day?"

2 …Assessment is everything… Like walking past a group and hear someone say something and you stop and you go back to the group and you're like…"what do you think about that?" and ask probing questions to the student…So you're constantly questioning students about what are they doing on a metacognitive level…

In Line 1 of this response, Brenda points to the daily reflection we did as co-design partners, formal and informal, as a key form of assessment. Her attention to "what are we seeing, what are we hearing, what do we want them to get out of this and should we go back to the next day?" speaks directly PV—explaining a pattern of noticing and interpreting what we notice as a way to make informed design decisions ("what should we go back to the next day?"). Brenda's attention in Line 2 to probing questions that get at students' metacognition can be linked closely to the design enactment presented in Extract 3—demonstrating Brenda's appreciation of probing questions and one-on-one check-ins with student groups as a way to understand their progress and what supports are (and are not) necessary. This post-interview extract is a triangulating data point. Here, Brenda labels the kind of intervention with small groups that occurred across Extract 3 as an essential form of formative assessment.

Across this co-design cycle, Brenda used student artifacts, informal afterschool reflection, and the work of joint video analysis to explore what coordination looked like for one student group and to better understand their process. This co-constructed reflection, grounded in shared artifacts, informed facilitation tailored to this student group. Though this facilitation was brief, it worked to make student thinking visible and led to a kind of recalibration for co-designers as we considered how to support students' communication of design ideas.

Conclusions and implications

Across co-design trajectories, shifts occurred in how Brenda noticed and interpreted student activity and her own facilitation—using noticing and interpretation to design scaffolds and script facilitation moves that supported students' collaborative work. Though only one design cycle and a selection of post-interview extracts are shared here, it is clear how Brenda's interpretations connected to design decisions (e.g., planning formative check-ins with students to make their thinking visible). This construction of PV appeared to be supported by the interactional work of co-design—particularly the work of joint video viewing and interpretation.

In the co-design cycle presented here, there was a focus on interpretation of student activity. The emergent focus on group norms and designing for productive collaboration led us to look specifically for moments of social discord and respond to them. Here, we worked together to analyze student artifacts in order to understand where student groups were in their understanding.

Attending to regular video viewing as a boundary object between co-design partners created space for dynamic noticing and interpretation (which could then be used to inform real time responses in classroom facilitation). This attention to video as a boundary object for design partners and as a space to cultivate and

interrogate PV on a daily basis extends prior teacher professional development research centered on video viewing. This study also considers video viewing experiences, and particularly video viewing of one's own teaching in real time, as a fruitful kind of joint problem-solving space for researchers and teachers (Teasley & Roschelle, 1993). Across the co-design cycles traced in this study, research and practice were mutually informative. Learning sciences theory (e.g., engagement as multifaceted, learning in context, PV as a key component of teaching) and practical perspective that comes with decades of teaching came together in this work. The study of this particular co-design partnership, and PV construction within it, might inform future work that endeavors to similarly stitch together a tapestry of researcher and practitioner perspectives.

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