Practice-Based Teacher Questioning Strategy Training with ELK: A Role-Playing Simulation for Eliciting Learner Knowledge

XU WANG, University of Michigan, United States
MEREDITH THOMPSON, Massachusetts Institute of Technology, United States
KEXIN YANG, Carnegie Mellon University, United States
DAN ROY, Massachusetts Institute of Technology, United States
KENNETH R. KOEDINGER, Carnegie Mellon University, United States
CAROLYN P. ROSE, Carnegie Mellon University, United States
JUSTIN REICH, Massachusetts Institute of Technology, United States

Practice is essential for learning. However, for many interpersonal skills, there often are not enough opportunities and venues for novices to repeatedly practice. Role-playing simulations offer a promising framework to advance practice-based professional training for complex communication skills, in fields such as teaching. In this work, we introduce ELK (Eliciting Learner Knowledge), a role-playing simulation system that helps K-12 teachers develop effective questioning strategies to elicit learners' prior knowledge. We evaluate ELK with 75 pre-service teachers through a mixed-method study. We find that teachers demonstrate a modest increase in effective questioning strategies and develop sympathy towards students after using ELK for 3 rounds. We implement a supplementary activity in ELK in which users evaluate transcripts generated from past role-play sessions. We have tentative evidence that a combination of role-play and evaluating conversation moves may be more effective for learning. We contribute design implications of using role-play systems for communication strategy training.

CCS Concepts: • **Human-centered computing** → *Empirical studies in HCI*; *Empirical studies in collaborative and social computing*; • **Applied computing** → **Computer-assisted instruction**; **Interactive learning environments**; **Collaborative learning**.

Additional Key Words and Phrases: teacher education; communication strategy training; scalable professional training; role-play; sympathy building; decomposition of practice; conversation; learning

ACM Reference Format:
Xu Wang, Meredith Thompson, Kexin Yang, Dan Roy, Kenneth R. Koedinger, Carolyn P. Rose, and Justin Reich. 2021. Practice-Based Teacher Questioning Strategy Training with ELK: A Role-Playing Simulation for Eliciting Learner Knowledge. *Proc. ACM Hum.-Comput. Interact.* 5, CSCW1, Article 51 (April 2021), 27 pages. https://doi.org/10.1145/3449125

Authors' addresses: Xu Wang, University of Michigan, Ann Arbor, United States, xwanghci@umich.edu; Meredith Thompson, Massachusetts Institute of Technology, Cambridge, United States, mtknight@mit.edu; Kexin Yang, Carnegie Mellon University, Pittsburgh, United States, kexiny@andrew.cmu.edu; Dan Roy, Massachusetts Institute of Technology, Cambridge, United States, danroy@mit.edu; Kenneth R. Koedinger, Carnegie Mellon University, Pittsburgh, United States, koedinger@cmu.edu; Carolyn P. Rose, Carnegie Mellon University, Pittsburgh, United States, cprose@cs.cmu.edu; Justin Reich, Massachusetts Institute of Technology, Cambridge, United States, jreich@mit.edu.

2573-0142/2021/4-ART51
https://doi.org/10.1145/3449125

1 INTRODUCTION

There are approximately 4.1 million K-12 school teachers in the 2017-2018 school year in the United States (U.S. Department of Education) [37]. Given their potential to impact the lives of young people, it is of great importance to support teacher learning and professional development [74]. However, in the United States, teacher professional learning programs provide insufficient opportunities for them to practice important skills and judgments [31]. Current teacher training programs consist primarily of observations and attending lectures or discussions [15, 38, 52, 73]. Teachers have few opportunities to rehearse and practice teaching. Moreover, feedback is scarce [8, 74], and the focus is often on evaluating performance rather than improving practice [22, 74].

Eliciting student thinking is a core teaching practice that is useful in many contexts and content areas [70]. Because effective teaching involves engaging students' preconceptions and building on their existing knowledge [9, 41], instructional practices that enable teachers to understand what students know are essential. Although decades of research has shown that it is essential for teachers to understand what students know in order to help them learn [3, 17, 68], teacher practice is still far from satisfactory. Pre-service teachers often regard students' misconceptions as barriers to learning, rather than useful starting points for instruction [51].

Current pre-service teaching programs need *scale* in helping teachers learn necessary skills in communication, more importantly generating useful questions in eliciting student knowledge. While seminars, workshops, and peer-classroom observation are the current norm [15, 38, 52, 73], role-playing simulations allow opportunities for teachers to rehearse and get feedback in a low-stakes environment. In this work, we use role-play simulations to help K-12 teachers learn to generate useful questions in eliciting student knowledge and we discuss the implications of technology design for communication skill training across contexts.

We introduce ELK (Eliciting Learner Knowledge), a role-playing simulation system that offers virtual sessions in which players can learn and practice discourse strategies on eliciting knowledge from their conversational partners. After two players join a role-play session, each of them assume the role of either a "Teacher" or a "Student", and respectively receive teacher or student profiles. The two players chat through a text-based interface. The goal of the "Teacher" player is to elicit as much as possible of the "Student" player's prior knowledge as indicated in their profile (Figure 1). Both players take a quiz in the end to assess and reflect on their performance.

We implement a supplementary activity in ELK –"Coding", where players evaluate authentic transcripts generated from past role-play sessions. As shown in Figure 4, in this "Coding" activity, players assign a qualitative code to each line of the transcript, indicating which questioning move was employed – such as "Telling", "Evaluating", or "Probing." The design of this feature is motivated by the constraints of role-play simulations and the demonstrated success of evaluation-type activities in other domains. For example, some role-play activities are found to be overly challenging and cause performance anxiety in players [32], organizers reported the overhead in pairing players when it requires multiple people to be present at the same time [16]. On the other hand, prior work has also demonstrated the strengths of evaluation-type activities for learning. For example, solving Parsons problems, i.e., evaluating correctness and ordering of coding snippets, is as effective for learning as writing the equivalent code[20], evaluating the quality of example survey questions is as effective for learning as writing new survey questions [79]. However, most of these prior work focuses on conceptual or technical skills that can be learned independently. We explore the feasibility of employing evaluation-type activities for learning communication strategies, such as eliciting knowledge from a conversation partner.

We evaluate ELK with 75 pre-service teachers to answer three research questions. First, how effective is ELK in helping players develop questioning strategies? A mixed-methods approach was

adopted in answering this question. To assess behavioral change, we look at how much improvement participants make in questioning moves from the first to the last (third) round of playing ELK. To assess conceptual and attitude change, we use an in-depth survey asking participants to reflect on their learning experiences with ELK. Second, does the "Coding" activity help participants develop questioning strategies? To address this question, we use the "Role-play" activity as the control condition, and compare their effects on helping users learn questioning moves. We also tease out the factor of receiving feedback from both conditions, resulting in a 2 by 2 experiment design, with the first factor being either in the "Role-play" or the "Coding" activity, and the second factor being whether users receive feedback or not. Third, what are users' experiences in ELK and what challenges do they encounter? How can we better design computer-based role-play systems to make them more engaging and useful? We address this question through an open-ended survey sent to participants after they use ELK for at least an hour.

Our key contributions include:

- New system: ELK (Eliciting Learner Knowledge), a text-based role-playing system that enables pre-service teachers to practice questioning moves through simulated "teacher-student" conversations.
- Evidence of support for learning and sympathy development: An evaluation with 75 pre-service teachers show participants demonstrate a modest increase in effective questioning moves after using ELK for three rounds. Our study also provides evidence of conceptual and attitude change from players. This is the first study to our knowledge that conducts a thorough evaluation of the educational benefits of a computer-based role-play system, using both performance and subjective outcome measures.
- Benefits of the "Coding" activity: We show that evaluating authentic transcripts generated by others is a useful activity in helping participants develop questioning strategies. We have tentative evidence that a combination of question generation and evaluation practice may be more effective than question generation practice alone in increasing the use of positive questioning moves. The "Coding" activity has practical benefits as it can be performed by a single participant alone, which serves as a viable supplementary activity for online role-play systems.
- Design implications for role-play systems for communication strategy training: the evaluation study of ELK reveals prospects and challenges of role-play systems for communication strategy training across contexts. We summarize the design implications and discuss the broader application scenarios.

2 RELATED WORK

In this section, we review relevant literature that our work situates in. First, we discuss prior work that emphasizes the importance of classroom discourse, more specifically eliciting student thinking for effective teaching. we also describe a framework drawn upon prior work to teach pre-service teachers how to elicit learner knowledge. Second, we review literature on prior curricula and technologies for teacher professional development, in particular techniques to support classroom discourse. Third, we describe relevant social computing systems for skill development, with a focus on peer-learning and role-play based learning systems. Finally, we review two lines of learning sciences theories including cognitive load theory and the decomposition of practice. The design of ELK is guided by existing practices and theories and complements existing literature in providing scalable practice and rehearsal opportunities for pre-service teachers to learn questioning strategies through role-play.

2.1 Eliciting Student Thinking

2.1.1 Importance of Eliciting Student Thinking. We describe two lines of reasoning on why classroom discourse, and more specifically eliciting student thinking is important. First, it facilitates multi-directional classroom discourse towards creating a student-centered learning environment. Second, it helps teachers understand students' prior knowledge to adjust their instruction towards more effective teaching and learning.

Conversations are an essential part of teaching and learning, thus researchers and educators have studied the patterns and nature of discourse in classrooms. The beliefs and practices of the teacher are important in understanding and guiding the path of the conversation. The typical pattern of classroom discourse often follows an initiation, response, evaluation (IRE) format [82], and is mediated almost entirely through the teacher in a unidirectional "univocal" manner [58]. This pattern of discourse rewards the right answer and limits the amount of student voice and exploration. A number of strategies have been developed to help educators move towards a multidirectional "dialogic" pattern of discourse, which gives learners more agency, and also shifts the focus of the classroom away from the teacher and towards the goals of the students. Simply adding more questions is not enough, as closed ended "right answer" questions can reinforce the default univocal format [61].

Eliciting student thinking is a core teaching practice that is useful in many contexts and content areas [70] In tutoring and teaching situations, understanding what learners know is essential to helping students learn [17] and has been identified as one of the fundamental activities of teaching[76]. Understanding common misconceptions that learners may have allows teachers to address those ideas and leads to better learning outcomes compared to teachers who are unaware of possible misconceptions [68].

Despite these benefits, pre-service teachers often regard students' misconceptions as barriers to learning, rather than useful starting points for instruction[51]. This belief reinforces the one way transmission of knowledge from teacher to student rather than an exchange of ideas between teachers and students [45]. Even seasoned teachers often focus on evaluating student work as right or wrong, rather than understanding student work as evidence of their current understandings [18]. We aim to address these issues by designing a role-play simulation to help educators both recognize the importance of eliciting learner knowledge and to learn and practice strategies to understand what students know.

2.1.2 How to Elicit Learner Knowledge. Prior work has studied effective "talk moves" for teachers to elicit learner knowledge, such as asking follow-up questions [17, 19, 23, 57]. We developed a framework for training pre-service teachers on effective questioning moves based on prior work. The framework contains five categories of questioning moves.

- Priming: preparing the class for learning
- Eliciting: asking questions that reveal learner's needs
- Probing: asking follow-up questions based on students' responses
- Evaluating: responding in the positive or negative about students' answers
- Telling: talking about the topic without listening to the student

Among the five questioning moves, we consider Priming, Eliciting and Probing to be effective ones in eliciting learner knowledge; and Evaluating and Telling to be ineffective ones for eliciting knowledge, since they are not optimal for teachers to understand what students know. (Telling and evaluating may be appropriate in other parts of the teaching sequence, but in the early phases of eliciting learner knowledge, it is critical to simply *understand* student thinking before attempting to "fix" or redirect student thinking.

This five-part questioning framework is central to our pedagogical aims and research efforts with ELK. In implementing ELK in educational methods classes, teacher educators explain and demonstrate these questioning strategies to pre-service students. ELK participants then use these questioning strategies to code talk moves in transcripts. In analyzing ELK transcript data, as researchers we use this framework to identify pre-service teacher development – we consider an increase in the three effective questioning strategies and the decrease in the two ineffective strategies over multiple rounds of ELK to be evidence of pre-service teacher fluency in eliciting learner knowledge.

2.1.3 Social Factors in Facilitating Classroom Discourse. The 5-part framework introduced above is developed mainly from a knowledge-centric view, focusing on what are the questioning moves we expect teachers to learn and use. At the same time, we acknowledge that effective questioning in the classroom depends not just on what the teacher asks a student about the subject-matter, but also on their mutual respect, understanding, history, trust, and power dynamics among other social factors [35, 36]. In addition to practicing effective talk moves in classrooms, teachers also need to develop culturally relevant pedagogy, where they need to understand the level of emotional awareness and emotional intelligence in the classroom to create a climate for optimal learning [46, 49]. These social and emotional factors are not currently accounted for in the design and evaluation of ELK. But we do value culturally relevant pedagogy in creating positive classroom climate, and fostering long-term rapport and relationship between teachers and students. We will address this again in the future work and limitations section on how we plan to integrate these factors in the future development of teacher education platforms.

2.2 Teacher Classroom Discourse Training and Support

Prior work has explored various ways for classroom discourse training. One line of work focuses on gathering curriculum materials for teachers' professional development. Michaels & O'Conor [57] proposed a framework of effective talk moves after two decades of qualitative classroom-based research on how some teachers skillfully orchestrate equitable and productive discussion [28, 55, 62]. The framework resulted in two professional development resources for teachers. The first is a book with classroom videos for teachers to read, watch and discuss [5, 14]. The second is a web-based, open-source site – Talk Science Project [60], with video and text resources. There are similar efforts following the initial proposal of talk moves on creating curriculum and resources of teacher professional development, including formative assessment moves [19], a coding scheme for analyzing classroom dialogue [33], websites with lots of information for teachers such as Ambitious Science Teaching [77].

A second line of work takes a more interactive method, having teacher educators or peers observe and record live class sessions to analyze teachers' instructional practices and offer feedback [2, 29, 30]. For example, Sleep's work involves recording teachers' one-on-one conversations with students and have experts review them afterwards [72]. Another approach creates face to face simulations, where teacher educators act as students with misconceptions, and pre-service teachers practice questioning strategies [70]. These are compelling approaches, but they are very demanding on teacher educator labor (to review video, act as students, provide individual feedback, etc.)

More recently, there has been explorations on systems to automatically generate feedback to teachers based on their class session recordings. For example, Wang et al. [81] used a wearable recording system for teachers to record classroom audio and did automatic analysis on turn-taking dynamics in classrooms. Ramakrishnan et al. [65] used classroom video and audio with deep learning techniques to automatically model classroom climate. However, these approaches have drawback such as they do not analyze any utterance content, are very expensive to implement and

may cause privacy concerns. A more recent system developed by Jensen and colleagues [39] used discourse modeling techniques to provide automatic feedback to teachers on a list of discourse variables.

In addition to systems that support classroom discourse development, researchers have proposed new techniques to support teacher professional development in general. For example, Holstein et al. presented a real-time system Lulimo, which alerts teachers when students need help when working with intelligent tutoring systems [34]. Xhakaj et al. developed a teacher dashbaord with usage data from an intelligent tutoring system for teachers to understand students progress [85]. Poskin et al. developed a smartphone application TeachFX [64] which models the proportion of teacher talk using classroom recordings. Aslan et al. proposed a system to alert teachers of student disengagement [7]. Gerritsen et al. presented a action-reflection-planning framework and a deployed system that enables teaching assistants to reflect on their data and conduct lesson planning [25]. Ahuja et al. developed a comprehensive sensing system EduSense that produces visual and audio features corrected with effective instruction using state-of-the-art computer vision techniques [1]. These are all exciting and promising technologies for teacher professional development but they do not fulfill the need of giving teachers more practice and rehearsal opportunities on classroom discourse, especially eliciting student thinking.

2.3 Social Computing Systems for Skill Development

We see an increasing number of social computing systems for skill development in the field of HCI and CSCW. We describe two lines of work that are mostly relevant for the design of ELK, peer learning and role-play based learning. Peer learning platforms provide scale for online learning because the efforts required from experts are greatly reduced. Some recent examples include peer feedback systems (e.g., PeerStudio) [12, 48], online peer discussion platforms [47] and team-based online classes [80, 83]. Learnersourcing systems [42] can be viewed as one type of peer learning systems as they harness data sources from past peers to benefit future learners. For example, LectureScape [43] and ConceptScape [53] help learners navigate online lecture videos using interaction data gathered from past peers. AXIS [84] presents past learners' explanations to future learners. UpGrade [79] leverages past students' written solutions to generate deliberate practice opportunities for future learners. Foobaz [26] and OverCode [27] use past students' code solutions as a basis for instructors to offer feedback more efficiently. These systems leverage peers in two ways. On the one hand, peers can interact in real-time, offering each other feedback; on the other hand, peer-generated data can be employed as instructional opportunities.

As we mentioned earlier, teachers often do not get sufficient opportunities to practice and rehearse teaching in low stakes settings [31, 52]. We borrow the framework of role-play and simulation-based training that is often adopted in the medical and business domains for professional training [6, 59], for example, for medical students to rehearse doctor-patient conversations [40], for nursing students to develop nurse-to-doctor handover communicative competencies [13, 88], and for business students to learn and apply influence tactics [32]. A recent work by Thompson et al. explored digial simulations for teachers to approximate teacher-parent conversations [75]. In addition, a number of educational games have been developed to help English Language Learners (ELL) learn and practice conversational skills [66, 69] In the design of ELK, we draw ideas from online peer learning platforms and role-play based professional training programs to develop a scalable solution for teacher-student discourse training.

2.4 Cognitive Load Theory and the Decomposition of Practice

In current teacher training programs, when teachers do engage in low-stakes simulated practice, it is often in the form of "rehearsals" where participants practice teaching as an entire activity or give

a lesson to a group of simulated students [50]. Teaching is immensely complex, and research on complex learning suggests that novices often struggle to practice a whole complex assemblage while improving at specific elements of the task [44]. Rehearsals of the whole assemblage of teaching, therefore, should be complemented by opportunities to practice more discrete skills and judgments in teaching practice [67]. In order to develop an awareness of and vocabulary for understanding students ideas, we use the conceptual framework of decomposition of practice. Decomposition facilitates learning complex tasks by reducing the activity into smaller, more manageable parts [31]. These smaller parts facilitate learners' reflection on their own behavior, and helps develop a shared language around instructional activities [56].

Although rehearsing the whole assemblage of teaching provides opportunities for authentic learning experiences, a downside is that these rich experiences may consume most of a learner's available cognitive load when they have not mastered the skills and knowledge needed to be successful at the activity. As suggested by the cognitive load theory, if the problem itself is sufficiently demanding, students may not have enough cognitive resources to learn from solving the problem [4, 63]. In the design of ELK, we purposefully decomposed learning about effective talk moves and acting out in authentic contexts. This drives our design of ELK as a text-based interface in the first place. We will come back to this again in the future work section about introducing more modalities to enrich the experience in ELK.

We implement a supplementary "Coding" activity in ELK grounded in cognitive science and instructional design. As shown in Figure 4, users assign a questioning move to each line of an authentic transcript generated from previous role-play sessions. The design of this activity is again motivated by the cognitive load theory[3, 21], aiming to further reduce the cognitive load required in learners and allow them to focus on the learning task. Prior work has shown that in some domains, evaluating the quality of solutions can support learning and performance on generating solutions afterwards, even with higher learning efficiency compared with practicing with generating solutions only. For example, Yannier et al. shows that evaluating "which towers would likely to fall" can be more effective in teaching kids physics principles around gravity and balance compared to having kids continuously build towers with LEGO [86]. Wang et al. shows that evaluating candidate solutions is equally effective in teaching college students how to design good survey questions compared to having students practice through generating survey questions [78, 79]. Ericsson et al. shows that when teaching programming, having students solve Parsons problems, i.e., evaluating the correctness and ordering of code snippets is equally effective for learning compared to having them write the equivalent code. However, prior work mostly focused on technical skills that do not require interpersonal communication. For skills such as asking questions, it remains unknown whether evaluating responses can be a useful exercise, and whether it is more, less, or equally useful for learning as generating improvisational responses to scenarios. For ELK, the "Coding" activity would be especially helpful when a partner is not present, giving users more independence in using the system.

3 ELK: A ROLE-PLAYING SIMULATION SYSTEM

ELK aims at helping teachers develop effective questioning strategies. The major function of ELK is a text-based role-play simulation, in which two players chat based on pre-written profiles. The goal is for the "Teacher" player to develop effective questioning moves in eliciting the "Student" player's knowledge. We adopted a text-based interface, in which players type to communicate. There are several considerations for designing the first iteration of ELK as a text-based interface. First, prior work has found some role-play activities to be overly challenging and can cause performance anxiety in players [32]. Second, text-based interface may reduce the cognitive load required from pre-service teachers as they role-play. Although this differs from the authentic teaching experience

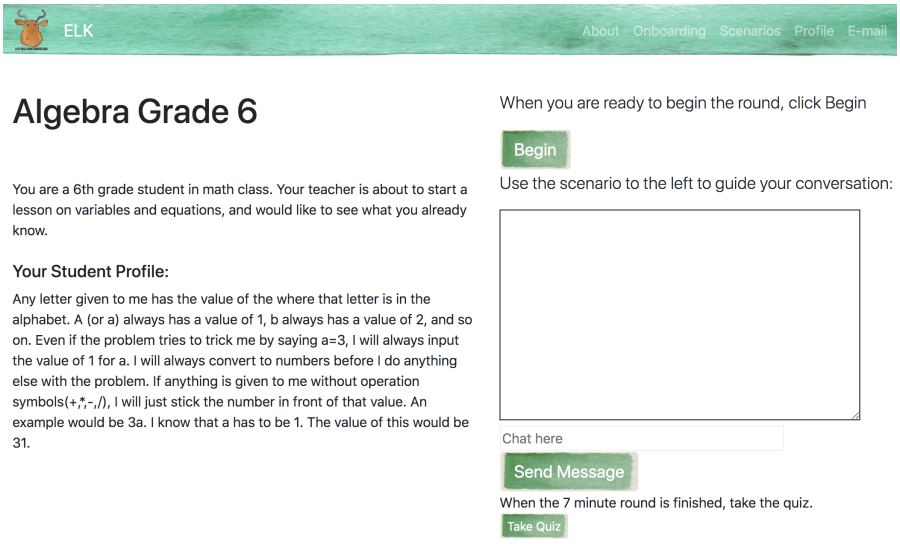

Fig. 1. "Role-play" interface in ELK for the "Student" player. The profile is shown on the left, including the student's (mis)conceptions about the topic. Players chat on the right.

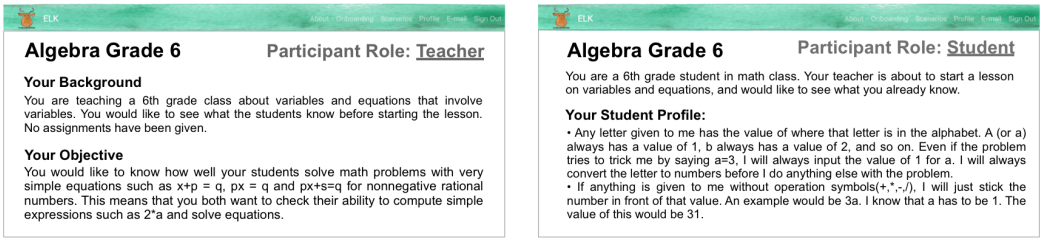

Fig. 2. Teacher and student profiles on the topic of Grade 6 Algebra

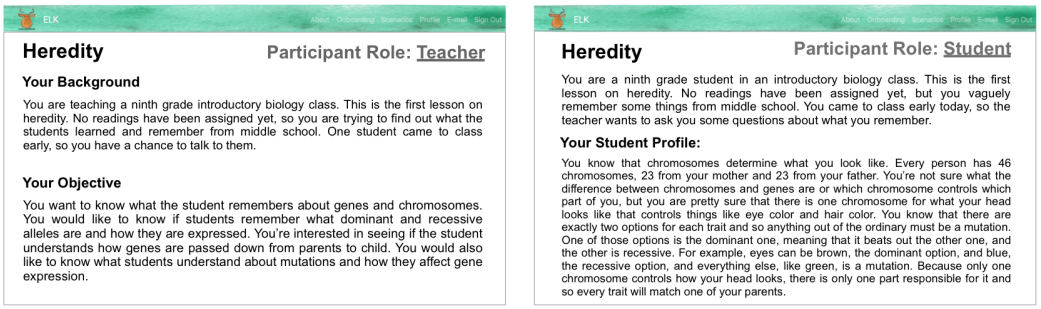

Fig. 3. Teacher and student profiles on the topic of Heredity

people may have, the goal of ELK is to provide focused practice for users to learn questioning moves without the cognitive load required in managing other aspects of their behaviors. Third, text-based

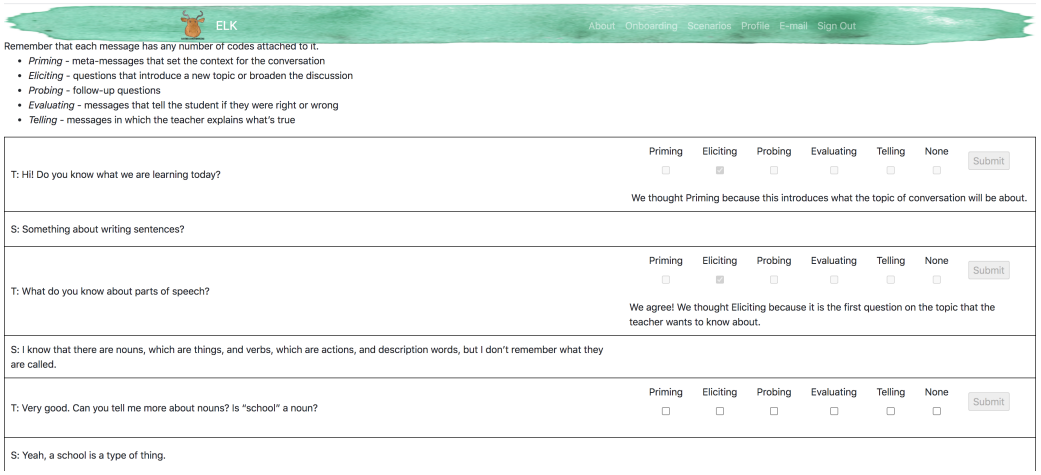

Fig. 4. "Coding" activity in ELK. The user reads an authentic‘ transcript generated from past role-play sessions and assign a questioning move to each line in the transcript.

communication provides more transparency into the process as players can review and adjust their performance accordingly [54]. Finally, from an application standpoint, the current form is low-cost, low-stake, more accessible and readily deployable. Players can engage any time, without the requirement of a camera or microphone. ELK is publicly available at: https://newelk.herokuapp.com.

3.1 Text-based Role-Play

3.1.1 Activity. The text-based role-play requires two players to be online at the same time and engage in conversations. Two players each take the role of a "Student" or a "Teacher". After entering the platform, players first select a topic, e.g., grade 6 algebra, or grade 3 multiplication. The interface for the "Student" role player is shown in Figure 1. The profile on the left specifies the prior knowledge held by the player, and the player should play out this persona. The "Teacher" role player enters the same interface with a"Teacher" profile. Two example pairs of "Teacher" and "Student" profiles are displayed in Figure 2 and Figure 3. These profiles are pre-written by researchers in the area and senior K12 teachers. Players press begin to start the conversation, each session takes 7 minutes. The goal of the "Teacher" player is to elicit as much prior knowledge from the "Student" player as possible.

3.1.2 Feedback. Both players take a quiz in the end in which they answer three True/False questions about the (mis)conceptions in the "Student" profile. For example, in the "Student" profile shown in Figure 1, a misconception is that the variable a is always equal to 1. One corresponding question in the quiz is: Is this statement "a+4=6 means that a=2" True or False? If the "Teacher" player understood the "Student" player's misconception, they would answer False, otherwise True. The quiz gives the "Teacher" player feedback on whether they successfully elicited the learner's knowledge.

3.2 Coding Activity

3.2.1 Activity. In the "Coding" activity, users read authentic transcripts generated from previous role-play sessions. We apply the five-part questioning framework in the coding activity. Users first read descriptions about each of the five questioning moves and then assign a move to each line

in the transcript, as shown in Figure 4. We consider the "Coding" activity as a novel example of a learnersourcing activity [42] using past conversation transcripts as input.

3.2.2 Feedback. To enable real-time feedback to players, two experts from the development team coded 5 transcripts in the dataset. With the labeled transcripts, the system provides real-time feedback to users after they make a selection and click submit. Example feedback is displayed in Figure 4.

4 EVALUATION OF ELK

The evaluation study aims to address the following three research questions.

RQ1: How effective is ELK in helping users develop questioning strategies and understand student misconceptions?

RQ2: How effective is the "Coding" activity? How does it compare to the "Role-play" activity in helping participants learn questioning moves?

RQ3: What are users' experiences with ELK and what challenges do they encounter? How can we better design systems for communication strategy training?

4.1 Participants

To address the above questions, we wanted to evaluate our system with pre-service teachers who are learning about classroom discourse and questioning moves. We reached out to teacher training programs at a small liberal arts college in the Mid-Atlantic region. Three faculties from the liberal arts college signed up to use ELK in their classes. In total, 75 participants, who are enrolled in an undergraduate teacher education program, completed the study.

4.2 Study Components

In response to RQ1, we adopt a mixed-methods approach and use both performance and self-reported measures to assess participants' behavioral and conceptual change on eliciting learner knowledge. In order to examine participants' behavioral change on adopting effective questioning moves, we use a performance measure by quantifying the effective questioning moves "Teacher"

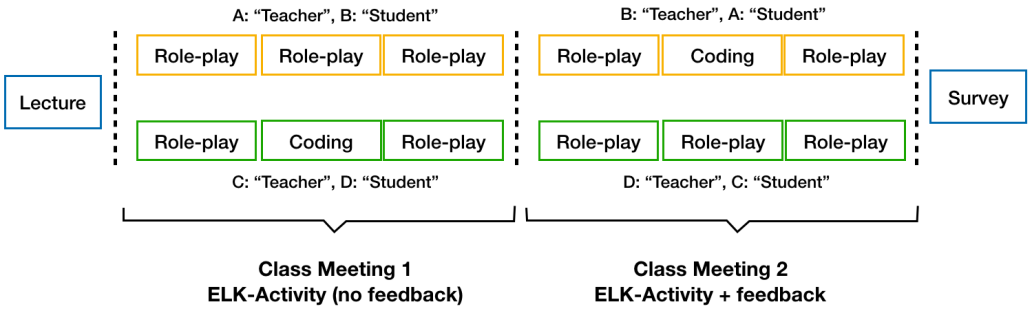

Fig. 5. The study spans two 90-minute class meetings. In the first class meeting, participants play three rounds of ELK without feedback. This means for the "Role-play" activity, the quiz is disabled, and for the "Coding" activity, participants do not get feedback after making a selection. Participants are paired and assigned to one of the two conditions. The only difference is whether they complete the "Role-play" or the "Coding" activity in the second round. In the second class meeting, participants play three rounds of ELK with feedback. Participants remain in the same pair and switch roles. The pairs that did the "Coding" activity in Round 2 will now do the "Role-play" activity in Round 5 and vice versa.

players displayed in the role-play chats. We design the study so that participants use ELK for multiple rounds, which enables us to see their behavioral change over time. In order to gauge participants' conceptual and attitude change, we design an in-depth survey asking participants to reflect upon their experiences.

In response to RQ2, in order to understand whether the "Coding" activity is helpful, we design an experiment to compare the effectiveness of the "Coding" activity with the "Role-play" activity in helping participants adopt effective questioning moves. One consideration here is that the "Role-play" and the "Coding" activities have different feedback mechanisms. Feedback for "Role-play" is provided through a post-hoc quiz, and feedback for the "Coding" activity is provided immediately as participants evaluate transcripts. To make a fairer comparison and make the results applicable for cases when feedback is not readily available, we decide to tease the effect of feedback apart from the activity itself. We administer two versions of both activities, a version without feedback, and a complete version as introduced in Section 3.

In response to RQ3, we include questions in the survey asking about participants' experiences and the challenges they encounter when using ELK. In the study design, we make sure that all participants experience both "Role-play" and "Coding" activities, and have played both "Teacher" and "Student" roles in the role-play sessions, so that they can comment on all aspects of the design of ELK.

4.3 Procedure

The study was conducted as a part of a teacher education course at the liberal arts college. we communicated the experimental procedure with the three course instructors that signed up, and they implemented the same procedure in their classes. The study spans across two 90-minute class meetings. An overview of the procedure is shown in Figure 5. Overall, there are four groups of participants, labeled as A, B, C, and D as shown in Figure 5. As an example, the sequence of activity for a participant in group A would be: Round 1 - "Teacher" in role-play with no feedback; Round 2 - "Teacher" in role-play with no feedback; Round 3 - "Teacher" in role-play with no feedback; Round 4 - "Student" in role-play with feedback; Round 5 - Coding with feedback; Round 6 - "Student" in role-play with feedback.

In the first class meeting, the instructor first gave a short lecture on how to elicit learner knowledge, covering effective and ineffective questioning moves. Participants then used ELK for three rounds, for about 30 minutes in total. Participants were randomly divided into two conditions and were paired within each condition. For each pair, one participant assumed the role of "Teacher", and the other assumed the role of "Student" for the entire class meeting. The only difference between the two conditions is whether they did the "Role-play" or the "Coding" activity in the second round. For the "Role-play" sessions, the "Teacher" profile is consistent across three sessions to reduce the amount of background knowledge and reading required, but the "Student" profiles are different in all sessions to make sure the "Teacher" role still needs to adjust their questioning moves to be able to elicit knowledge from their partners. For the first class meeting, we disabled the feedback function for both activities, meaning participants do not do the quiz at the end of the "Role-play" chat, and do not receive feedback when they evaluate the transcripts.

In the second class meeting, all participants remained in the same pair and switched roles. This means that the participant who played the "Teacher" role will now play as a "Student" with the same partner. The pairs that did the "Role-play" activity in Round 2, e.g., A and B, will now complete the "Coding" activity in Round 5, and vice versa. Feedback is enabled for both the "Role-play" and the "Coding" activities.

At the end of the second class meeting, all participants would have experienced all roles and activities in ELK. We sent a survey via Google Form that asked participants to reflect on their

experiences in ELK. We consider this design to best utilize the participant resources we have and provide us with insights about the effectiveness of ELK.

4.4 Outcome Measures

4.4.1 Frequency of Effective Questioning Moves in Role-play Chats. This learning outcome measure only concerns participants who play the role of "Teacher" in the role-play sessions. We developed a coding framework to gauge the quality of questions asked by the "Teacher" player. The coding framework was developed based on prior work on how to elicit learner knowledge. As we develop the coding manual, we make sure that on the one hand this can cover the nuances between questioning moves we have seen in our pilot data, such as "Eliciting" and "Probing". On the other hand, we also make sure this connects with existing work on what types of questioning moves are effective, so that it can help us quantify the quality of questions being asked by the players.

A brief version of the coding manual is shown in Table 1. The full version can be found at https://web.eecs.umich.edu/~xwanghci/ELKCoding.pdf. In the coding manual, for each category of questioning move, we provide multiple examples including explanation of edge cases. As shown in 1, "Priming", "Eliciting" and "Probing" are considered to be effective moves in understanding what the students already knew, whereas "Telling" is considered as an ineffective move towards eliciting student knowledge and does not support student-centered classroom conversations. "Evaluating" moves often lead to "Telling" messages that also do not contribute to understanding student (mis)conceptions. When counting the frequency of effective questioning moves in a chat, we summarized the number of "Priming", "Eliciting" and "Probing" messages uttered by the "Teacher" player. The five categories are not mutually exclusive, meaning each line of the teacher's dialogue can have multiple codes. As shown in Figure 7, the orange texts indicate the questioning moves assigned to each line of the "Teacher" role's dialogue. The excerpt to the left has a total of 5 effective questioning moves, and the excerpt to the right has a total of 9 effective questioning moves. The coding framework enables us to quantify the quality of questions asked by the participants.

The coding manual was developed and refined through an iterative process. Two of the authors first independently coded subsets of the dataset and addressed disagreements, enriched the definitions and examples in the coding manual, and added categorization for edge cases. When the coding manual is complete, two of the authors independently coded 100 lines of "Teacher" dialogues and reached high agreement on all 5 categories in the coding manual, with Cohen's Kappa of 0.73 for "Priming", 0.8 for "Eliciting", 0.72 for "Probing", 0.76 for "Evaluating" and 0.78 for "Telling". One author continued to code all transcripts in our dataset following the coding manual.

4.4.2 Open-ended Survey. In addition to behavioral changes, we are also interested in knowing participants' experiences of using ELK. To achieve this goal, we administered an open-ended survey at the end of the second class meeting. The survey questions include:

- *Please let us know more about how ELK may or may not have helped you learn questioning strategies for eliciting learner knowledge*
- *Please let us know more about how ELK may or may not have helped you learn about students' conceptions about a specific topic (e.g., algebra or heredity)*
- *Did you change the way you asked questions during the game? Please elaborate on your answer above.*
- *What, if anything, did you find difficult about role-playing in ELK?*
- *What suggestions do you have for improvements to ELK?*

Questioning Move	Definition	Example
Priming	These are meta-messages that set the context for the conversation. They might appear at the beginning of the conversation or later to bring the conversation back to the topic/goal.	[after a student asks, "Is that right?"] I will tell you all about that during class today, but for now I just want to understand your ideas.
Eliciting	These are questions that introduce a new topic or broaden the discussion.	Teacher: If I were to give you x+p=q, would you know how to solve? What do you know about the area of a circle?
Probing	These are follow-up questions that go deeper into what the student thinks. It is often impossible to tell the difference between Eliciting and Probing messages without context.	Teacher: What do you know about word order? (Eliciting) Student: The noun comes before the verb. Teacher: Is this always true? Or are there ever nouns after verbs in a sentence? (Probing)
Evaluating	These messages tell the student if they were right or wrong, either explicitly or implicitly. They often lead to Telling messages and distract the student from the goal of figuring out their preconceptions.	That's right. Not quite.
Telling	These are messages in which the teacher explains what's true. While important during instruction, they are distracting if the goal is to figure out what the student already knew or believed.	The circumference of a circle in $2\pi r$.

Table 1. Brief version of the coding manual, with definitions and examples of the 5 questioning moves.

4.5 Survey Analysis Method

After we see the survey responses, we realized that many participants shared their experiences, takeaways, and challenges in their answers regardless of which question they were responding to. In our analysis, we broke down the boundaries between the questions and conducted a thematic analysis [10] of all the participants' responses. First of all, two of the authors read and familiarized themselves with all the responses. They then did open coding of all of the responses independently. The two authors met and went over each of their comment and merged all the ideas into a list of themes. The two authors discussed and summarized 6 major themes from the data with a list of sub-topics within each theme. We will present our findings in response to each of the research question in the next section.

5 RESULTS

In the experiment, all 75 participants played the "Teacher" role. The number of participants in each condition is shown in Table 2. Through a thematic analysis of the survey responses, we identified 6 major themes, including 1) Awareness about eliciting learner knowledge, 2) Adaptation in questioning moves throughout the process, 3) Gaining perspectives about the student stakeholder, 4)"Coding" helps 5) Unfamiliarity with the content domain makes it difficult, 6) Tweaks about ELK features can make it better. We present both experimental results and survey finding in response to each of the three research questions.

Participants #	Round 1	Round 2	Round 3	Feedback
19	Role-play	Coding	Role-play	disabled
18	Role-play	Role-play	Role-play	disabled
19	Role-play	Coding	Role-play	enabled
19	Role-play	Role-play	Role-play	enabled

Table 2. Distribution of participants across conditions

5.1 Effectiveness of ELK

5.1.1 Participants displayed modest increase in effective questioning moves from Round 1 to 3. We ran a paired t-test on the total number of effective questioning moves from Round 1 to Round 3 for all participants across conditions. We see that participants displayed significantly more effective moves in Round 3 compared to Round 1 (p = 0.01). The average number of effective moves per chat in Round 1 was 4.9, and the average number in Round 3 was 5.6. The average number of effective moves across conditions is shown in Figure 6. We see a trend that for all conditions, participants show modest increase in positive questioning moves.

Here is one example of behavioral change from Round 1 to Round 3 by P68 (Figure 7). In Round 1, as shown in the transcript to the left, the participant used multiple "Telling" messages. P68 directly told the student what was the correct answer, without trying to understand why the student came to a wrong answer in the first place. However in Round 3, as shown in the transcript to the right, under a similar circumstance where the student made a mistake, P68 started to use "Eliciting" and "Probing" questioning moves to understand why the student made the mistake. We have attached two additional full transcripts from the study in the Appendix.

5.1.2 Participants showed more awareness about eliciting learner knowledge. One emerging theme from the survey responses is that participants disclosed they realized the importance of understanding student knowledge and began to set expectations about what they would experience when they

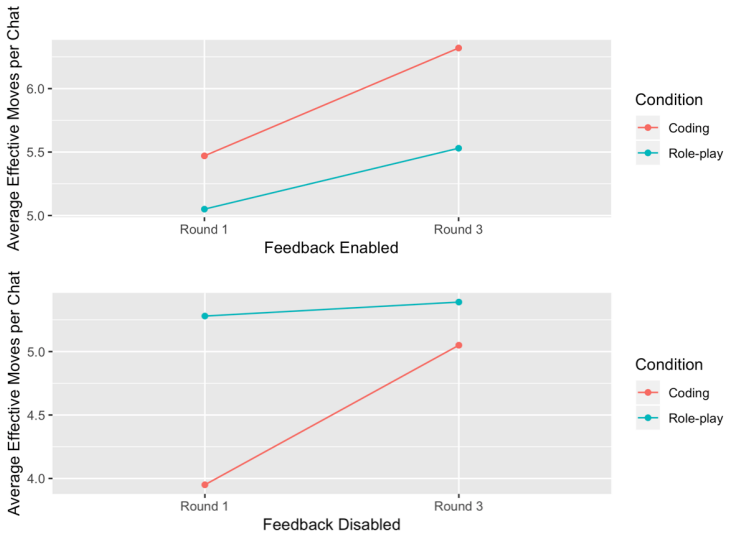

Fig. 6. Participants increased positive questioning moves from Round 1 to Round 3 across conditions.

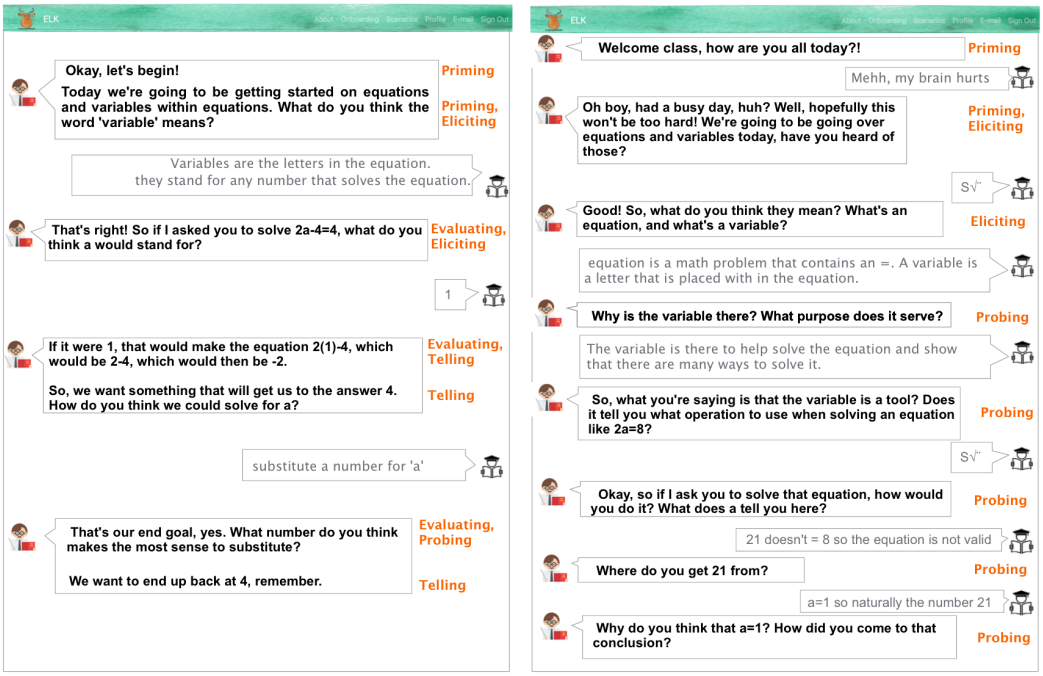

Fig. 7. Left: excerpts from Round 1 of P68 playing the "Teacher" role. The participant used multiple "Telling" moves and directly told the student the correct answer when the student made a mistake. Right: excerpts from Round 3 of P68 playing "Teacher" role. When the student gave an unexpected answer, P68 used "Eliciting" and "Probing" moves to understand the thinking process of the student.

became teachers. On the one hand, some participants mentioned that they became to realize how difficult it is to understand student thinking and the frustration they could experience as teachers, *"This just showed me how difficult it is to find deficiencies or misconceptions. You almost need to know what you are looking for. And open ended question will not suffice sometimes. I enjoyed practicing as the teacher. It helped. (P37)"*, *"It gives me an insight as to what it is like to be a teacher and have students not understand the concept of a topic or not remember. It is very frustrating. (P21)"*

Participants also shared the conceptual knowledge they have gained throughout the process, for example P42 said : *"It helped me to really know the difference between eliciting and probing and how to ask good, open-ended probing questions."*, and P71 said : *"ELK helped me learn how to ask particular questions to get students to reconsider their answers and think of new ideas. Directly telling a student if they are right or wrong is ineffective and should be used sparingly. Teachers should guide students to new knowledge by asking questions that prompt their thinking."*

5.1.3 Participants talked about adaptation of questioning moves throughout the process. This is an important theme we summarized from the survey responses. Participants talked about how they changed their tactics in asking questions as they engaged with ELK. Participants mentioned that they are now trying to ask more questions and explain less. *"I made a few changes to the way I asked questions and I ended up asking more questions rather than trying to explain the material (P44)"* More specifically, P8 who played the teacher role teaching the topic of heredity said: *"Instead of saying what a gene was and then asking a question I started from the very beginning I asked do you know what a gene is?"*

People also talked about switching from fact-based questions to more open-ended ones. *"Rather than asking yes or no questions, i tried to ask questions that made the student participate in the discussion. Open-ended, leading questions helped to let me know what the student knew. (P6)"*, *"Also asking questions that get the students to expand on what they know and why they knew what they did and how they got it. (P23)"*

Participants mentioned adapting their questions to the student responses allowed them to more quickly get at students' prior knowledge and misconceptions. For example, P20 mentioned how they changed from Round 1 to Round 2: *"I started out asking standard questions about the topic. I made slight changes to my approach during the next round. In the 2nd round, I asked the student to explain their reasoning to me so that I could understand their misconceptions."* P50 and P8 shared their experiences of tweaking questions based on the students' responses in order to more effectively elicit their students' prior knowledge. *"If the student seemed to know more about a certain area I would continue on that path. If it seemed like they didn't I would veer to another realm of the subject. I tried to learn as much about what the student knew. (P50)"*, *"Some questions I asked only got me generic answers that, while still helpful, were only helpful in finding out what my student definitively knows about the basics, but not what they know about the subject at hand. So I was able to tweak my questions to get to the heart of the matter more quickly."*

Some participants referred to the questioning moves they have learned in ELK and shared their experiences of using them. P8 and P29 talked about using probing and eliciting questions in their conversations: *"Probing questions, giving praise and minor corrections when needed to encourage the student to keep talking to me. (P8)" "I tried to ask a variety of general (eliciting) questions along with probing questions to get a good balance in the conversation (P29)"* While P49 shared that by changing the wording of the questions, the questions could be more useful in eliciting the learner's prior knowledge. *"I really only changed the wording of my questions. Probing questions were still probing, but they became more like leading questions, where I was actively trying to get information out of the student, instead of just passively seeing what the student knows. (P49)"*

5.1.4 Participants disclosed that they gained the perspectives of students through role-playing as students in ELK . This is an important emerging theme from the survey responses and many participants talked about the benefit of switching perspectives in the role-play. Some participants disclosed that knowing what a student may think through acting out as a student was "eye-opening".

For example, P8 said after role-playing as a "Student": *"Students can come up with some odd associations, and seeing some of them written out helped remind me to be more flexible as a teacher because sometimes the associations make sense to others as well, and sometimes they only barely make sense to the student, so the teacher needs to be patient and open-minded."*

P17 gave a more concrete example of a student misconception they would never have thought of after role-playing as a "Student": *"When learning about variables, students thought the alphabet and the certain letter was paired up with where the number is in the alphabet. I never thought about it like that until then."*

Participants also mentioned that playing ELK helped them understand that every student is different and thus understanding student thinking is critical yet challenging. *"It shows that all students have different knowledge and different ways of thinking, and teachers must adapt quickly to answer questions that their students have. (P74)", , "ELK taught me that each student has a different concept of a topic. It is the job of a teacher to work through that and help the individual but also the whole class. (P50)" , "I learned that unless you ask the right type of questions students aren't going to be able to explain what they know randomly. (P4)" "ELK also made them realize that it was not easy to get information out of students. (P5)"*

5.2 "Coding" is an Effective Supplementary Activity in ELK

In order to evaluate the effectiveness of the "Coding" activity, we used the "Role-play" activity as a control condition in the experiment design. On the one hand, the feedback mechanism for both activities are very different. On the other hand, considering broader use cases of evaluation-type activities for learning communication strategies, expert annotated transcripts and feedback may not always be available. Because of these reasons, in the first half of the experiment, we disabled the feedback feature in ELK. This is to investigate to what extent is evaluating transcript helpful even when feedback is absent, when comparing to generating question moves in role-play sessions. In the second half of the experiment, we enabled the feedback feature in ELK, the goal is to compare both activities using the full setup in ELK.

In both cases, the second Round, being either "Coding" or "Role-play" is the intervention, and we compare their impacts on participants' use of questioning moves from Round 1 to Round 3. We run two separate comparisons for the first half (ELK without feedback) and the second half (ELK with feedback) of the experiment.

We run a repeated-measures linear regression model on the long table format of the data, with each row being an observation. Each participant has two rows, with one being the performance for Round 1 and the other for Round 3. We use the number of effective questioning moves as the dependent variable, and the independent variables include Condition (a binary variable indicating whether Round 2 is "Role-play" or "Coding"), Round (a binary variable indicating whether this observation is from Round 1 or Round 3), and the interaction between Condition and Round. We included a random intercept for each participant ID in the model to account for individual differences. For both settings, the estimates of the parameters in the model are displayed in Table 3.

Both models show that participants demonstrated modest increase in questioning moves from Round 1 to Round 3 regardless of whether they did "Role-play" or "Coding" in Round 2. As shown in Figure 6, one big limitation of this experimental study is that the randomization did not work. In the no feedback setting, participants in the two conditions had significant difference in their performance in Round 1, with participants in the "Coding" condition being lower performing. Even though the "Coding" condition had a bigger leap in the no feedback setting, also indicated by a weak interaction between Round and Condition in Table 3, it is not clear whether it is because it is harder for participants in the "Role-play" condition to improve.

We want to point out here that having participants evaluate transcripts could be a useful activity for beginners. Even though we do not observe a significant difference between the two conditions, there is a weak marginal interaction effect for the no feedback setting, suggesting that the "Coding" condition has a higher increase compared to the "Role-play" condition as shown in Figure 6. In the "Coding" condition, participants experienced both role-play and coding activities, whereas in the "Role-play" condition, participants only did the role-play activity. We have tentative evidence that a combination of question generation and evaluation practice may be more effective than question generation practice alone in increasing the use of effective questioning moves. The coding activity can be especially helpful when it is hard to find partners to role-play.

5.2.1 Coding activity experiences. In the survey, participants also talked about their experiences with the coding activity. Some participants found the "Coding" activity to be helpful for them to understand the questioning moves. *"Coding transcripts really helped me to understand the difference in question types (P37)"*, *"I liked being the teacher because I thought it was easier to be the teacher, especially after doing the coding. It was easier to guide the conversation and focus on gathering the student's knowledge. (P11)"*, *"It really had me thinking and what I was doing as a Teacher and a Student. I really liked the Coding activity we did, it helped out understanding the different ways teachers interact with the students."*

	No Feedback Setting		**With Feedback Setting**	
	Coefficient Estimate	p-value	Coefficient Estimate	p-value
Condition (Role-play)	0.11	0.10	-0.04	0.65
Round (Round 3)	0.09	0.018*	0.07	0.13
Interaction Term	-0.08	0.13	-0.03	0.63

Table 3. Parameter estimates and p-value for both repeated-measures linear regression models comparing the effectiveness of "Coding" and "Role-play" activities. Both models show that there is no observed difference between the two conditions, and the trend is favoring the "Coding" condition.

Some participants said that the coding practice made them change their questioning moves. For example, P74 said: *"After the coding and switching roles I changed my answers by using the different types of questions and my questions also changed based on the students prior knowledge about the subject."*

5.3 User Experiences, Challenges and Feedback

5.3.1 Unfamiliar content makes it very difficult. This is the most prevalent theme we have identified from the survey responses. Many participants found the content domain to be critical for successful role-play. Some participants said that if they were not familiar with the content, e.g., heredity, it was hard for them to think of questions to elicit learner knowledge. *"Make the content easier and maybe geared toward a younger age group. It's hard to be the teacher when you don't know whether the student is right or wrong."* , *"Please provide teachers with a brief overview of the material because the content was really getting in the way. Or revise the material and make it simpler. "*

5.3.2 Trying to stay in character is hard. When taking the role of a "Student", participants find it hard to stay in character, especially when they do not have the same conceptions about the subject matter. Participants mentioned that trying to separate the role-play from their real-world knowledge is challenging. For example, P43, P2 and P3 said: *"Trying to stay in character was difficult. It was hard not to elaborate on answers with too much information before the teacher asked the question. You really had to have balance in how much you said and let the teacher try to pull it from you, rather than trying to help your friend who was playing the teacher."* , *"It's hard to separate my real-world knowledge from the student's. Acting as though I am confused or have limited knowledge is far harder than acting like I know more than I do. (P2)"*, *"it was kind of difficult because when I knew the answer was wrong I wanted to be able to answer it correctly and explain myself but I still had to follow the profile (P3)"*

5.3.3 Multiple opportunities and realistic experience through simulation. Participants enjoyed having multiple opportunities to tweak questions and appreciated the seemingly real experience provided by ELK. For example, P 42 said: *"It allowed me to play around with questions in order to elicit what they students already know (their conceptions).(P42)"*

P43 and P1 talked about having realistic experiences in ELK: *"ELK was really cool because it gave you seemingly real experience in trying to see what a student may or may not know about a topic". (P43)" "The student profiles seemed to have much more detailed information about what students knew and what they misunderstood. They seemed pretty realistic. I'm never going to be teaching algebra, but I can see how a student would be very confused and just think that a=1 no matter what. (P1)"*

5.3.4 Provide more flexibility in the system. Participants also wanted to have more flexibility with the length of the sessions, with some hoping the sessions to be longer, and other hoping them to be shorter. *"Bit longer time for the rounds, please. Seven minutes is not really enough when you're not talking audibly, and have to type; not everyone can type super fast. " (P8)* , *"I felt rushed to ask so many questions in the short 7 minutes. I felt like time was up just when I was getting started." (P59)* *"Maybe a 5 minute simulation instead of 7, and give more background for the teacher. " (P56)*

6 DESIGN IMPLICATIONS

Although ELK is a domain-specific solution that provides training for teachers on eliciting student thinking, we consider the insights gained from this study applicable in developing systems for training communication strategies across contexts. Communication and interpersonal skills are critical for many professions, such as medical workers [40], researchers [11], and teachers [24]. One consistent challenge with the training of communication skills is that practice and rehearsal opportunities are limited and people are often expected to pick up the skills "on the job" as they converse[13, 32, 40, 88].

Role-play simulations show promises of providing practice and rehearsal opportunities for novices learning about communication strategies in a low-stakes environment, for example, for medical students to rehearse doctor-patient conversations [40], for nursing students to develop nurse-to-doctor handover communicative competencies [13, 88], and for business students to learn and apply influence tactics [32]. With the design, development and evaluation of ELK, we provide insights on how future systems could be designed to provide scalable communication strategy training across contexts.

First, role-play is found to be a promising framework to provide scalable collaborative learning experience in learning communication strategies. In domains other than teacher education, e.g., mentoring, consulting, medical and business training, role-play platforms can be adopted. On the one hand, it provides a collaborative experience that is engaging and at scale, on the other hand, it provides practice and rehearsal opportunities in a low-stakes environment. Second, we found that role-play helps participants gain perspectives of relevant stakeholders. In other contexts where stakeholders often hold diverse or opposite perspectives, e.g., AI ethics education and communicating algorithm tradeoffs [71, 87], similar approaches can be adopted to facilitate perspective taking and empathy building among stakeholders. Third, the components within ELK that made it work could be applied in developing systems that facilitate communication strategy training in a variety of contexts. For example, the decomposition of practice reduces the cognitive load from learners as it gives players more time to think and reflect without the need to manage other aspects of their behaviors. Offering focused practice through evaluating past transcripts is also a useful activity, and can happen without the presence of a partner. We describe the design implication in detail below.

6.1 Content Domain Knowledge is Essential

As mentioned by many participants, if they were not familiar enough with the content domain, it gets in the way of practicing communication skills. Participants also talked about providing a bigger pool of "Teacher" and "Student" profiles for players to choose from. For example, P20 said: *Please add different subjects. I'm a history and political science major. I don't remember much from biology class.* , and P1 said: *"Please include more topics that have to do with the humanities! I know very, very little at this point about algebra and biology."* We are implementing a new feature in the system now that enables players to contribute "Teacher" and "Student" profiles. The goal of this is to enrich the profile pool to give players more options to choose from.

In addition to supporting teachers develop classroom discourse, this also applies to exercising other types of communication skills through role-play simulations. Allowing users to customize user profiles and providing background content knowledge to users could better prepare them to focus on developing the communication strategies of interest.

From the study we also learned that when participants know the subject matter very well, it requires some form of extra "acting" and some form of "restraint" to be able to provide the nuance of confusion as a "Student" without giving too much to the "Teacher" role. One role-play feature that would be useful to explore in systems similar to ELK is the allocation of roles between participants, e.g., when the participant is unfamiliar with the content domain, they can be good candidates for the "Student" role.

6.2 Role-Play Helps Participants Gain Perspectives of Relevant Stakeholders

In our study, many participants expressed that ELK made them aware of student misconceptions and the very different thinking processes students may have. Participants found acting out as a student is "eye-opening" for them to gain perspectives as a student. In addition to teachers, many professions are interpersonal and involve multiple stakeholders, such as doctors and patients, judges and victims, and mentors and mentees. When supporting these professionals develop communication competencies, role-play systems have great potentials and an adds-on benefit of helping learners gain perspectives from other relevant stakeholders.

6.3 Focused Practice through Evaluation Activities

The experiment suggests that having novices evaluate past transcripts can be an effective instructional activity, which also has the practical benefit as it can be performed by a single participant alone. For future communication strategy training programs, such evaluation-type activities can be applied before role-play sessions to foster understanding.

6.4 Different Modalities of Role-Play

ELK is a text-based platform where participants type to communicate. The design consideration is to reduce the cognitive load from players to manage their behaviors. In the survey, participants also mentioned the inconvenience of a text interface where they have to type. For example, P9 mentioned that *"maybe more of a face to face interaction, it take a lot of time to type the responses"* Future design of such system could provide different modes of interaction, e.g., as users become better in eliciting learner knowledge with the original text interface, they can go ahead and try a speech-based version.

One participant raised a point that it was hard for adults to imitate 6th graders in the conversation. *"It was hard to find a balance between talking as if I really was in 6th grade and saying things I would actually say as an adult (using words like "correspond," for example."* Although the role-play sessions did not require the players to act like 6th graders, it is an interesting idea to scaffold players to talk in the same way as the persona specified in the profiles. This would offer a more realistic role-play experience for all participants.

7 LIMITATIONS AND FUTURE WORK

In this work, the effectiveness of ELK is evaluated in the role-playing sense and not when applied to a real-world scenario. This is a major limitation. This first experiment provides some initial insights on whether ELK works and why it works. We will continue to improve the platform and we will leave it to future work to fully evaluate the effectiveness of ELK in instilling the skill to teachers in authentic contexts after training. Here are some exciting future directions we would like to pursue. First, as suggested by our participants, future design could provide different modes of interaction

for users to choose from, e.g., text-based, speech-based and video-based. Users would thus have more flexibility in practice and rehearsal. Practicing in a speech-based or video-based environment would be more authentic and could potentially facilitate transfer of learning. Second, to promote culturally relevant pedagogy and encourage teachers to understand students' interests and needs in addition to questioning moves, future work could explore co-designing the player profiles with students to cater towards the topics that targeted students are excited about. Third, to support the role-play performance of the "Student" role, future work could increase the details in the "Student" profile and explore methods to assign roles to players based on their expertise. For example, the system could pose a survey on players' prior knowledge before assigning roles to them.

8 CONCLUSION

All across the helping professions – teaching, medicine, social work, clerical work, and so forth – eliciting thoughts, feelings, and understandings from people is a critical part of professional practice. In this work, we demonstrate a system that supports simulated practice of questioning strategies through two learning modalities: question generation and question evaluation. In a teaching context, we find evidence that ELK helps participants value learner knowledge, empathize with the challenges of students as they develop understanding of STEM topics, and increase their use of questioning strategies that effectively elicit learner knowledge. We have tentative evidence that a combination of question generation and evaluation practice may be more effective than question generation practice alone in increasing the use of teacher questioning strategies.

While the scenarios in ELK are customized primarily to deal with STEM topics; ELK could be customized to support the development of interpersonal skills in a wide variety of contexts and professions. ELK's digital platform supports a variety of educational implementations (in face to face classes, in online classes, as out of classwork, etc.) and collects data for participants, educators, and researchers to better understand how learners develop effective questioning strategies.

9 ACKNOWLEDGEMENT

This work was funded by the Woodrow Wilson National Fellowship Foundation and NSF grants ACI-1443068 and DRL-1740798. In addition, we thank Brandon Hanks, Gwen Jones, Denise Lindstrom, Jenny Martin, Anhong Guo and all our participants.

REFERENCES

[1] Karan Ahuja, Dohyun Kim, Franceska Xhakaj, Virag Varga, Anne Xie, Stanley Zhang, Jay Eric Townsend, Chris Harrison, Amy Ogan, and Yuvraj Agarwal. 2019. EduSense: Practical classroom sensing at Scale. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 3, 3 (2019), 1–26.

[2] Martha W Alibali, Mitchell J Nathan, Matthew S Wolfgram, R Breckinridge Church, Steven A Jacobs, Chelsea Johnson Martinez, and Eric J Knuth. 2014. How teachers link ideas in mathematics instruction using speech and gesture: A corpus analysis. *Cognition and instruction* 32, 1 (2014), 65–100.

[3] Susan A Ambrose, Michael W Bridges, Michele DiPietro, Marsha C Lovett, and Marie K Norman. 2010. *How learning works: Seven research-based principles for smart teaching.* John Wiley & Sons.

[4] Susan A Ambrose, Michael W Bridges, Michele DiPietro, Marsha C Lovett, and Marie K Norman. 2010. *How learning works: Seven research-based principles for smart teaching.* John Wiley & Sons.

[5] NC Anderson, SH Chapin, and CO O'Connor. 2012. Classroom discussions in math: A facilitator's guide to support professional learning of discourse and the Common Core. *Sausalito, CA: Math Solutions* (2012).

[6] Ewa Pihammar Andersson. 1993. The perspective of student nurses and theirperceptions of professional nursing duringthe nurse training progranune. *Journal of Advanced Nursing* 18 (1993), 808–815.

[7] Sinem Aslan, Nese Alyuz, Cagri Tanriover, Sinem E Mete, Eda Okur, Sidney K D'Mello, and Asli Arslan Esme. 2019. Investigating the impact of a real-time, multimodal student engagement analytics technology in authentic classrooms. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–12.

[8] Deborah Loewenberg Ball and David K Cohen. 1999. Developing practice, developing practitioners: Toward a practice-based theory of professional education. *Teaching as the learning profession: Handbook of policy and practice* 1 (1999),

3–22.

[9] John D Bransford, Ann L Brown, Rodney R Cocking, et al. 2000. *How people learn*. Vol. 11. Washington, DC: National academy press.

[10] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qualitative research in psychology* 3, 2 (2006), 77–101.

[11] Sara E Brownell, Jordan V Price, and Lawrence Steinman. 2013. Science communication to the general public: why we need to teach undergraduate and graduate students this skill as part of their formal scientific training. *Journal of undergraduate neuroscience education* 12, 1 (2013), E6.

[12] Julia Cambre, Scott Klemmer, and Chinmay Kulkarni. 2018. Juxtapeer: Comparative peer review yields higher quality feedback and promotes deeper reflection. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. 1–13.

[13] Narges Toghian Chaharsoughi, Shahnaz Ahrari, and Shahnaz Alikhah. 2014. Comparison the effect of teaching of SBAR technique with role play and lecturing on communication skill of nurses. *Journal of caring sciences* 3, 2 (2014), 141.

[14] S Chapin and Catherine O'Connor. 2012. Project Challenge: Using challenging curriculum and mathematical discourse to help all students learn. *High-expectation curricula: Helping all students succeed with powerful learning* (2012), 113–127.

[15] Nancy Van Note Chism, Matthew Holley, and Cameron J Harris. 2012. 9: Researching the Impact of Educational Development: Basis for Informed Practice. *To improve the academy* 31, 1 (2012), 129–145.

[16] Amy Shannon Cook, Steven P Dow, and Jessica Hammer. 2017. Towards Designing Technology for Classroom Role-Play. In *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*. 241–251.

[17] National Research Council et al. 2004. *How students learn: History, mathematics, and science in the classroom*. National Academies Press.

[18] Sandra Crespo. 2000. Seeing more than right and wrong answers: Prospective teachers' interpretations of students' mathematical work. *Journal of Mathematics Teacher Education* 3, 2 (2000), 155–181.

[19] Brent Duckor and Carrie Holmberg. 2017. *Mastering formative assessment moves: 7 high-leverage practices to advance student learning*. ASCD.

[20] Barbara J Ericson, James D Foley, and Jochen Rick. 2018. Evaluating the efficiency and effectiveness of adaptive parsons problems. In *Proceedings of the 2018 ACM Conference on International Computing Education Research*. 60–68.

[21] K Anders Ericsson, Ralf T Krampe, and Clemens Tesch-Römer. 1993. The role of deliberate practice in the acquisition of expert performance. *Psychological review* 100, 3 (1993), 363.

[22] Peter J Fadde and Gary A Klein. 2010. Deliberate performance: Accelerating expertise in natural settings. *Performance Improvement* 49, 9 (2010), 5–14.

[23] Erin Marie Furtak and Howard M. Glasser. 2016. Using Formative Assessment Data for Science Teaching and Learning. (2016).

[24] David Gerritsen. 2018. *A socio-technical approach to feedback and instructional development for teaching assistants*. Ph.D. Dissertation. Carnegie Mellon University.

[25] David Gerritsen, John Zimmerman, and Amy Ogan. 2018. Towards a framework for smart classrooms that teach instructors to teach. International Society of the Learning Sciences, Inc.[ISLS].

[26] Elena L Glassman, Lyla Fischer, Jeremy Scott, and Robert C Miller. 2015. Foobaz: Variable name feedback for student code at scale. In *Proceedings of the 28th Annual ACM Symposium on User Interface Software & Technology*. 609–617.

[27] Elena L Glassman, Jeremy Scott, Rishabh Singh, Philip J Guo, and Robert C Miller. 2015. OverCode: Visualizing variation in student solutions to programming problems at scale. *ACM Transactions on Computer-Human Interaction (TOCHI)* 22, 2 (2015), 1–35.

[28] Lynne Godfrey and Mary Catherine O'Connor. 1995. The vertical hand span: Nonstandard units, expressions, and symbols in the classroom. *The Journal of Mathematical Behavior* 14, 3 (1995), 327–345.

[29] Ricki Goldman, Roy Pea, Brigid Barron, and Sharon J Derry. 2014. *Video research in the learning sciences*. Routledge.

[30] Amelia Wenk Gotwals, Joanne Philhower, Dante Cisterna, and Steven Bennett. 2015. Using video to examine formative assessment practices as measures of expertise for mathematics and science teachers. *International Journal of Science and Mathematics Education* 13, 2 (2015), 405–423.

[31] Pamela Grossman, Christa Compton, Danielle Igra, Matthew Ronfeldt, Emily Shahan, and Peter Williamson. 2009. Teaching practice: A cross-professional perspective. *Teachers College Record* 111, 9 (2009), 2055–2100.

[32] Maria Riaz Hamdani. 2018. Learning how to be a transformational leader through a skill-building, role-play exercise. *The International Journal of Management Education* 16, 1 (2018), 26–36.

[33] Sara Hennessy, Sylvia Rojas-Drummond, Rupert Higham, Ana María Márquez, Fiona Maine, Rosa María Ríos, Rocío García-Carrión, Omar Torreblanca, and María José Barrera. 2016. Developing a coding scheme for analysing classroom dialogue across educational contexts. *Learning, Culture and Social Interaction* 9 (2016), 16–44.

[34] Kenneth Holstein, Bruce M McLaren, and Vincent Aleven. 2018. Student learning benefits of a mixed-reality teacher awareness tool in AI-enhanced classrooms. In *International conference on artificial intelligence in education*. Springer, 154–168.
[35] Bell Hooks. 2003. *Teaching community: A pedagogy of hope*. Vol. 36. Psychology Press.
[36] Bell Hooks. 2014. *Teaching to transgress*. Routledge.
[37] IES. 2020. Teacher characteristics and trends. https://nces.ed.gov/fastfacts/display.asp?id=28
[38] Andy Jacob and Kate McGovern. 2015. The Mirage: Confronting the Hard Truth about Our Quest for Teacher Development. *TNTP* (2015).
[39] Emily Jensen, Meghan Dale, Patrick J Donnelly, Cathlyn Stone, Sean Kelly, Amanda Godley, and Sidney K D'Mello. 2020. Toward automated feedback on teacher discourse to enhance teacher learning. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–13.
[40] Beres Joyner and Louise Young. 2006. Teaching medical students using role play: twelve tips for successful role plays. *Medical teacher* 28, 3 (2006), 225–229.
[41] Jeremy Kilpatrick, Jane Swafford, Bradford Findell, National research council, et al. 2001. *Adding it up: Helping children learn mathematics*. Vol. 2101. Citeseer.
[42] Juho Kim. 2015. *Learnersourcing : improving learning with collective learner activity*. Ph.D. Dissertation. Cambridge, MA, USA.
[43] Juho Kim, Philip J. Guo, Carrie J. Cai, Shang-Wen (Daniel) Li, Krzysztof Z. Gajos, and Robert C. Miller. 2014. Data-driven Interaction Techniques for Improving Navigation of Educational Videos. In *Proceedings of the 27th Annual ACM Symposium on User Interface Software and Technology* (Honolulu, Hawaii, USA) *(UIST '14)*. ACM, New York, NY, USA, 563–572. https://doi.org/10.1145/2642918.2647389
[44] Paul A Kirschner and Jeroen Van Merriënboer. 2008. Ten steps to complex learning a new approach to instruction and instructional design.
[45] Eric Knuth and Dominic Peressini. 2001. Unpacking the nature of discourse in mathematics classrooms. *Mathematics Teaching in the Middle School* 6, 5 (2001), 320.
[46] Herbert Kohl. 1994. I won't learn from you! Confronting student resistance. *Rethinking our classrooms: Teaching for equity and justice* 1 (1994), 134–135.
[47] Chinmay Kulkarni, Julia Cambre, Yasmine Kotturi, Michael S Bernstein, and Scott R Klemmer. 2015. Talkabout: Making distance matter with small groups in massive classes. In *Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*. 1116–1128.
[48] Chinmay E Kulkarni, Michael S Bernstein, and Scott R Klemmer. 2015. PeerStudio: rapid peer feedback emphasizes revision and improves performance. In *Proceedings of the second (2015) ACM conference on learning@ scale*. 75–84.
[49] Gloria Ladson-Billings. 1995. Toward a theory of culturally relevant pedagogy. *American educational research journal* 32, 3 (1995), 465–491.
[50] Magdalene Lampert, Megan Loef Franke, Elham Kazemi, Hala Ghousseini, Angela Chan Turrou, Heather Beasley, Adrian Cunard, and Kathleen Crowe. 2013. Keeping it complex: Using rehearsals to support novice teacher learning of ambitious teaching. *Journal of teacher education* 64, 3 (2013), 226–243.
[51] Douglas Larkin. 2012. Misconceptions about "misconceptions": Preservice secondary science teachers' views on the value and role of student ideas. *Science Education* 96, 5 (2012), 927–959.
[52] Arthur Levine. 2006. Educating school teachers. *Education Schools Project* (2006).
[53] Ching Liu, Juho Kim, and Hao-Chuan Wang. 2018. ConceptScape: Collaborative Concept Mapping for Video Learning. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (Montreal QC, Canada) *(CHI '18)*. ACM, New York, NY, USA, Article 387, 12 pages. https://doi.org/10.1145/3173574.3173961
[54] Janet Macdonald. 2003. Assessing online collaborative learning: process and product. *Computers & Education* 40, 4 (2003), 377–391.
[55] O Mary Catherine and Chairman Director Sarah Michaels. 1993. Aligning academic task and participation status through revoicing: Analysis of a classroom discourse strategy. *Anthropology & Education Quarterly* 24, 4 (1993), 318–335.
[56] Morva McDonald, Elham Kazemi, and Sarah Schneider Kavanagh. 2013. Core practices and pedagogies of teacher education: A call for a common language and collective activity. *Journal of teacher education* 64, 5 (2013), 378–386.
[57] Sarah Michaels and Catherine O'Connor. 2015. Conceptualizing talk moves as tools: Professional development approaches for academically productive discussion. *Socializing intelligence through talk and dialogue* (2015), 347–362.
[58] Luisa Molinari and Consuelo Mameli. 2013. Process quality of classroom discourse: Pupil participation and learning opportunities. *International Journal of Educational Research* 62 (2013), 249–258.
[59] Sonia Moore. 1984. *The Stanislavski system: Professional Traning of an Actor*. Viking Penguin Inc.
[60] NSF Inquiry Project. 2020. Talk Science Professional Development. https://inquiryproject.terc.edu/prof_dev/pathway5/index.html

[61] Catherine O'Connor and Sarah Michaels. 2007. When is dialogue 'dialogic'? *Human Development* 50, 5 (2007), 275–285.
[62] Mary Catherine O'Connor and Sarah Michaels. 1996. Shifting participant frameworks: Orchestrating thinking practices in group discussion. *Discourse, learning, and schooling* 63 (1996), 103.
[63] Fred Paas, Alexander Renkl, and John Sweller. 2003. Cognitive load theory and instructional design: Recent developments. *Educational psychologist* 38, 1 (2003), 1–4.
[64] Poskin, Jamie and Coker, Berk. 2020. TeachFX. https://teachfx.com/
[65] Anand Ramakrishnan, Erin Ottmar, Jennifer LoCasale-Crouch, and Jacob Whitehill. 2019. Toward automated classroom observation: Predicting positive and negative climate. In *2019 14th IEEE international conference on automatic face & gesture recognition (FG 2019)*. IEEE, 1–8.
[66] Curt Reese and Terri Wells. 2007. Teaching academic discussion skills with a card game. *Simulation & Gaming* 38, 4 (2007), 546–555.
[67] Justin Reich, Yoon Jeon Kim, Kevin Robinson, Dan Roy, and Meredith Thompson. 2018. Exploring Authenticity and Playfulness in Teacher Practice Spaces. (2018).
[68] Philip M Sadler, Gerhard Sonnert, Harold P Coyle, Nancy Cook-Smith, and Jaimie L Miller. 2013. The influence of teachers' knowledge on student learning in middle school physical science classrooms. *American Educational Research Journal* 50, 5 (2013), 1020–1049.
[69] Anisha Sasidharan and Kok Eng Tan. 2017. Pupils'and Teachers' Perceptions of a Language Board Game, Challenge. *The English Teacher* 3 (2017), 20.
[70] Meghan Shaughnessy and Timothy A Boerst. 2018. Uncovering the skills that preservice teachers bring to teacher education: The practice of eliciting a student's thinking. *Journal of Teacher Education* 69, 1 (2018), 40–55.
[71] Hong Shen, Haojian Jin, Ángel A Cabrera, Adam Perer, Haiyi Zhu, and Jason I Hong. 2020. Designing Alternative Representations of Confusion Matrices to Support Non-Expert Public Understanding of Algorithm Performance. *Proc. ACM Hum.-Comput. Interact.* 4, CSCW 2 (2020).
[72] Laurie Sleep. 2012. The work of steering instruction toward the mathematical point: A decomposition of teaching practice. *American Educational Research Journal* 49, 5 (2012), 935–970.
[73] Ann Stes, Liesje Coertjens, and Peter Van Petegem. 2010. Instructional development for teachers in higher education: Impact on teaching approach. *Higher education* 60, 2 (2010), 187–204.
[74] James W Stigler and Kevin F Miller. 2018. 24 Expertise and Expert Performance in Teaching. *The Cambridge handbook of expertise and expert performance* (2018), 431.
[75] Meredith Thompson, Kesiena Owho-Ovuakporie, Kevin Robinson, Yoon Jeon Kim, Rachel Slama, and Justin Reich. 2019. Teacher Moments: A digital simulation for preservice teachers to approximate parent–teacher conversations. *Journal of Digital Learning in Teacher Education* 35, 3 (2019), 144–164.
[76] University of Michigan. 2020. TeachingWorks. http://www.teachingworks.org/
[77] University of Washington. 2020. Tools for Ambitious Science Teaching. https://ambitiousscienceteaching.org/tools/
[78] Xu Wang, Carolyn Rose, and Kenneth Koedinger. 2021. Seeing Beyond Expert Blind Spots: Online Learning Design for Scale and Quality. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*.
[79] Xu Wang, Srinivasa Teja Talluri, Carolyn Rose, and Kenneth Koedinger. 2019. UpGrade: Sourcing Student Open-Ended Solutions to Create Scalable Learning Opportunities. In *Proceedings of the Sixth (2019) ACM Conference on Learning @ Scale* (Chicago, IL, USA) *(L@S '19)*. ACM, New York, NY, USA, Article 17, 10 pages. https://doi.org/10.1145/3330430.3333614
[80] Xu Wang, Miaomiao Wen, and Carolyn Rose. 2017. Contrasting explicit and implicit support for transactive exchange in team oriented project based learning. Philadelphia, PA: International Society of the Learning Sciences.
[81] Zuowei Wang, Kevin Miller, and Kai Cortina. 2013. *Using the LENA in Teacher Training: Promoting Student Involement through automated feedback*. Vol. 4. na.
[82] Gordon Wells. 2007. Semiotic mediation, dialogue and the construction of knowledge. *Human Development* 50, 5 (2007), 244–274.
[83] Miaomiao Wen, Keith Maki, Steven Dow, James D Herbsleb, and Carolyn Rose. 2017. Supporting virtual team formation through community-wide deliberation. *Proceedings of the ACM on Human-Computer Interaction* 1, CSCW (2017), 1–19.
[84] Joseph Jay Williams, Juho Kim, Anna Rafferty, Samuel Maldonado, Krzysztof Z. Gajos, Walter S. Lasecki, and Neil Heffernan. 2016. AXIS: Generating Explanations at Scale with Learnersourcing and Machine Learning. In *Proceedings of the Third (2016) ACM Conference on Learning @ Scale* (Edinburgh, Scotland, UK) *(L@S '16)*. ACM, New York, NY, USA, 379–388. https://doi.org/10.1145/2876034.2876042
[85] Françeska Xhakaj, Vincent Aleven, and Bruce M McLaren. 2017. Effects of a teacher dashboard for an intelligent tutoring system on teacher knowledge, lesson planning, lessons and student learning. In *European conference on technology enhanced learning*. Springer, 315–329.
[86] Nesra Yannier, Kenneth R Koedinger, and Scott E Hudson. 2015. Learning from mixed-reality games: Is shaking a tablet as effective as physical observation?. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in*

Computing Systems. ACM, 1045–1054.

[87] Bowen Yu, Ye Yuan, Loren Terveen, Zhiwei Steven Wu, Jodi Forlizzi, and Haiyi Zhu. 2020. Keeping Designers in the Loop: Communicating Inherent Algorithmic Trade-offs Across Multiple Objectives. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference*. 1245–1257.

[88] Mi Yu and Kyung ja Kang. 2017. Effectiveness of a role-play simulation program involving the sbar technique: A quasi-experimental study. *Nurse Education Today* 53 (2017), 41–47.

10 APPENDIX

Round 1 chat	**Round 3 chat**
T: Good morning! Today we are going to be talking about Chromosomes and Alleles S: yippeeeeee T: Can you tell me about either of those? what do you already know about chromosomes S: I have 23 chromosomes! S: I got one chromosome from my mom and one from my dad and the last one is from both of them combined T: where did you get 23 from? you aren't too far off T: Yes that is true however you are missing some information S: Well, I have dominant and recessive alleles T: Well you aren't wrong you do have at least 23 chromosomes T: And you do have dominant and recessive traits! S: The extra chromosome I have is a combination of both T: You don't quite have an extra set of chromosomes, everyone has 46, did you think that you had 23 because you got a set from each parent? S: No? I have 23. S: One from each parent and the 23rd one is a combination from both of them T: You are correct you have at least 23 but the correct number is 46 you receive 23 from each parent S: I was told i have 23. T: I'm sorry but today we will learn why you have 46 chromosomes, it's going to be fun and we are going to learn a lot! T: What do you know about alleles	T: Good morning Class today we will be talking about genes, and chromosomes, and dominant and recessive traits! S: yAY T: Let's start with chromosomes! tell me what you understand about chromosomes S: Everyone has 46! S: 23 from my mother and 23 from my father T: YES that's correct! excellent! now on to dominant and recessive traits T: what do you know about these S: What are alleles? T: Do you know anything about them at all? T: Tell me what you know and understand first then we can move on from there S: Well i heard someone mention alleles earlier but I thought dominant and recessive traits were about chromosomes S: Because chromosome are like genes and there is one for each part of your body T: Alleles is just another term for gene or chromosomes, they all relate to heredity and traits T: Do you know what a recessive allele is? S: I know that if my dad has brown eyes and he has the dominant chromosome then that covers up my moms recessive chromosomes S: So I would have brown eyes T: something like that, do you understand how that works? S: Well...yeah i just told u T: We will come back to this, what do you understand about mutations?

Table 4. Full transcript of an example role-play session (1)

Round 1 chat	**Round 3 chat**
T: Good morning, so nice to have you in my class today. We are going to be learning about genes and chromosomes today! S: okay T: Do you remember anything about genes and chromosomes from middle school? S: I remember that we have 23 chromosomes that are passed down from our parents T: Great! Do you remember what recessive and dominant alleles are? S: They determine what we look like. T: Great! Is there a difference between the two? S: Something about if one parent has brown eyes which is a dominant color and the other has blue which is recessive then the kid will have brown eyes because thats the dominant color T: Great! You seemed to have really retained that information from middle school! T: Do you remember how those genes are passed down from the parents to the child? S: thank you S: genes are a part of chromosomes T: Okay. How is that so?	T: Good morning! Today we are learning about genes and chromosomes. Do you remember anything about that from middle school? S: we have 46, 23 from each parent T: Okay. Im so happy to hear that you seem to remember things from middle school. T: What do chromosomes do? S: they determine what we look like T: Okay. What do you know about dominant alleles? S: that its one of two options. it beats out the other one. T: Okay. Interesting way of phrasing it. Are there any exceptions? S: something like if the kid has green eyes it a mutation T: Well, I was talking about something a little different. S: well... T: What about recessive genes? Is ever it possible to have a recessive trait? How? S: no dominant beats recessive T: Okay. Interesting point of view. We will learn more about this later and test your theory. S: okay T: How are these genes passed down? S: no clue

Table 5. Full transcript of an example role-play session (2)