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GAMIFYING COMPUTATIONAL THINKING SKILLS WITH A COMMUNITY OF PRACTICE OF TEACHERS

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This design case describes an online synchronous teacher training on computational thinking (CT) skills for a community of practice (CoP) of in-service teachers in India. The training used gamification, reflection, and localization as instructional strategies. The purpose of this training was to help in-service K-12 teachers identify subject-specific examples of CT that they could then integrate into an online teaching context. The PRADA model of CT constructs was used as a framework for this training. The design decisions were guided by the instructional design theory of gamification and CoP theory in situated cognition. The training was developed using Google suite tools to ensure ease of use and access, minimal technical onboarding, and no cost of technology integration. A two-pronged approach was taken post-evaluation of the first iteration leading to remediation and second-iteration design.

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INTRODUCTION

This paper is a design case that describes the design process of a teacher training on computational thinking (CT) skills, presents the rationale behind the design decisions, and gives an account of the implementation and evaluation of the training. It also describes the post-evaluation two-pronged approach leading to a remediation design and a second iteration of the training design. This design case is intended to disseminate design precedents and experiences of the designer through observational and material records of the design (Boling, 2010; Gray, 2020). Such design precedents may be proactively used by fellow instructional designers (both expert and novice), teacher trainers, and researchers, as examples to build their knowledge and ideas towards future use. This design case may also be used reactively when faced with similar design challenges or situations (Boling, 2010). Thus, the primary focus of this paper is to share the experience of designing for a community of practice (CoP) of learners using the pedagogical techniques of gamification, reflection, and localization of content.

Real-world problems surpass subject-specific boundaries such as science, mathematics, social science, etc., and require problem-solving skills that can transfer between these areas seamlessly (Fischer et al., 2011; Niedelman, 1991). Computing as a tool is rapidly being adopted in various fields to solve real-world problems more effectively and efficiently. This is changing the nature of jobs in the 21st century with an increased demand for computational literacy even in non-computing fields such as computational biology, computational architecture, computational economics, and computational law (Grover, 2018; Wing, 2011). Thus, students need to develop CT skills as thought processes involved in formulating and tackling complex real-world problems using the computing tools available to them (Grover, 2022; Haseski et al., 2018; Lu & Fletcher, 2009; Wing, 2011).

Developing subject-agnostic CT skills among K-12 students involves integrating CT in classroom teaching across all subjects. Despite several efforts to inform curriculum development in CT (Conery et al., 2011; CSTA, 2016), most teachers lack the awareness and skill of how to integrate CT in their classrooms (Sands et al., 2018). Teachers report issues of insufficient resources, lack of support (Sentance & Csizmadia, 2016), and low self-efficacy (Bower et al., 2017). One of the competencies necessary for teachers to successfully integrate CT in their subjects is the ability to design learning activities that engage students in applying CT skills to subject-specific problems (Caskurlu et al., 2022). This requires teachers to identify subject-specific examples of CT problems and develop pedagogies and content around these examples (Kale et al., 2018). Preparing teachers to come up with subject-specific examples is a first step toward improving CT integration in K-12 classrooms.

CSPathshala, an initiative in India, promotes the teaching and learning of CT skills by offering continuous professional development to in-service teachers. The leading committee members of CSPathshala are computing professionals who work in key roles in industry and academia in India. They have created a community of practice (CoP) of 700+ K-12 teachers to whom they provide free webinars, awareness workshops, and training programs. "Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (Wenger, 2011, p.1). Since 2016, when the CSPathshala initiative was first launched, they have developed grade-appropriate CT curricula, syllabi, and lesson plans for teachers, which are available as open educational resources in English and three regional languages on their website.

The first author was approached by a CSPathshala coordinator to design, develop, and implement CT professional development during the pandemic to help the CoP teachers transition CT integration to an online setting while also helping them strengthen their ability to integrate CT using subject-specific examples. These CoP teachers needed to switch to online teaching when the pandemic hit. The sudden shift led to a steep learning curve for teachers to transition their teaching methods to a fully online setting. Teachers who had recently started integrating CT in their subjects were now presented with a new challenge of not just moving instruction to an online setting but also making it engaging for their students. They expressed the need for support in this transition. To address these needs, we designed, developed, and implemented a gamified synchronous online teacher training that used reflection activities to enable the transfer of CT concepts (Brown et al., 2011) to their subjects. The purpose of this training was to help teachers identify subject-specific examples of CT that they could integrate into an online teaching context.

DESIGN PROBLEM

To define the design problem in this design case, it is important to fully understand the needs of learners and stakeholders. This section describes the learning and performance context analysis for the participants of this design case. It then defines the learning objectives that guided the design and development of the online teacher training.

CATEGORY	SUB-CATEGORY	NO. OF TEACHERS
Grade Level Taught	Primary (Grades 1—5)	23
	Primary (Grades 1—5) & Secondary (Grades 6—10)	11
	Secondary (Grades 6—10)	29
	Secondary (Grades 6 -10) & Higher Secondary (11 -12)	2
	Higher Secondary (11—12)	4
Subject Taught	Math	44
	Science	11
	Computer Science	9
	Social Science	3
	English Language	2

TABLE 1. Demographic Distribution of Participants.

Learners, Stakeholders, and Context

Participants of this online synchronous training were 69 in-service teachers from the CoP who teach in a group of 13 schools in India. This group of schools had one training coordinator who oversaw and coordinated the professional development opportunities for teachers. The participating teachers taught math, science, social science, English language, and computer science in primary (Grades 1—5), secondary (Grades 6—10), and higher secondary (Grades 11—12). Some but not all teachers had received prior professional development on CT skills through CSPathshala. Table 1 shows the demographic distribution of participant teachers.

The training was also attended by three master trainers and two school principals as observers of teacher participation and of the effectiveness of the training. The master trainers were either current or retired teachers who had more than three years of experience in teaching the CSPathshala CT curriculum and had been trained by CSPathshala as master trainers to train other teachers. They were also typically involved with volunteering for other CSPathshala tasks such as helping translate the CSPathshala curricula into regional languages. In this paper, we use the term 'stakeholders' to collectively refer to the CSPathshala coordinator, the training coordinator of the group of schools, the three master trainers, and two school principals.

Participants' Background

A questionnaire was sent to the CSPathshala coordinator to gather learner and performance context information. This questionnaire was designed based on Dick and Carey's (2015) guidelines that prescribe knowing your learners' entry skills, prior knowledge, attitudes, motivations, learning context, availability of support, and the physical and social context of the learning and teaching environment of the teachers. Questions related to each of these categories were included in the questionnaire for learner and performance context analysis.

The learner analysis revealed that teachers had between 8 and 25 years of teaching experience. The math and computer science teachers had previously attended professional development training in CT skills through CSPathshala and had been integrating CT for the past 3 years. The other subject teachers had not received any CT training before and had no experience in teaching CT. The typical student-teacher ratio is 25:1. However, teachers are often required to teach two classes at the same time making it 50:1. All teachers were a part of the CSPathshala CoP, which acts as a support system for teachers to share their experiences and learn from each other. In addition to the learner and performance context analysis, we requested the CSPathshala coordinator to allow us access to training material previously used by them in their face-to-face training programs. On receiving access, we found that the training materials used activity-based unplugged pedagogies in their previous training programs.

Learning Objectives

The following learning objectives were formulated for the online synchronous training based on the needs identified through learner analysis and discussions with the CSPathshala coordinator:

- Teachers will be able to identify CT examples specific to the subjects that they teach.
- Teachers will express confidence in their ability to conduct CT activities in online teaching environments.

DESIGN CONSIDERATIONS AND DECISIONS

The design and development journey began with the identification of design challenges and design constraints. Design challenges are the decision points we needed to consider while planning the training (for example, what concepts of CT to include in the training, how to design for a CoP, and what instructional strategy to use). The design constraints are the limitations and restrictions such as time (3 hours due to time zone overlap issues) and format (online synchronous) that we needed to work around while designing. In this section, each of the design challenges and constraints are discussed separately within a subsection. A detailed account of the relevant design decision is given within every sub-section supported by relevant instructional design and learning theories that informed the decision. Although presented linearly in this paper, these design challenges were identified over several conversations with the CSPathshala coordinator, and the design decisions were made with the coordinator's insights about the learner's needs and contexts.

Design Constraints

The learner and performance context analysis revealed that the training activities needed to be designed to suit learners of varying levels of expertise. In a conversation with the CSPathshala coordinator, we understood that the technology tools used to facilitate activities needed to be easy to use and accessible with minimal additional cost to the school or the teachers, so they could replicate them in their teaching. There was not much time to on-board teachers to a new technology since the school administration wanted teachers to begin online integration of CT as soon as possible and be able to sustain it with limited technological resources available to the schools during the pandemic.

For easy replication in online teaching, the training was designed using the Google suite of applications. These applications are free to use, easy to access, and easy to implement. They do not require teachers to undergo extensive technology onboarding or create additional expenses. Google Slides were used for the training presentation, Google Forms were used for the design and facilitation of the *Treasure Hunt* activity, and Google Spreadsheet was used to facilitate the *Bulls and Cows* activity.

As the first author initiated the scheduling of the training, new constraints arose. The participating teachers were based in India, and the primary facilitator (first author) was based in the United States (a time zone difference of 11 hours). The synchronous format necessary to model the facilitation of activities in online settings for the teachers, required participants, and all stakeholders to have uninterrupted internet connection for the duration of the training. Up to 3-4 hours of training time was allocated by the training coordinator of the group of schools based on her prior experience of the attention span of teachers in an online setting and the available overlap of working hours in the two time zones.

Design Challenge 1: Defining CT Constructs

Literature in CT research operationalizes CT skills for practitioners using various constructs and concepts that differ from each other (Brennan & Resnick, 2012; Conery et al., 2011). Our primary task for the design of this training was to base the content of the training on a specific set of theory-informed CT constructs that would remain consistent throughout all professional development received by the teachers to develop a common understanding among the members of the CoP and minimize confusion.

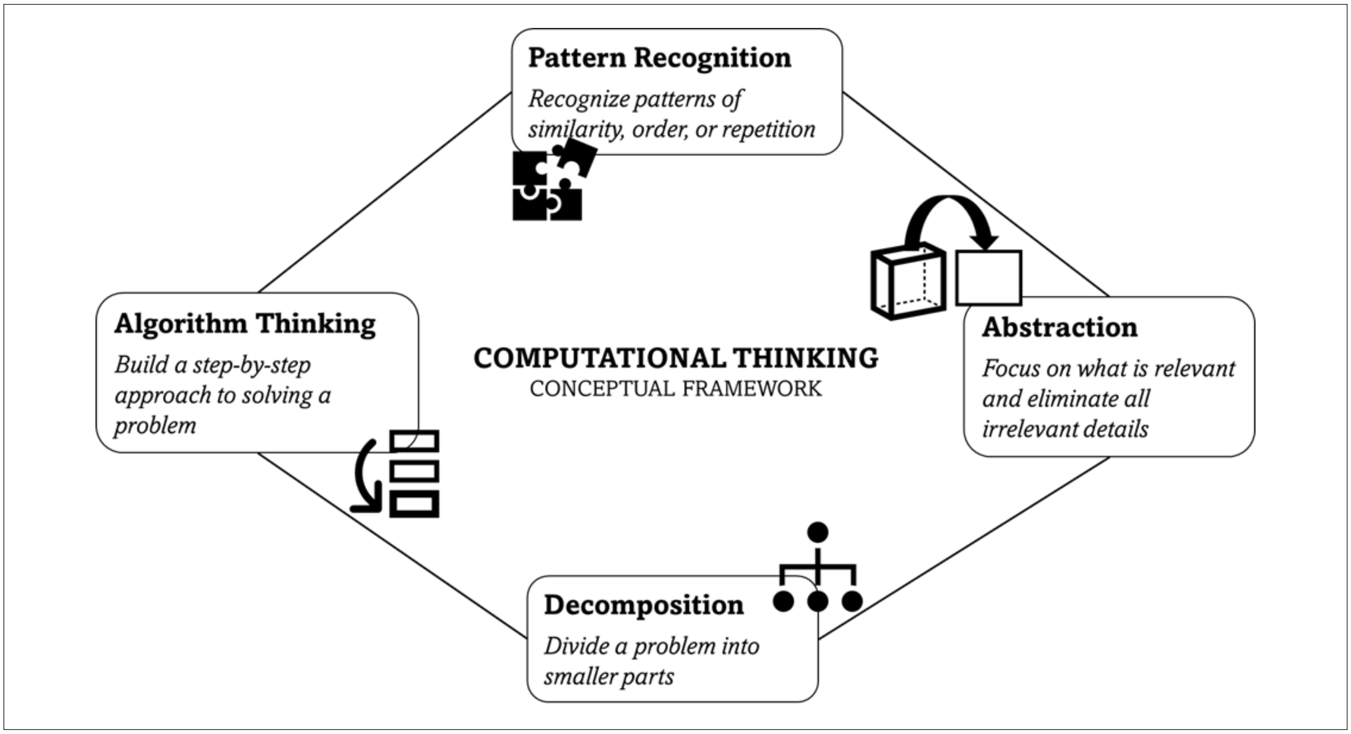

FIGURE 1. Computational Thinking Conceptual Framework.

CSPathshala's prior CT training programs, designed jointly by computing experts from industry and educational experts from various educational institutions, were found to be based on the constructs of Pattern Recognition, Abstraction, Decomposition, and Algorithm Thinking (PRADA). On investigation, we found evidence that indicates that these were the top four most frequently assessed CT constructs by researchers (Haseski & Ilic, 2019). Furthermore, Dong et al. (2019) have successfully demonstrated this model (PRADA) to be appropriate for the professional development of non-computing teachers. Thus, we chose these four CT constructs (Figure 1) to design the online professional development training for the CoP of teachers.

Design Challenge 2: Designing for a Community of Practice

Our second design challenge was to design for the varying level of teachers' prior knowledge and ability within the CoP. Amongst the group of 13 schools, they had three teachers who served as master trainers as the 'core group' of the CoP (Wenger et al., 2002). They acted as torchbearers in the community's progress towards the learning goal by providing guidance and support prior to and during the CT implementation in schools. They helped train other teachers in CT and participated in the process of content creation for CSPathshala's teacher training.

Math and computer science teachers had been integrating CT in their subjects for three years and had previously received CT training. They could be seen as the 'active group' of the CoP (Wenger et al., 2002) who had identified subject-specific examples of CT and had been using them to integrate CT in their class. They needed support in transferring their CT integration skills to online settings.

The group of schools now also wished to expand this integration to other subjects including science, social sciences, and English language. The other subject teachers had no exposure to CT yet; they had mainly been observers of the CT implementation in their schools to that point. They could be classified as the 'peripheral members' of the CoP (Wenger et al., 2002).

This variation between the core, active, and peripheral members is typical of a CoP where learners with different levels of expertise engage with one another to share knowledge, skills, and passion in a specific domain (Wenger et al., 2002). The participants shared three characteristics that are crucial for a group of individuals to qualify as a CoP: the domain of interest that brings them together (CT skills); the community in which members engage in activities, discussions, and sharing of information; and the practice of the domain of interest itself (integrating CT in their teaching) (Wenger, 2011). To achieve the purpose of the training, this design project was required to meet two needs—to help the peripheral group understand the concepts of CT and identify examples of CT from their subjects, and to help both active group and peripheral group teachers develop confidence in the use of these subject-specific examples in online teaching.

Thus, we planned to create an environment where participants engaged in mastery of knowledge through interaction between the core group, active group, and peripheral members resulting in the gradual enculturation of the new peripheral members and the development of expertise among the active group members (Floding & Swier, 2012; Lave & Wenger, 1991). We accomplished this by including some activities that the active group had experienced in prior training and some activities that were completely new to them. The inclusion of familiar activities invited active participation from the active group, allowing them to model their processes for the peripheral group, and encouraged collaborative problem-solving during training. It also ensured that the active group teachers were challenged beyond what they already knew and thus were engaged in the training.

The core group (master trainers) were involved in the development phase of the training as well as during facilitation to support and scaffold the active group and peripheral group during the activities. Details on how master trainers contributed to the development and facilitation are discussed in the 'Development and Implementation' section of this paper.

Design Challenge 3: Instructional Strategy

Drawing from the design decision made for design challenge 2, the overarching question was to decide what instructional strategy to use in an online synchronous training that includes old and new activities to engage learners in a CoP in collaborative problem-solving. Prior face-to-face CSPathshala training programs used unplugged gamified activities designed to model the facilitation of gamified activities in classroom teaching so that teachers could replicate them. A second purpose for the use of gamified activities was to enhance K-12 students' and teachers' engagement with the new CT concepts and increase their motivation. Game elements and game mechanics facilitate learner engagement, encourage learners' active participation in activities, and increase learner motivation and autonomy (Kapp, 2017) resulting in better self-regulated learning (Pekrun, 2006; Harley et al., 2016). "Gamification is using game-based mechanics, aesthetics, and game thinking to engage people, motivate action, promote learning, and solve problems" (Kapp, 2012, p.66). Gamification lends itself very well to CT as a skill used for solving complex real-world problems (Wing, 2011; Zhong et al., 2016). Thus, we chose gamification as a suitable instructional approach for its ability to engage learners, its capacity to promote problem-solving, and its replicability in online teaching.

We integrated game elements such as challenge, mystery, role play, scoring, and story/narrative within the online training. Clues/puzzles were used in the gamified activities to encourage active participation during the online synchronous training. We designed different levels of challenge in the gamified activities to allow different members from the active and peripheral groups to take turns to solve it while those who found it too challenging could observe and learn. The mystery in the activity narratives and the challenge in CT application were designed to keep the teachers engaged. While most activities in the training were designed to be collective participation and response type, one activity (*Treasure Hunt*) was designed to be an individual problem-solving activity where each participant solved it separately on their devices. In this activity, the participants needed to solve each clue correctly to get to the next one which allowed them to test and practice their newly learned CT skills on similar problems.

Design Challenge 4: Learning Transfer

The first learning objective of this training was to help teachers make connections to identify examples of CT constructs from their subjects which involved transfer of learning across domains (Foley & Kaiser, 2013). 'Transfer of learning' is a learner's capacity to repurpose and reorganize the knowledge gained such that it can be used in a similar or new context (Bossard et al., 2008). Learning activities and instruction should have context-agnostic cues and encourage introspective and reflective thought processes to minimize context-dependency in the transfer of learning (Smith & Vela, 2001). Planned metacognitive instruction, which provides opportunities to reflect, revisit the learning process, and make comparisons with prior knowledge, can support transfer (Foley & Kaiser, 2013; Georghiades, 2000). Thus, we introduced reflective activities in the design of this training that encouraged teachers to identify concepts from their subjects that aligned with each CT construct. These reflective activities were interspersed with the gamified activities so that teachers got the opportunity to reflect after every CT construct had been demonstrated and practiced through activities.

It was also important to choose examples and references of CT from the local socio-cultural context of India not only to help teachers relate to the content and encourage their participation in authentic learning activities (Wolfenden & Adinolfi, 2019) but also to ease the transfer of learning. Localization is the 'purposeful contextualization' of educational content to make learning more relevant and meaningful to the learners' culture, religious values, geography, and worldview (Bradshaw, 2022). It involves adapting the educational content using relevant examples, names, and narratives from the local context. As such, in the design of the training, the construct of pattern recognition was explained using *rangoli*, a cultural sand art form in India used to decorate homes during festivals. Similarly, we used an audio-visual of a person playing the *Teentaal* (a rhythmic percussion with repeating patterns of beats in Indian classical music) on the *Tabla* to help convey how patterns could be experienced through different sensory experiences.

PURPOSE	CT CONSTRUCT	ACTIVITY/EXAMPLE
Icebreaker Entry Skill Evaluation	All four	*Bulls and Cows*
Reflection Activity	-	What Did We Learn?
Reflection Activity	-	Why CT Skills?
Learn and Apply	Decomposition	Area of a 10-sided Figure
Reflection Activity	Decomposition	Where have you used Decomposition in your subject?
Learn and Apply	Algorithm Thinking, Patterns, & Decomposition	*Guess My Birthday*
Learn and Apply	Pattern Recognition	*Guess the Animal*
Examples	Pattern Recognition	Other Patterns Around Us; Patterns in Numbers
Reflection Activity	-	Recognize Patterns Around You
Apply	All four	*Treasure Hunt*
Reflection Activity	Abstraction	Identify Abstraction used in *Treasure Hunt* and think of examples in your subject

TABLE 2. List of Activities—First Iteration.

Such examples were also meant to trigger teachers to reflect on what other similar patterns they had experienced around them. Thus, together the reflection activities and the localization of content supported teachers' transfer of learning to the subject that they teach.

First Iteration Design

Table 2 shows the list of activities that we included in the first design of the training in the order that they were conducted. The table also shows what constructs of CT were focused on in each activity.

We used three major sources to compile the content in the training presentation: content created by the first author, from the CSPathshala training material, or existing media from external public sources such as YouTube and Google Images.

The training was conducted via Zoom in a 3-hour synchronous online session. The training began with a gamified activity (*Bulls and Cows*) where teachers needed to apply all four CT skills to arrive at the solution. This activity was meant to be an icebreaker and a formative assessment of teachers' entry-level skills in CT. This was followed by a reflection activity to acquaint teachers with how and where each of the CT constructs could be used in *Bulls and Cows*. At this point, teachers were also asked to define their rationale for integrating CT in their subjects, encouraging them to think about the value of CT integration to their subject-specific goals.

After this, teachers were presented with examples and activities focused on one CT construct at a time—for example, decomposition was exemplified through the *Area of a 10-sided Figure* or pattern recognition through *Guess the Animal*. In each activity, the participants collectively interacted with the facilitator (first author); they would volunteer to speak or type their responses in chat in English. This allowed everyone to observe other participants' thought processes and answers. It fostered a sense of competition for speed and accuracy in solving the clues. When some activity was too challenging for both the active group and the peripheral group (typically manifested through the silence of participants during an activity), the core group members jumped in to give hints and encourage them to think in a certain direction. If the hints helped them, the session would resume where someone volunteered to show how they would solve it, while others prompted if they had other ideas or observed and learned. A reflection activity was included after the completion of every CT construct to allow teachers to think of and type in the chat some examples of that construct from their subjects. Finally, the training ended with *The Treasure Hunt*—another activity that needed them to apply all four CT constructs.

Our final design products included training presentation slides, a facilitator's guide, and gamified activity files. Google Slides was used to supplement the synchronous facilitation. The gamified activity files served to facilitate learner participation in the activities. All the training material can be found at The Training Center.

DEVELOPMENT AND IMPLEMENTATION: FIRST ITERATION

Based on the design decisions outlined in the previous section, we planned to create a gamified online training using reflection activities and localization to promote learning transfer. This marked the beginning of the development phase.

Rapid Prototyping

In the first iteration, the development of the training material was done in phases of rapid prototyping. The list of activities, examples, and external resources were first compiled into the training presentation. This was sent to the stakeholders—the CSPathshala coordinator, the training coordinator, and the master trainers—for review. Stakeholders shared their review comments via email. Changes were consequently made to the order of activities based on stakeholder review. This was followed by the creation of the virtual *Treasure Hunt* activity. Next, the *Treasure Hunt* was sent to the stakeholders who themselves pilot-tested it by solving each clue and suggested minor clarification or changes in some clues. For example, the CSPathshala coordinator pointed out an error in a clue in the treasure hunt:

> *"It [the clue] says—'area of this* ***one-sided*** *shape is what will help you to escape…Can you find the answer to this clue?' Shouldn't this read as area of this four-sided shape and not one-sided?"*

Changes were carried out based on their feedback. Then, a joint meeting was held with the stakeholders to plan the implementation of the activities. In this meeting, the stakeholders agreed that the first author should be the primary facilitator of this training. However, the master trainers expressed the need for a facilitator's guide to help them conduct the same training with different groups of schools in the future. The facilitator's guide provides a descriptive guideline on how to conduct each activity from the training; this was developed to be shared with the master trainers and the participant teachers so that they could design similar activities to train other teachers or in their online classes, respectively.

For the first iteration, specific roles were assigned to each stakeholder to ensure the active participation of all groups in the CoP. For example, during the *Treasure Hunt* activity, each of the three core group members (master trainers), and the first author were to act as experts for one clue respectively. This would ensure that teachers at different stages of learning could seek help without disclosing any hints or answers to the other teachers. It also encouraged one-on-one interaction between participants and the core group.

FIGURE 2. Patterns in a Rangoli—An Indian Festive Decoration Using Colored Sand.

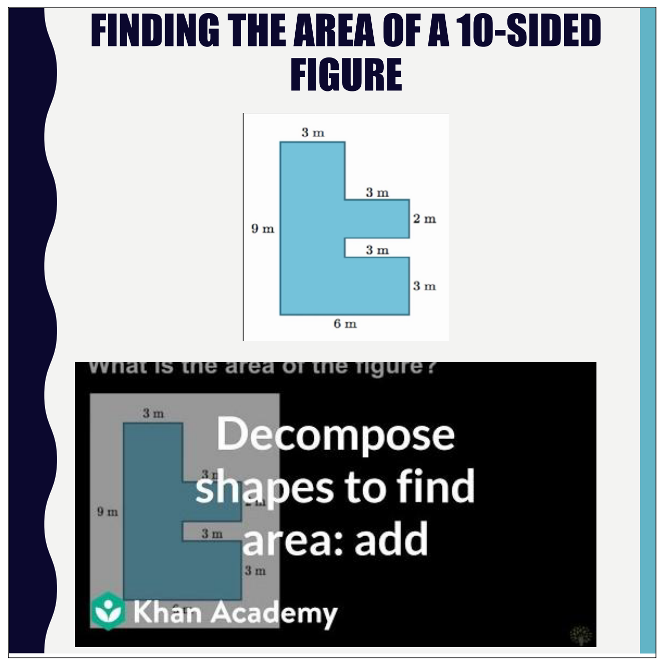

FIGURE 3. Screenshot of a Khan Academy Video Demonstrating Decomposition (Khan Academy, 2016).

Training Products and Synchronous Facilitation

This section describes the examples and activities developed for the training and how they were facilitated during the synchronous training session.

Computational thinking examples: Cultural context

We chose examples of CT constructs (in the form of pictures, videos, and/or audio) that are observed in the local environment of the teachers, thus emphasizing their utility in problem-solving. Videos that demonstrated the use of a construct to solve a problem were included as a way to model typical CT-based problems. Figure 2 shows an example chosen from the local culture (rangoli, a cultural sand art in India) to showcase familiar patterns to the teachers. Figure 3 shows a screenshot of a video demonstrating decomposition in geometry.

As part of the reflection activities, teachers were encouraged to think of and type into chat the concepts from their subject areas that aligned with a specific CT construct. For example, in the reflection activity after the decomposition construct was demonstrated using the video and learning activity in Figure 3, teachers typed examples that use decomposition from their subjects such as "solving of word problems" and "proving a theorem" in math; "creating algorithms and flowcharts" in computer science; "performing lab experiments" in science; and "decomposition of a sentence in parts of speech" in language learning. Then, some of these answers were discussed as part of the facilitation.

Computational Thinking-Based Gamified Activities

The first author chose, adapted, or developed gamified activities that used CT constructs. For example, *Guess My Birthday* was an activity from the prior CSPathshala training that was repurposed for the online setting. It mainly focused on algorithm thinking but also used other constructs such as patterns and decomposition. The gamified activities included game elements such as 'challenge' in *Guess My Birthday*, *Bulls and Cows*, and *Area Finding* activity; 'scoring' in the *Bulls and Cows* activity; and 'mystery' and 'story/narrative' in the *Treasure Hunt* activity. These game elements were introduced to encourage active participation by teachers in solving the clues and puzzles resulting in an increased level of engagement.

Bulls and Cows. *Bulls and Cows*, based on a popular code-breaking game, *Mastermind*, was selected as an activity to exemplify the application of all four CT constructs. In this game, the goal is to minimize the number of guesses needed to correctly identify a four-letter word (the secret code). After each guess, the facilitator disclosed a feedback clue for that guess which is the number of *Bulls* (correct letters in the correct position) and *Cows* (correct letters in an incorrect position). For example, if participants' first guess was 'FISH' and none of the letters in this word were there in the secret code, the clue given would be *0 Bulls*, *0 Cows*. Based on the feedback clue received, the participants took a new guess. In this case, participants now knew that the letters "F", "I", "S", and "H" were not in the code. They could either have chosen to guess a word that has none of these letters or guessed a word that had some of these letters and some new letters to help in elimination in the next round of guessing. Thus, in the process of playing this game, learners recognized possible patterns of letters in a four-letter word based on the clues, decomposed the code into the four individual letters to eliminate incorrect letters, used abstraction to extract information from the clues given, and created an algorithmic approach to identify the code in the fewest possible turns. This continued until players guessed the code correctly (4 *Bulls*).

Number of Guesses	GUESS	BULLS	COWS
1	FISH	0	0
2	SHOW	0	2
3	SLOW	0	3
4	BLOW	1	3
5	BOWL	4	0

FIGURE 4. *Bulls and Cows* Clue Spreadsheet.

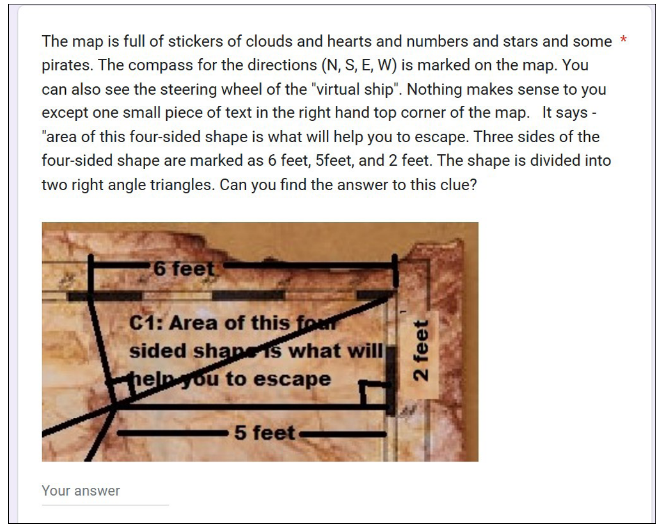

FIGURE 5. Story/Narrative and Mystery Elements in The Treasure Hunt.

To conduct this activity, the facilitator shared her screen with the participants in Zoom and used Google Spreadsheet to give feedback clues for each guess made by participants. Participants took turns guessing or used the raise hand feature in Zoom. The spreadsheet helped keep track of all guesses made and every clue given during the game. Figure 4 shows the screenshot of a clue spreadsheet the participants played for the code "BOWL".

The Treasure Hunt. The *Treasure Hunt* was designed as an online gamified activity using Google Forms that presented the participants with mysterious clues through a story or narrative (see Figure 5). This was an individual activity where each participant solved clues independently to uncover hidden elements of the mystery and get the next clue. Each of the three clues was a CT-based problem presented as a mysterious story. These clues would require teachers to apply one or more of the CT constructs to achieve the final aim of the activity of finding the treasure which would appear only if they solved all three clues correctly.

This was the last activity in the training and was designed to be an opportunity for teachers to apply and practice what

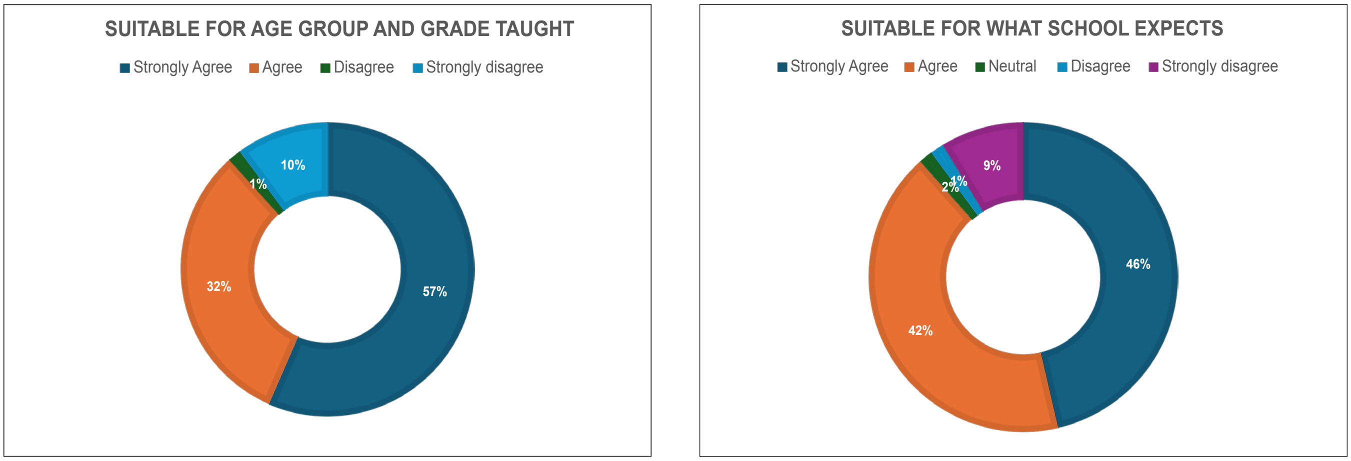

FIGURE 6. Relevance of Training Content.

they had learned during the training. It was also meant to serve as a formative assessment of teachers' learning from the training. Teachers were given the link to the *Treasure Hunt*, and 20 minutes were allotted during the synchronous training for them to solve the clues and get to the treasure. Each core group member (master trainer) and the facilitator were nominated as experts for a specific clue in the *Treasure Hunt*. If the teachers were stuck on a clue, they were encouraged to ask for help from the respective expert assigned to that clue through direct chat on the video conferencing tool. At the end of the *Treasure Hunt* activity, the facilitator conducted a group debrief with the teachers to capture their experience with the activity.

Guess My Birthday. The *Guess My Birthday* activity from the original CSPathshala training material was chosen and adapted to online settings by the first author. Since the active group members (math and computer science teachers) were familiar with this activity, they could model CT skill application for the peripheral group members through enthusiastic participation during the synchronous facilitation of the activity.

For this activity, participants needed to guess the facilitator's birth date (a hypothetical date chosen by the facilitator) by asking only yes/no questions. The goal was to guess the correct date using as few questions as possible. CT skill application was involved in forming questions that helped eliminate the largest group of numbers from the 30 or 31 days of a month. This activity was used to teach the binary search algorithm concept from programming in an unplugged environment. It required the application of pattern recognition among numbers, algorithm thinking for the fastest elimination, and decomposition to divide numbers into meaningful groups with similar patterns (for e.g. odd numbers and even numbers).

To facilitate this activity, an image of a calendar month was used to show the dates and players volunteered to ask questions one at a time during the synchronous session. It is worth noting that the players did not consult each other (as in a collaborative activity) before volunteering to ask the next question. This led to some questions being more effective in eliminating more dates than others. This was done so that participants could experience both good and poor questions and the results of asking both. It also allowed them to understand different thought processes and perspectives within the group and consider the advantages and disadvantages of those.

EVALUATION

During the development phase, we had also planned and created questionnaires for training evaluation based on the *Reaction* and *Learning* levels of Kirkpatrick's evaluation model (Kirkpatrick & Kirkpatrick, 2016). The *Reaction* level in this evaluation model measures "The degree to which participants find the training favorable, engaging, and relevant to their jobs" (Kirkpatrick & Kirkpatrick, 2016, p. 39). The *Learning* level measures "The degree to which participants acquire the intended knowledge, skills, attitudes, confidence, and commitment based on their participation in the training" (Kirkpatrick & Kirkpatrick, 2016, p. 42). Separate questionnaires were created for learners, master trainers, and school principals. Table 3 shows the questions from the learner feedback questionnaire.

In the last 10 minutes of the training, participants and stakeholders were asked to fill out the evaluation forms. Results were analyzed using a spreadsheet and using the descriptive summary provided by Google Forms. The outcome of the evaluation is shared below.

Participant Feedback

Relevance of training content

Eighty-nine percent (89%) of teachers strongly agreed or agreed that the training content was suitable for the age group and grade that they taught. Eighty-eight percent

QUESTION TYPE	LEARNER FEEDBACK QUESTIONNAIRE
Short answer	First Name and Last Name
Short Answer	Name and City of the School You Teach in
Multiple Choice Multiple Answer (MCMA)	I am a teacher in: • Pre-School • Primary School (1st—5th Grade) • Secondary School (6th-10th Grade) • Higher Secondary School (11th—12th Grade)
5-point Likert Scale	The activities and content of the training session was suitable for the age group and grades that I teach Strongly Disagree → Strongly Agree
5-point Likert Scale	The training session was suitable for what my school expects me to teach Strongly Disagree → Strongly Agree
Long Answer Text	Give Reason for your answer to the previous question
Long Answer Text	What topic or concept do you think you need more help in? What kind of help?
MCMA	Select all that apply. Activities from today's session that you think will be difficult to conduct in your class/ school • Guess My Birthday • Area of a Figure (Decomposition) • Guess the Pattern • Bulls and Cows • Treasure Hunt • None. I think I can conduct all
Long Answer Text	Give reasons for your answer to the above question
Long Answer Text	Name resources/materials used in our training activities today that might be difficult to get in your classroom and may become a hindrance to conducting the activities in your class (e.g. google forms, google sheet, internet, laptop, any other.)

TABLE 3. Learner Feedback Questionnaire for Evaluation.

(88%) of teachers strongly agreed or agreed that the content was aligned with what the school expected them to teach in CT. Figure 6 shows the distribution of responses for each of these questions.

Perceived knowledge and skill

One of the questions asked participants to specify what topic they needed more help with. While 21 participants said 'none' indicating that they do not need help in any of the topics, 15 participants said 'abstraction' and 12 participants said 'decomposition'. Eight participants specified names of activities that they needed help with, six of which said *Treasure Hunt*. Only three participants needed help with pattern recognition. One participant did not state any topic but mentioned that they needed more practice. Figure 7 illustrates the distribution of responses.

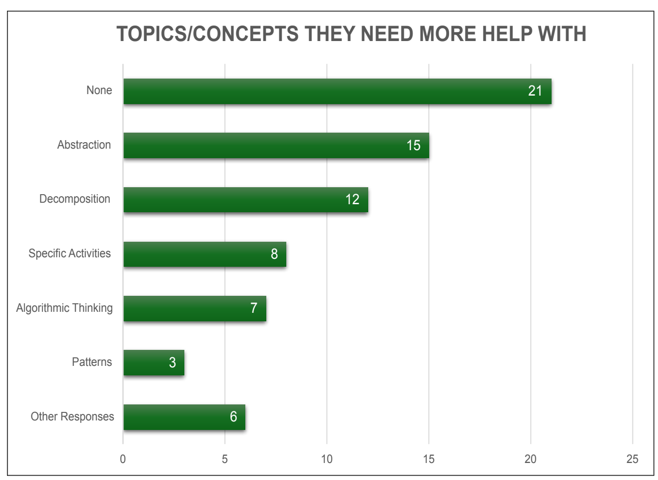

FIGURE 7. Perceived Knowledge and Skills.

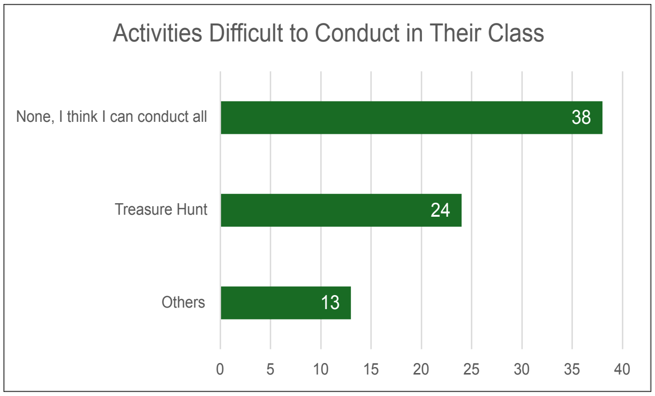

FIGURE 8. Confidence to Conduct Activities in Their Class.

Confidence to conduct activities in their class

When asked, 38 teachers said they could conduct all activities, 24 said that conducting the *Treasure Hunt* would be difficult, and 13 chose activities other than *Treasure Hunt* that they thought would be difficult to conduct in their class (see Figure 8).

Teachers' rationale for lack of confidence to implement the *Treasure Hunt* was found to be low self-efficacy in solving the clues, time constraints, difficulty with online implementation, and lack of clarity in instruction. Participant responses included the following:

- L6: "I need to be very confident first in this to carry out"
- L48: "It's time-consuming"
- L54: "Complicated clues"
- L55: "[Teaching in] Online classes [is] not possible"
- L62: "Unable to understand the instructions"

This was triangulated with the first author's observation during the training session, which revealed that only 12 teachers had been able to solve all clues and complete the *Treasure Hunt*. Additionally, some teachers verbally communicated that the clues were based on mathematics concepts and teachers who did not teach mathematics were not able to solve them.

Master Trainers and Principals' Feedback

Master trainers' feedback confirmed these findings. All master trainers believed that teachers needed more practice in solving the *Treasure Hunt* and support in how to create the *Treasure Hunt*. Two master trainers stated that most teachers could identify subject-specific examples in each of the four CT concepts. While one said that very few teachers could name examples in 'abstraction'. All master trainers observed that most teachers showed a positive attitude and commitment to conducting the activities with their students. School principals stated that teachers showed moderate to high confidence in their ability to conduct these activities in their classes.

FEEDBACK INTERPRETATION AND DESIGN MODIFICATIONS

The evaluation results indicated that the training had an overall positive impact on the participants. Teachers found the training appropriate for the age and grade level that they taught and suitable for what the school expected from them. It was apparent from the learner feedback that several participants found the *Treasure Hunt* activity quite complex and difficult to solve and also challenging to create a similar activity for the classes that they taught. They showed moderate to high confidence in their ability to implement the other activities in their class. Among the four CT constructs, abstraction appeared to be unclear to several participants closely followed in number by decomposition. Teachers reported the highest perceived knowledge and skills in the construct of pattern recognition.

Post-Evaluation Debriefs

After collecting the evaluation data, the CSPathshala coordinator held a debrief session with the training coordinator and the core group (master trainers) to discuss their observations from the training. This was not attended by the authors. Specific observations from the master trainers and training coordinator were noted by the CSPathshala coordinator. The first author then held a second reflection debrief session with the CSPathshala coordinator to understand the interpretations and observations discussed in the first debrief and to corroborate those with the evaluation feedback data.

During the second debrief, the CSPathshala coordinator and the first author discussed that several of the activities, including those repurposed for online mode of delivery from the original CSPathshala training, were perceived to be based on math by the teachers, although not all of them were math based. For example, *Guess My Birthday* is an activity based on elimination using binary search logic; it involves searching for the specific birth date by eliminating dates based on information given in the course of the game. This involves dates (numerical information) but does not involve any advanced math knowledge other than a basic understanding of the number system (e.g. odd and even numbers, greater than and less than, prime and non-prime numbers). Another instance was the activity of *Bulls and Cows*. The activity was conducted using four-letter words while the scoring was done using a code system that uses numbers (e.g. 2 *Bulls* 2 *Cows*). Similarly, basic arithmetic was used in the decomposition activity and in the clues created in the *Treasure Hunt*. The primary concern was there were very few examples used from other subjects (science, social science, English language) to help teachers visualize the use of the CT constructs in their subject. Lastly, we also concluded that abstraction, as a construct, is complex to understand and warrants its own activity for better understanding among teachers.

FIGURE 9. A Clue based on Rhyme Scheme as Pattern Recognition (top) and a poetry clue on the torch (bottom).

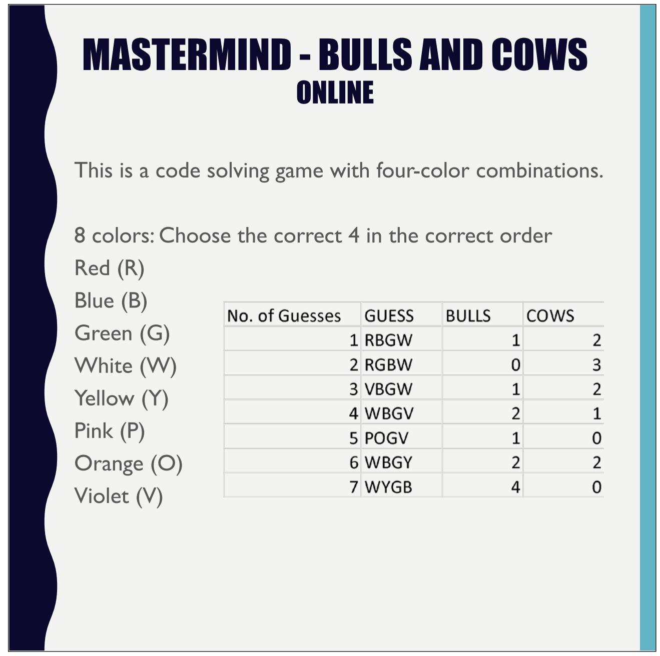

FIGURE 10. A New Approach to *Bulls and Cows*.

Two-Pronged Plan

Based on the debriefs, two separate strands were defined as next the steps for the project. First, a remedial follow-up session was planned for the participants of the training that would focus on addressing the specific concerns around the *Treasure Hunt* activity and the construct of abstraction. Second, the original training would be modified through a second iteration of training design and development based on the feedback received to ensure better impact in any future training.

Remedial: The follow-up

A new *Treasure Hunt* was designed to include clues based on concepts from English language, science, social science, and math. For example, the rhyme scheme of a poem was used to illustrate pattern recognition (see Figure 9). The story and narrative elements were used to build in abstraction within the clues. Each clue was designed to include a hint (a hyperlink to relevant context or reading about the topic) that would help ease the process of solving the clue.

During the remedial training session, the *Treasure Hunt* was facilitated as a collaborative activity instead of an individual task. Teachers discussed and shared ideas as they worked through the *Treasure Hunt*. It was observed that more teachers were now able to solve all clues and complete the *Treasure Hunt*. Teachers appeared to be more confident and excited about creating a *Treasure Hunt*.

After the remedial session, teachers engaged in creating a *Treasure Hunt* activity for their subject-specific teaching and these were shared with the first author for feedback a few days after the remedial session. The first author provided guidelines for peer and self-review. A first round of peer and self-review was conducted for the participant teachers to review each other's activity design. The teachers then made changes to their designs based on the review feedback followed by which the first author provided constructive feedback on each of their treasure hunt activities to help teachers finalize their designs.

The second iteration

For the second iteration, the original training design was modified to incorporate the feedback received from the first iteration. Since teachers' perceived knowledge and skill in pattern recognition were high, we inferred that this construct is relatively easy to understand. Hence, we reordered the activities to introduce pattern recognition first so that the difficulty level of the concepts is gradually increased through the training. The *Guess My Birthday* activity was moved up as the icebreaker and entry skill assessment allowing the active group teachers, who were already familiar with it, to model CT skill application to peripheral group members at the very beginning of the training. The *Bulls and Cows* activity was moved down towards the end. This was done to help learners appreciate the application of all four CT constructs once they had experienced them individually. In addition, a modified version of this activity that was more similar to the original mastermind game was created to include a new adaptation with colors instead of four-letter words. This was done to help teachers see the activity as not a math-based activity but a code-breaking activity and to offer alternative approaches to conducting this activity (see Figure 10).

A new role-play activity was added to illustrate the construct of abstraction in day-to-day conversations. Participants were prompted to volunteer to assume the role of a house owner and describe their house first to their young child, then to their adult cousin, and finally, to a potential buyer—all characters played by the facilitator in different turns). This allowed participants to witness how one abstracts information in day-to-day conversations based on who one speaks to and the purpose of the conversation.

Next, a 4-step process was defined that helped teachers identify and use abstraction in a given context (see Figure 11). This process was explained using an example of a fruit bag containing an assortment of fruits. The problem at hand was to find the number of fruits left in the bag after 1 banana and 1 mango had been eaten. It was emphasized that to identify abstraction, it was first important to identify and define the problem that needed to be solved. Only when the problem was defined could one identify what information was necessary to solve the problem and what information was too specific or unnecessary. In this example, the type of fruit or vegetable in the bag was not important for solving the problem. Once identified, one could eliminate this unnecessary information to define the problem in more simple terms. For the example in Figure 11, one would use abstraction to define the problem as: *There are 9 fruits and 5 potatoes in the bag. Two fruits were eaten this morning. How many fruits are left in the bag?* This process of abstraction helped reduce the problem to a simple subtraction problem.

Finally, the reflection activity for decomposition was modified to include hints from other subjects. The new *Treasure Hunt* designed for the remedial session was used to conclude the training. The reflection activity after the *Treasure Hunt* was removed since we had modified the new *Treasure Hunt* to be facilitated as a collaborative activity that allowed teachers to discuss during the activity. Table 4 (next page) shows the feedback versus the modifications made to the training in the second iteration.

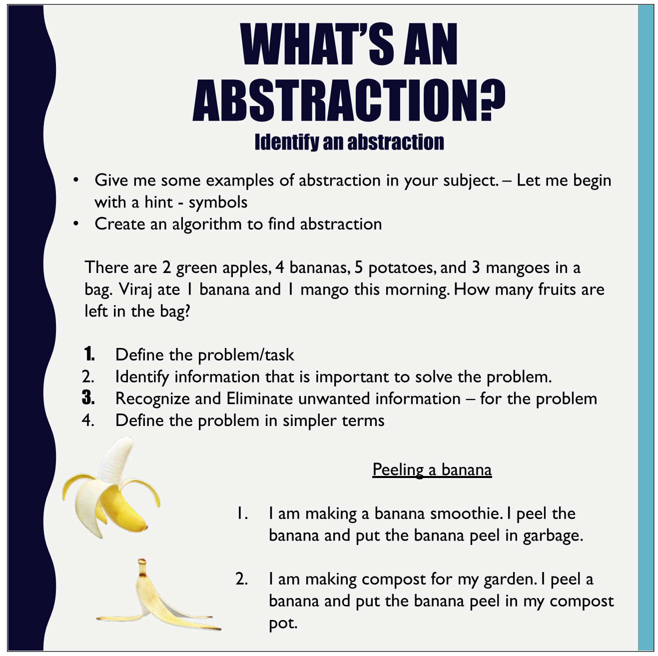

FIGURE 11. A Step-by-step Process to Identify and Use Abstraction.

DESIGNERS' REFLECTION

This section presents a reflection by the first author based on their experience of designing and implementing the training. During the first implementation of the training, the gamified elements

in the activities helped to draw and retain attention during facilitation. The scoring and challenge elements in *Bulls and Cows* and the mystery and story/narrative elements in the *Treasure Hunt* increased teachers' engagement with the content as teachers attempted to make connections and solve the clues or codes. The feedback from the first iteration highlighted the importance of using subject-specific examples in the training content as a way of scaffolding this connection-making and transfer. Teachers' engagement induced a healthy competition to solve a clue as fast as possible. However, the teachers struggled with the *Treasure Hunt* activity. The lead author observed that teachers who did not finish the *Treasure Hunt* seemed frustrated that they did not have the right content knowledge to solve the math-based clues. At times, some teachers also voiced that they found the difficulty level of the clues higher than they could solve or that the story or narrative element was very complex, and it was hard for them to use abstraction to identify the problem that needed to be solved. In the remedial follow-up, changing this activity to a collaborative problem-solving format and including links to relevant content knowledge as hints really transformed this experience into an enjoyable one. Teachers' confidence and motivation in conducting these activities in their classes seemed to increase.Another locus of observation in the first iteration was the functioning of the CoP. It was evident that at the beginning of the training, most of the teachers engaging in the icebreaker activity were the active group teachers (math and computer science) who had received prior training and had been teaching CT for three years. The other teachers were observers. However, as the training progressed, with some encouragement from the facilitators, the teachers from the peripheral group began to participate in making connections. Several science and English language teachers began to type examples from their subjects in the chat box. It was observed that the participation was highest during the reflection activity that followed the pattern recognition activity as teachers could easily identify examples of patterns from their subjects. This observation of the active group teachers leading the participation and the peripheral group teachers gradually engaging with the topic is typical of a CoP. The gamified activities allowed the active group teachers to further hone their skills while the reflection activities helped peripheral group members to make connections

FEEDBACK	DEBRIEF INTERPRETATION	DESIGN MODIFICATION
Teachers need more help with Abstraction	Abstraction is a difficult concept to understand and warrants its own activity.	New Activity Added: *What's an Abstraction?—Role Play* Steps to identify an abstraction defined and discussed: *What's an Abstraction?—Identify an Abstraction*
Teachers lack confidence in facilitating the *Treasure Hunt* in their class due to complicated clues	Most clues were math based. Teachers struggled with the content knowledge needed to solve clues.	*New Treasure Hunt* was designed with clues based on different subjects including Science, Geography, English Language, and Math. Each clue was designed to include a hint. The facilitation was changed to a collaborative problem-solving type rather than an individual activity.
Teachers needed more help with Decomposition.	Master Trainers observed that this activity was primarily math- based. Need more examples from other subjects.	*New examples from different subjects* were added to the Decomposition section in the Reflection activity.
Master Trainers thought most activities were perceived as math based.	Some activities need to be modified for better reception by teachers of other subjects.	A *modified version of Bull and Cows* that included colors instead of 4-letter words was included.
Principals stated that moderate to high confidence was observed among teachers to conduct these activities in their classroom	A gradual increase in difficulty of constructs introduced to teachers might help in boosting confidence.	*The order of activities in the training was modified* to begin with an activity that teachers were already familiar with followed by topics that were perceived to be easier to understand and gradually proceed into the more difficult constructs such as Abstraction.

TABLE 4. Debrief Interpretations and Design Modifications—Second Iteration.

and engage with the content. The *Treasure Hunt* activity in the end gave all teachers the opportunity to begin to apply what they had learned. This indicated that the training could successfully leverage the existing system of the CoP to promote learning.

Lastly, the first author observed that teachers were very comfortable with the Google suite of tools. There were no technical difficulties or issues reported during or after the training. When particularly asked about their comfort with Google's suite of apps, teachers responded by saying that they were very familiar with them, and some who had questions regarding sharing and privacy settings received help from master trainers and fellow teachers. Overall, no problems were reported regarding the online aspect of the training. This reflected the seamlessness of the technology being used during the training. It also modeled a replicable approach to facilitating CT-integrated teaching in an online setting for the teachers.

TAKEAWAYS AND CONCLUSION

This design and implementation experience brought to light some important aspects of the instructional design process. This section summarizes our takeaways from this process and grounds them in instructional design literature.

Our first takeaway was about the strengths of leveraging the attributes of a CoP in training design and facilitation. We designed the training in a way that enabled the core group, the active group, and the peripheral group members to engage in different levels of participation in accordance with their roles and functions in the CoP (Wenger et al., 2002). The core group members (master trainers) were involved in the development and implementation stages as they reviewed the training design, pilot tested activities, and acted as subject matter experts during the training facilitation. The active group, comprising the math and computer science teachers, was given the opportunity to model CT concepts and practices by demonstrating how to apply CT to problems during activities. The peripheral group was able to learn and familiarize themselves with the content by observing the active group and engaging in the activities. Such an alignment with the existing structure and function of their roles in the community enabled maximum engagement during the training.

Our design focused on building experience through the practice and use of knowledge and skills while developing learner identities as contributing members of a community (Barab & Duffy, 2012). It also recognizes the expertise and skills that members of the community already have and leverages this expertise to catalyze the learning process (McDonald & Star, 2006). This exemplifies Hoadley's (2012) call for educators and instructional designers to capitalize on the CoP model by identifying the existing roles and knowledge of the stakeholders and learners and leveraging it in the design, development, and implementation phases.

Yet, designing meaningful instruction for CoPs comes with its challenges such as time constraints as discussed by McDonald and Star (2006). For CoPs to succeed in meaningful learning, there needs to be continuous ongoing engagement of the learners in the practice of the domain of interest. Thus, the time constraint of a 3-hour synchronous session was a key limitation of this training which was partially managed by setting up the remedial follow-up session and continued engagement with the teachers for the design of their treasure hunt activities. Future training sessions need to allow for longer-term interaction of the teachers within the CoP.

Our second takeaway is that the in-session observations by the author and the stakeholders discussed during the post-evaluation two-tiered debrief sessions proved to be essential in interpreting the feedback received in the evaluation stage and were crucial in understanding teachers' experiences holistically. The ad-hoc debrief discussions informed our design decisions in the second iteration and remedial follow-up. Since the debrief was an unplanned collaborative effort after the training implementation, we believe that future instructional design projects should involve pre-planned facilitation-observation as an additional source of data especially in the *Learning* and *Reaction* stages of evaluation as proposed in Hamtini's (2008) adaptation of Kirkpatrick's model for e-learning. This could be done by journaling stakeholder observations, including open-ended questions about stakeholders' observations in the evaluation questionnaire, and/or conducting and recording debrief sessions collaboratively.

This experience also stresses the need for pilot testing instructional design projects with target learners before the final implementation. Despite pilot testing it with the stakeholders, it was observed that the need for introducing subject-specific examples in activities was not identified before the first iteration. Often, time and resource constraints and lack of access to target learners result in instructional designers skipping the pilot testing stage (Rabel, 2019; Tessmer & Wedman, 1990; White & Branch, 2001). This design case reiterates the importance of pilot testing as defined by the classical instructional design process models (Dick et al., 2015; Smith & Ragan, 2005) as some learner needs may be unique and may not be identifiable by stakeholders.

This design case describes an experience of designing, developing, and implementing an online synchronous gamified teacher training on computational thinking skills for a CoP of in-service teachers. It showcases how the instructional designer theoretically grounded every design decision. It illustrates a unique experience of using open-source tools, specifically the Google Suite, which are easy to access, do not require any technical on-boarding, are free of cost, and widely familiar to teachers. The training content developed during this project is available under the Creative Commons License—Share Alike attribution.

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REFERENCES

Barab, S. A., & Duffy, T. (2012). What is a community of practice and how can we support it? In S. Land & D. Jonassen (Eds.) *Theoretical foundations of learning environments* (pp. 296–310). Routledge. https://doi.org/10.4324/9780203813799-18

Boling, E. (2010). The need for design cases: Disseminating design knowledge. *International Journal of Designs for Learning*, *1*(1). https://doi.org/10.14434/ijdl.v1i1.919

Bossard, C., Kermarrec, G., Buche, C., & Tisseau, J. (2008). Transfer of learning in virtual environments: a new challenge?. *Virtual Reality*, *12*, 151–161. https://doi.org/10.1007/s10055-008-0093-y

Bower, M., Wood, L. N., Lai, J. W. M., Howe, C., & Lister, R. (2017). Improving the computational thinking pedagogical capabilities of school teachers. *Australian Journal of Teacher Education*, *42*(3), 53–72. https://doi.org/10.14221/ajte.2017v42n3.4

Bradshaw, E. D. (2022). *Localization of Open Educational Resources by Facilitators of a Human Rights Course in Ghana*. ProQuest Dissertations Publishing.

Brennan, K., & Resnick, M. (2012). New frameworks for studying and assessing the development of computational thinking. *Proceedings of the 2012 annual meeting of the American Educational Research Association*, Vancouver, Canada.

Brown, T., McCracken, M., & O'Kane, P. (2011). 'Don't forget to write': How reflective learning journals can help to facilitate, assess and evaluate training transfer. *Human Resource Development International*, *14*(4), 465–481. https://doi.org/10.1080/13678868.2011.601595

Caskurlu, S., Yadav, A., Dunbar, K., & Santo, R. (2022). Professional development as a bridge between teacher competencies and computational thinking integration. In A. Yadav & U. D. Berthelsen (Eds.), *Computational thinking in education: A pedagogical perspective* (pp. 136 -150). Routledge. https://doi.org/10.4324/9781003102991-2

Conery, L., Stephenson, C., Barr, D., Barr, V., Harrison, J., James, J., & Sykora, C. (2011). *Computational thinking: Leadership toolkit* (1st ed.). International Society for Technology in Education. https://www.yumpu.com/en/document/read/43967234/computational-thinking-leadership-toolkit-iste

CSTA. (2016). *K-12 Computer Science Framework*. 297.https://dl.acm.org/citation.cfm?id=3079760

Dick, W., Carey, L., Carey, J. O. (2015). *Systematic design of instruction* (8th Edition). Pearson.

Dong, Y., Catete, V., Jocius, R., Lytle, N., Barnes, T., Albert, J., Joshi, D., Robinson, R., & Andrews, A. (2019). PRADA: A Practical Model for Integrating Computational Thinking in K-12 Education. *Proceedings of the 50th ACM Technical Symposium on Computer Science Education*, 906–912. https://doi.org/10.1145/3287324.3287431

Fischer, A., Greiff, S., & Funke, J. (2012). The process of solving complex problems. *Journal of Problem Solving*, *4*(1), 19-42. http://dx.doi.org/10.7771/1932-6246.1118

Floding, M., & Swier, G. (2012). Legitimate peripheral participation: Entering a community of practice. *Reflective practice: Formation and Supervision in Ministry*, *31*.

Foley, J. M., & Kaiser, L. M. (2013). Learning transfer and its intentionality in adult and continuing education. *New Directions for Adult and Continuing Education*, 2013(137), 5-15. https://doi.org/10.1002/ace.20040

Georghiades, P. (2000). Beyond conceptual change learning in science education: focusing on transfer, durability and metacognition. *Educational Research*, *42*(2), 119-139. https://psycnet.apa.org/doi/10.1080/001318800363773

Gray, C. M. (2020). Markers of quality in design precedent. *International Journal of Designs for Learning*, *11*(3), 1–12. https://doi.org/10.14434/ijdl.v11i3.31193

Grover, S. (2018, Feb 25). *The 5th 'C' of 21st century skills? Try computational thinking (not coding)*. EdSurge. https://www.edsurge.com/news/2018-02-25-the-5th-c-of-21st-century-skills-try-computational-thinking-not-coding

Grover, S. (2022). Computational thinking today. In A. Yadav & U. D. Berthelsen (Eds.), *Computational thinking in education: A pedagogical perspective* (pp. 18-40). Routledge. https://doi.org/10.4324/9781003102991-2

Hamtini, T. M. (2008). Evaluating e-learning programs: An adaptation of Kirkpatrick's model to accommodate e-learning environments. *Journal of Computer Science*, *4*(8), 693–698. https://doi.org/10.3844/jcssp.2008.693.698

Harley, J. M., Poitras, E. G., Jarrell, A., Duffy, M. C., & Lajoie, S. P. (2016). Comparing virtual and location-based augmented reality mobile learning: emotions and learning outcomes. *Educational Technology Research and Development*, *64*(3), 359–388. https://doi.org/10.1007/s11423-015-9420-7

Haseski, H. I., & Ilic, U. (2019). An investigation of the data collection instruments developed to measure computational thinking. *Informatics in Education*, 18(2), 297–319. https://doi.org/10.15388/infedu.2019.14

Haseski, H. I., Ilic, U., & Tugtekin, U. (2018). Defining a new 21st century skill-computational thinking: Concepts and trends. *International Education Studies*, *11*(4), 29-42. https://doi.org/10.5539/ies.v11n4p29

Hoadley, C. (2012). What is a community of practice and how can we support it? In S. Land & D. Jonassen (Eds.), *Theoretical foundations of learning environments* (pp. 286—299). Taylor & Francis Group.

Kale, U., Akcaoglu, M., Cullen, T., Goh, D., Devine, L., Calvert, N., & Grise, K. (2018). Computational what? Relating computational thinking to teaching. *TechTrends*, *62*(6), 574–584. https://doi.org/10.1007/s11528-018-0290-9

Kapp, K. M. (2012). Games, gamification, and the quest for learner engagement. *T+D*, *66*(6), 65-68. Gale Academic OneFile: https://link.gale.com/apps/doc/A292513787/AONE?u=purdue_main&sid=bookmark-AONE&xid=6e6ea2b8

Kapp, K. M. (2017). Gamification designs for instruction. In C. M. Reigeluth, B. J. Beatty, & R. D. Myers (Eds.), *Instructional-design theories and models, volume IV: The learner-centered paradigm of education* (pp. 351-385). Routledge.

Khan Academy. (2016, June 13). Decomposing shapes to find area [Video]. *Youtube*. https://www.youtube.com/watch?v=JTg8gyQ37pM

Kirkpatrick, J. D. & Kirkpatrick, W.K. (2016). *Four levels of training evaluation*. ATD Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.

Lu, J. J., & Fletcher, G. H. L. (2009). Thinking about computational thinking. *SIGCSE Bulletin Inroads*, *41*(1), 260–264. https://doi.org/10.1145/1539024.1508959

McDonald, J., & Star, C. (2006, December). Designing the future of learning through a community of practice of teachers of first year courses at an Australian university. In *Proceedings of the First International LAMS Conference* (pp. 65-76).

Niedelman, M. (1991). Problem solving and transfer. *Journal of Learning Disabilities*, *24*(6), 322–329. https://doi.org/10.1177/002221949102400601

Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review*, *18*(4), 315–341. https://doi.org/10.1007/s10648-006-9029-9

Rabel, D. K. (2019). *An examination of the decision-making process instructional designers use to complete projects with the constraints of limited time and tools* [Doctoral dissertation, ProQuest Dissertations Publishing].

Sands, P., Yadav, A., & Good, J. (2018). Computational thinking in K-12: In-service teacher perceptions of computational thinking. In *Computational Thinking in the STEM Disciplines* (pp. 151-164). Springer International Publishing. http://dx.doi.org/10.1007/978-3-319-93566-9_8

Sentance, S. & Csizmadia, A. (2016). Computing in the curriculum: Challenges and strategies from a teacher's perspective. *Education and Information Technologies*, *22*(2), 469–495. https://doi.org/10.1007/s10639-016-9482-0

Smith, P. L. & Ragan, T. J. (2005). Instructional design (3rd ed.). J. Wiley & Sons.

Smith, S. M., & Vela, E. (2001). Environmental context-dependent memory: A review and meta-analysis. *Psychonomic Bulletin & Review*, *8*(2), 203–220. https://doi.org/10.3758/BF03196157

Tessmer, M., & Wedman, J. (1990). A layers-of-necessity instructional development model. *Educational Technology Research and Development*, *38*(2), 77-85. http://dx.doi.org/10.1007/BF02298271

Wenger, E. (2011). *Communities of practice: A brief introduction*. https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/11736/A%20brief%20introduction%20to%20CoP.pdf?sequence=1&isAllowed=y

Wenger, E., McDermott, R. A., & Snyder, W. M. (2002). *Cultivating communities of practice: A guide to managing knowledge*. Harvard Business School Press.

White, B. S., & Branch, R. M. (2001). Systematic pilot testing as a step in the instructional design process of corporate training and development. *Performance Improvement Quarterly*, *14*(3), 75–94. https://doi.org/10.1111/j.1937-8327.2001.tb00219.x

Wing, J. M. (2011, March 06). *Computational thinking: What and why*. http://www.cs.cmu.edu/link/research-notebook-computational-thinking-what-and-why

Wolfenden, F., & Adinolfi, L. (2019). An exploration of agency in the localisation of open educational resources for teacher development. *Learning, Media and Technology*, *44*(3), 327-344. https://doi.org/10.1080/17439884.2019.1628046

Zhong, B., Wang, Q., Chen, J., & Li, Y. (2016). An exploration of three-dimensional integrated assessment for computational thinking. *Journal of Educational Computing Research*, *53*(4), 562–590. https://doi.org/10.1177/0735633115608444