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Research Article

Integrating cognitive presence strategies: A professional development training for K-12 teachers

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ABSTRACT

For K-12 teachers to improve effective teaching skills, cognitive presence (CP) integration into teaching and learning process is of utmost value. CP strategy training can serve as a facilitating component in supporting K-12 teachers' instructional capacity. This study presents findings of a teacher professional development training aiming CP strategy implementation at K-12 level. Following a mixed-method methodology, the present research was carried out with 53 teachers from four different campuses and grade levels, who were guided to implement CP strategies in their teaching context. The data sources were CP-integrated lesson plans, trainers' feedback on these lesson plans, teacher responses on a questionnaire. The data collection methods were utilizing an end-of-the-training questionnaire directed to teachers, lesson plan evaluation through a CP rubric, content analysis of trainer feedback on lesson plans and revised lesson plans. Results unveiled that this professional development training designed and implemented for K-12 teachers led to significantly positive changes in teachers' CP strategy integration into lesson plans regardless of levels, subjects or topics. This study could also provide important contributions to designing teacher professional development training for researchers, practitioners and teacher trainers, particularly in CP dimension.

Keywords: cognitive presence, professional development, K-12, learning community, practical inquiry model

INTRODUCTION

The community of inquiry (CoI) is a theoretical framework that facilitates critical thinking, critical inquiry, and discourse in online learning environments (Garrison et al., 2000). In addition to presenting the details of the teaching and learning engagement in a systematic fashion (Perry & Edwards, 2005), CoI framework supports and consolidates *deep* and *meaningful learning* through the interplay among three types of presences: social presence (SP), cognitive presence (CP), and teaching presence (TP). Thus, this framework has been extensively adopted to foster the quality of teaching and learning.

Garrison et al. (2001) define CP as "the extent to which learners are able to construct and confirm meaning through sustained reflection and discourse" (p. 11). The processes and outcomes in an iterative cycle assist individuals to arrive at answers and test solutions in a learning community (Akyol, 2009), with CP standing at the heart of this iteration, and contributing substantially to its establishment.

CP is operationalized through the practical inquiry model (PIM), comprising four phases. The descriptions and indicators of each phase are as follow:

1. Triggering event: This phase refers to learners' understanding, restating, and clarifying the content (Garrison et al., 2000) through testing different conceptual hypotheses. The triggering event phase is characterized as "a state of dissonance" or "feeling of unease" (Garrison & Archer, 2000) resulting from an experience.
2. Exploration: This phase focuses on learners' exploring the issue at hand (Garrison et al., 2000), allowing them to seek further information, knowledge or other alternatives that may help mitigate the problem or lead to further insights into the situation (Garrison & Archer, 2000).
3. Integration: This phase is where learners move towards a more focused and structured phase to construct meaning (Garrison & Anderson, 2003), and develop solutions by making connections across the knowledge (Garrison & Arbaugh, 2007).
4. Resolution: The final phase is pertinent to the resolution of the problem or dilemma, through developing a context specific solution (Garrison & Anderson, 2003) in the form of applying a new idea or testing a hypothesis in a different environment (Garrison & Archer, 2000). This phase could be realized by taking direct or vicarious action (Garrison & Anderson, 2003).

The triggering event and exploration phases represent the lower levels of CP, while the integration and resolution phases represent higher levels (Sadaf & Olesova, 2017). Anderson and Krathwohl (2001) identified the lower levels as remembering, understanding, and applying, and the higher levels as analyzing, evaluating, and creating in their revision of PIM through Bloom's taxonomy.

Vaughan and Garrison (2005) argued that the online and face-to-face components of training programs should be designed appropriately as complementary to one another to help reach higher levels of learning (integration and resolution). Meyer (2003) suggested that lower levels of learning (triggering event and exploration) could take place in the face-to-face environment.

The integration and resolution stages, on the other hand, necessitate time and reflection; therefore, reflective online environments could aid learners' progress through creating solutions and transferring knowledge. This contributes to learners' epistemic growth (Krzyszkowska & Mavrommati, 2020) with the help of formative feedback and facilitation. If a particular lesson requires further reflection and discussions, the utilization of reflective online environments could equip students with further discussion topics (Vaughan et al., 2013) and lead to achieving higher learning outcomes. Factors that inhibit learners from reaching higher levels of learning through the phases of PIM are the length of the program (Akyol, 2009), gender (i.e., the multiple responsibilities of women) (Müller, 2008), the design of learning activities (i.e. assigning the learner a role in a debate completely aligned with their existing perspective) (Akyol, 2009; Darabi et al., 2011), moderator's presence in the discussion (i.e., being too dominant or absent) (Dennen, 2005), and the course content (i.e., being too narrow or specific) (Garrison et al., 2001).

Impact of Interplay Between Presences in Community of Inquiry Fostering Cognitive Presence

The interrelationship of CP, SP, and TP of CoI has been validated by several studies placing CoI framework at the core of their designs (Arbaugh et al., 2008; Garrison & Anderson, 2003; Garrison et al., 2010; Kozan & Richardson, 2014; Mirabolghasemi et al., 2011; Stein et al., 2007). CoI is effective in providing deep and meaningful learning processes and attaining learning outcomes, however, there is a dearth of studies focusing on the validation of the interplay among three presences with diverse populations, such as professional development communities, and across different disciplines (Cohen & Holstein, 2018; Gokturk Saglam & Dikilitas, 2020).

Having a prominent role in the facilitation of deep learning (Akyol, 2009), CP has a dynamic relationship with TP. Garrison (2009) states that attainment of the higher levels of CP depends on the design of tasks, facilitation, and direction (constituting the three categories pertaining to TP). In fostering CP, Garrison (2017) and Akyol (2009) revealed that the following have a critical role: teaching methods and learning activities (design and organization) and sharing several resources with learners (facilitation). Other factors found to have a positive impact on CP were, as follows: effective facilitation of meaningful student-to-student interaction (Arend, 2009), and the leadership exercised by the instructor (Garrison & Cleveland-Innes, 2005) through creating an appropriate design to provide coaching and feedback (Stein et al., 2013), employing multiple discussion strategies, such as peer facilitation, initiating cognitive talk to encourage learners to think about their own interpretations and understanding, as well as sharing their thinking, and finally, protocol discussion prompts (DeNoyelles et al., 2014; Zepeda et al., 2019).

Maintaining and developing SP is considered integral to the establishment of collaboration and critical discourse (Garrison & Anderson, 2003) to leverage the quality of critical thinking in a learning community. SP has a crucial role in the development of CP (Akyol, 2009) through the construction of new information with community members (Picciano, 2002), sharing and exchanging ideas, as well as receiving the support of peers (Yildirim & Seferoglu, 2021). Dewey placed inquiry and community at the forefront of his philosophy and postulated that the latter was fundamental to individual development (Swan et al., 2009). The community spirit ignited by CoI enhances the information flow, the availability of support mechanisms, devotion to shared goals, and rapport among group members (Rovai, 2002), reflecting the two-way relationship between the community and shared learning that leads community members to process and construct knowledge through collaborative inquiry (Garrison et al., 2000).

Interaction is of paramount importance in learning and a more prominent point in online learning. The role of structured collaboration and coherent interaction of discourse (Garrison & Cleveland-Innes, 2005) are emphasized for the sake of deeper learning of the content. Resonating with Garrison and Cleveland's (2005) elaboration on the concept of interaction that while interaction may be a key feature of effective learning, the high levels of interaction and idea exchanges do not guarantee that learners are cognitively invested in meaningful learning. In doing so, while structuring the lesson, teachers should use modeling to aid learners' understanding of how to approach a given task, how to manage and monitor their own learning, as well as how to construct their personal meaning, thereby assisting the learners in becoming critical thinkers and self-directed learners (Garrison, 2017). Modeling contributes to the establishment of CP by gradually creating a trusting, collaborative environment where students can effectively and appropriately share their ideas, and where TP is also distributed amongst students (Garrison, 2017) attenuating the authoritative role of the teacher (Rourke & Anderson, 2002). Reaching higher levels in PIM is more concerned with the quality rather than quantity of interaction, Thus, SP is considered a prerequisite for CP; however, not sufficient on its own to help learners move forward the integration and resolution phases. Neglecting to provide students with structure and guidance (Garrison & Cleveland-Innes, 2005) may cause surface interactions, consisting of repetitive statements bound up with personal experiences, rather than the critical discourse PIM ultimately aims at moving learners towards.

Discussion questions play a critical role in the establishment of CP through teachers' facilitation of the design in discussion threads (Darabi et al., 2011; Garrison et al., 2000; Meyer, 2003; Tastle et al., 2005). Some studies reveal results in favor of well-written questions to enhance the critical thinking and deep learning processes (Toledo, 2006), but others emphasize the need for ill-structured questions to trigger the thinking process (Gaševic et al., 2015; Jonassen 1997). To contribute to the meaningful inquiry among participants, the following methods are suggested: using pre-structured threads (Brooks & Jeong, 2006), asking probing questions (Whipp, 2003), providing online scaffolding (Schindler & Burkholder, 2014), integrating case-based discussions leading to debates and topic-based discussions (Richardson & Ice, 2010; Vaughan et al., 2013), utilizing authentic tasks (Sadaf & Olesova, 2017) and finally, the establishment of a non-judgmental environment (Hosler & Arend, 2012). In this regard, it is important to note that the low level of CP in online discussions could be related to the nature of the task and the wording of the question prompts (Darabi et al., 2011; McLoughlin & Mynard, 2009); thus, rather than an incremental design stemming from a deficient and lacking approach, the discussion should be aligned with the educational objectives, and discussion questions should consider students' metacognition (Vaughan et al., 2013).

Deriving from the nature of the metacognition, it is critical to provide learners with clear expectations of the program (Ergulec, 2019), complement the lessons with assignments aligned with the educational objectives, and to establish clarity with direct, timely and constructive feedback, to help students move towards deeper learning and more meaningful inquiry (Hosler & Arend, 2012). Developing rubrics that communicate the desired cognitive objectives helps learners reach higher levels of inquiry (Baldwin et al., 2018) by providing competency-based formative feedback (Ergulec, 2019) in the process of learning. It is noteworthy that the quality of responses may be severely affected when grades are delivered taking the frequency of responses into account (Vaughan et al., 2013). Using a rubric alleviates these quality-related issues by allowing learners to understand the expected competencies (Dunlap & Lowenthal, 2018).

Research on Professional Development: Weak and Strong Aspects

Along with the epistemological shifts taking place over decades (Johnson, 2009), the focus in professional development (PD) programs has shifted away from teachers' role as passive recipients of knowledge towards reflective practitioners (Crandall, 2000), achieved through collaboration, meaningful interaction, and devotion to shared goals (Sheppard & Brown, 2014). One of the major criticisms towards professional development programs is the lack of theoretical grounding (Mishra & Koehler, 2006). Professional development programs lacking such bases may not promote higher levels of learning (i.e., content transmission mode where teachers simply copy and paste some activities and/or strategies without carefully examining the needs and requirements), resulting in lack of transfer to the performance context (Rivera et al., 2017; William & Leahy, 2014). Furthermore, research studies on PD highlight the lack of facilitation, lacking follow up across the stages of PD and insufficient scaffolding, the incoherence between theory and practice, lack of resources and guidance (Hertz et al., 2022). Attempting to alleviate such issues, several PD studies highlight that professional development programs should be designed to incorporate interactive experiences (Parsons et al., 2019), integrating authentic tasks and content that can easily be transferred to classrooms (Reeves & Pedulla, 2013), peer review (Gamage et al., 2017), construction of knowledge through interaction, incorporating active learning (Desimone et al., 2002), reflection and feedback, supporting teacher collaboration (Darling-Hammond et al., 2017; Kabilan & Veratharaju, 2013; Kuusisaari, 2014; Turudu, 2020). In line with the findings of such high-quality professional development programs, this study presents a professional training designed for K-12 teachers to help them implement PIM to enhance students' CP.

METHODOLOGY

The present study was conceptualized and designed as a mixed-method study employing qualitative and quantitative data collection instruments and methods. One of the reasons why a mixed methods design was selected for this research is when used together, the qualitative and quantitative methods add a complementary feature and lead a more robust analysis (Tashakkori & Teddlie, 2008). Creswell and Plano Clark (2018) divide mixed methods designs into three categories: concurrent, sequential and multiphase combination. Employing the qualitative and quantitative data collection instruments and methods, the sequential exploratory design was used in this mixed method research. It was aimed to explore the implementation of each phase in PIM and unveil the underlying factors fostering deep learning.

Participants and Setting

Convenience sampling, which is one of the non-probability sampling techniques, was selected considering the accessibility of the participant teachers to the researchers. The participants were 53 K-12 teachers from four different campuses and grade levels working in a private school in Turkey, which was also the research-site. The participants were between the ages of 29 and 45, and variously taught at kindergarten, elementary, middle and high schools. Their teaching experience varied between four and 20 years; and none had previously received any training on CP. The private school where they worked had a history of more than a hundred years.

The researchers were also the trainers in the professional development program. Working as academics at state and foundation universities, they all had expertise and at least 10 year-experience in the educational technology field, and more specifically, in teacher training for CoI and CP, self-regulated learning and active

Table 1. 16-week professional development program

Subjects	Activity	Task	Delivery
Introducing CP *(2 weeks)*	*Understanding CP (1. Triggering event, 2. Exploration, 3. Integration, 4. Resolution) *Trainers' experiences *Participants' reflective thinking	Introduction & suggested readings for teachers	Synchronous online
Introducing CP rubric *(2 weeks)*	*CP rubric introduction *CP rubric adaptation to four grade levels	Collaborative rubric adaptation to four grade levels by pertinent participants	Asynchronous online
CP activities *(1 week)*	*Sharing a list of evidence-based CP activities	Determining potential areas for CP activities in lesson plans	Asynchronous online
Alignment of CP activities *(2 weeks)*	*Fine-tuning & aligning activities with grade level needs	Alignment of CP activities with four grade levels as a group task	Synchronous online
CP integration into lesson plans *(2 weeks)*	*'How to use CP in a lesson' through model lesson plans	Integrating CP activities in lesson plans & sharing on Google Site	Asynchronous online
Implementation *(2 weeks)*	*Transferring lesson plan content into their teaching context	*Implementing CP components in their lesson plans	Synchronous online
Trainer evaluation *(1 week)*	*Volunteering teachers' lesson plans being evaluated live online by trainers	Trainer evaluation of CP in sample lesson plans on Google Classroom through rubric	Synchronous online
Trainer feedback *(3 weeks)*	*Feedback by trainers on lesson plans	Trainer feedback for uploaded lesson plans on Google Site through rubric	Asynchronous online
Sharing day & wrap-up workshops *(1 week)*	*Best practices by teachers in four grade levels & online break-out room visits by trainers *Sending training evaluation form to participants	Teachers' meeting with colleagues in their branches & sharing best CP practices	Synchronous online

learning training. With relevant national and international publications and project-based scholarly work, the trainers were the main actors in designing and delivering the teacher training program on CP. They had relevant roles, which allowed them to carry out various tasks at the design, development, implementation, evaluation, and reporting stages of the professional development training under consideration.

The consent for conducting CP strategies teacher training on students' learning experiences was obtained and ensured through an official contract between the private school and parents before the research, commencing at the beginning of the new semester in 2020-2021 academic year. The online sessions and teaching activities were also open to parents' visits and observation as a policy of the school, to maintain accountability. The present training, as well as a number of others, were within a broad teacher training program organized by this private school. Morrison et al. (2011) state that a participant who selects one or more training options (i.e., a course, workshop, or seminar), in fact, states an expressed need. The motive behind working with this school was its administration and teachers' awareness of their needs in equipping themselves with high-quality teaching and instructional technology skills, while also supporting its students with optimum learning skills; CP training was one component of a series of trainings to reach this goal. Offered as one significant part of their working conditions counted in their teaching hours, all the teachers attended and participated in the training through live and asynchronous sessions, lesson plan preparation, in-class implementation and reporting, and sharing day activities. Over three school years, this program has delivered content on areas including distance learning, CP, self-regulated learning, and active learning training.

Professional Development Program to Promote Cognitive Presence in K-12 Level

The professional development program to integrate CP into the teaching process was designed as a continuing and interactive in-service teacher training, and lasted for 16 weeks, a full academic term for K-12 levels. Three different approaches, the Kemp instructional design model (Sims & Jones, 2002), PIM (Garrison et al., 2000), and learning community framework (Lave, 1991; Palincsar et al., 1998) were adopted in the design of the professional development program, as shown in **Table 1**.

The models were purposefully utilized in order to motivate and enable the participating teachers to gain the essential conceptual and theoretical knowledge, obtain and implement target teaching practices and to revise learned materials as necessary. Moreover, a virtual learning community was created allowing trainers' and teachers' presence in the online learning spaces specially designed for the training (Google Classroom and Google Site). In these online learning spaces, trainers shared fundamentals of CP, announcements and feedback on lesson plans, and participating teachers shared discussions and lesson plans.

Delivered in a fully web-based hybrid fashion, six synchronous online sessions each lasting for up to two hours were presented through the tele-conferencing system, in addition, four asynchronous tasks were completed through online tools (Google Classroom, Google Drive, Google Docs, and Google Site) over eight weeks. For the synchronous online sessions, trainers and teachers met through a teleconferencing system to cover the theoretical ground for CP, to discuss sample lesson plans enriched by CP strategies, and to share experiences with their colleagues while also to hold concluding Q&A sessions. As for the asynchronous part, relevant content, readings and tasks were shared with the teachers through the content management system (Google Classroom). In the synchronous online meetings, in addition to idea-sharing and discussing the theoretical and practical tenets of CP, there were a variety of tailored teaching and learning events, including discussing the trainers' feedback on the participants' lesson plans. During these sessions, as well as the trainer feedback, the teachers were able to benefit from the experience and expertise of their colleagues, which created a learning community experience. Afterwards, according to the feedback received, the teachers revised their lesson plans and implemented CP strategies.

The first part of the training program focused on understanding CP, making inferences from trainers' experiences, and teachers engaging in reflective thinking activities on teaching practices. Weekly topics were the triggering event, exploration, integration and resolution as phases of CP, and the focus was on understanding the rubric, and transferring this knowledge to teachers' professional context. Later in the program, trainers introduced CP rubric (Akyol & Garrison, 2011), the aim was to provide the teachers with knowledge, skills, and strategies that would allow them to integrate CP into their lesson plans. The rubric introduction was followed by a collaborative adaptation task in which the teachers adapted the rubric so that its final form would more closely match and meet the needs of each of the four grade levels.

In the interactive and synchronous online sessions, the teachers were presented with a list of CP promotion strategies to promote students' cognitive capacity and meaningful participation in their own learning by *triggering* their attention, giving students opportunities to *explore* the content alone or in collaboration with the teachers, *integrate* learning, and conclude with *resolutions* on the results and relevance of their transferable learning to real life events. The teachers were asked to develop and implement lesson plans focusing on these four phases of CP, write a reflection, share lesson plans in synchronous online trainer evaluation sessions, and make them accessible on the Google Site to both the trainers and their colleagues. This enabled the trainers to give feedback on the teachers' lesson plans before the implementation. The teachers also had the chance of revising their lesson plans based on the trainer's feedback. The teachers from all four campuses, the trainers and the leadership team of the private school met online for a special sharing day to observe the teachers' achieved progress. On this day, in separate meetings for each grade level, teachers shared their best practices and discussed ways to improve their understanding and to maximize the utilization of CP strategies. As a concluding task, the teachers were asked to fill in a training evaluation questionnaire designed by the trainers, composed of Likert-type and open-ended questions.

Data Collection

The study involved five data sources as listed in **Table 2**, consisting of both qualitative and quantitative data sources, emerging from the lesson plans (two), lesson plan feedback (one), and the training evaluation questionnaire (two). 53 participants each presented one lesson plan:

(a) four lesson plans at kindergarten level,

(b) 11 at elementary school level,

(c) 16 at middle school level, and

(d) 22 at high school level.

Table 2. Data sources and data collection Instruments

Data source	Instrument	Data type
Lesson plans	Adapted CP instrument (with constructs as triggering event, exploration, integration, resolution, educational technology, learner support, & interaction)	Quantitative
Trainer feedback on lesson plans		Qualitative
Revised lesson plans		Qualitative
Participant opinions	Training evaluation questionnaire (Likert-type questions)	Quantitative
	Training evaluation questionnaire (open-ended questions)	Qualitative

Quantitative data were derived from the lesson plan evaluations through the collaboratively adapted instrument to scale CP in the relevant *lesson plans*. Another source of *quantitative data* was *the training evaluation questionnaire,* which involved Likert-type questions directed to the participants at the end of the training. *The qualitative data* were obtained from

(a) the trainer feedback on the lesson plans, which was uploaded asynchronously by the participant teachers on Google Site,

(b) *the lesson plans*, which the teachers revised after receiving the trainer feedback, and

(c) the training evaluation questionnaire, which involved open-ended questions directed to the participants at the end of the training.

An instrument was created to help teachers understand the fundamentals of CP, integrate CP into their lesson plans, and to evaluate previously prepared lesson plans in terms of CP. Four professors and a doctoral researcher (PhD candidate) in educational sciences collaborated with different grade level teachers to ensure that the instrument accurately matched the grade level needs. This instrument was developed by adapting the online community of inquiry syllabus rubric (Rogers & Van Haneghan, 2018) (ICC: 0.821 $p<0.01$, 95% CI [0.40, 0.932]) and the cognitive presence scale developed by Arbaugh et al. (2008), itself adapted into Turkish by Ozturk (2012).

First of all, the language adaptation of the online community of inquiry syllabus rubric was completed through the forwarding translation process (Acquadro et al., 2004). The forwarding translation process carried out by three Turkish bilingual translators:

(1) an experienced translator,

(2) a PhD candidate English teacher, and

(3) a professor in the field of educational technology.

After reaching a consensus, this jointly agreed version was then back-translated by two translators (an experienced English teacher and a PhD candidate English teacher). To confirm the compatibility with the original rubric, the back-translated version was evaluated, and the rubric was finalized. After the process of language adaptation, the Turkish version of the rubric was checked by two experienced Turkish language teachers.

After the adaptation process, the instrument including both rubric and scale was shared with participating teachers, who were asked to comment on the suitability of each item in the rubric and scale for their particular grade level and their courses. A total of 21 teachers from four different campuses at different grade levels (including kindergarten (two), elementary (two), middle (eight), and high school (nine) and branches provided feedback over a period of two weeks. The teachers revised the explanations in the dimensions in the rubric considering their own fields and student groups, and evaluated whether it was possible to carry out each of the items in the instrument in their own lessons providing clear justifications (e.g., “middle school students may need to be guided by the teacher so that they can reach reliable sources”, “I do not think they will have the opportunity to test the subjects because my branch is history”, “I think the visuals and videos I use in my lessons will be enough to attract their attention”, etc.). All the documents containing the teachers’ feedback were reviewed, the comments were compiled and returned to the teachers to get their final comments, and then based on this, the rubric and scale items were finalized. With the finalization of the scale, it was found that each item in the instrument could be grouped under the four different themes of CP.

To maximize the instrument's quality, for internal and external validity, synchronous online meetings were held, and asynchronous time was allocated for sharing comments and evaluations. In their final versions, the categories of the online community of inquiry syllabus rubric were updated as

(1) Instructional design for cognitive presence,

(2) Educational technology for cognitive presence,

(3) Student support, and

(4) Interaction.

The categories of the instrument based on the cognitive presence scale consist of

(1) Triggering event,

(2) Exploration,

(3) Integration, and

(4) Resolution.

This instrument development process also gave the teachers a pre-preparation opportunity to design their lesson plans to promote CP, to become familiar with the subject and increase their readiness for the development of lesson plans.

The training evaluation questionnaire was prepared by the four trainers and aimed at gathering participants' scores and responses. It was composed of Likert-type and open-ended questions regarding the training content, quality, transfer, trainer effectiveness, and suggestions, if any. The questionnaire was composed of seven open-ended questions and 12 Likert-type questions, each to be evaluated with four-degree criteria, as follows: *I strongly disagree (1), I disagree (2), I agree (3),* and *I strongly agree (4).* Both open-ended and Likert questions attempted to unveil the participant teachers' views and experiences regarding the training content, training activities, trainers, and overall suggestions. After expert review of the instrument, with four trainers, the questionnaire took the final form.

Data Analysis

First of all, by utilizing the instrument, the researchers evaluated the lesson plans in terms of four phases of CP, namely triggering event, exploration, integration and resolution, in addition to the educational technology, learner support and interaction dimensions. This displayed the overall quantitative characteristics of the lesson plans separately for grade level, namely for kindergarten, elementary, middle and high school levels (Braun & Clarke, 2016). Another set of *quantitative data* emerged from Likert-type questions in *the training evaluation questionnaire,* which revealed important data as descriptive statistics, mainly, the means of teacher evaluations for each of the four grade levels.

The qualitative data were obtained from the trainer feedback on the lesson plans, *the lesson plans* revised after receiving trainer feedback, and *the participants' open-ended responses in the training evaluation*. These data sources were analyzed through theme-analyzing, which relies on inductive analysis. The revisions in the lesson plan content meant the plans were suitable for thematic analysis. Inductive analysis of the lesson plans and trainer feedback was conducted as it provided a suitable space for a bottom-up understanding of the training outcomes regarding teachers' grasp of the subject matter (Saldaña & Omasta, 2017). Being qualitative in nature, this enabled the researchers to observe and assess the teachers' ability to transfer CP strategy training into their teaching context, as well as allowing the overall evaluation of the training. Thematic analysis of *the trainer feedback, the lesson plans,* and *the participants' open-ended responses* helped to reveal the strong and weak aspects of teachers' skills, as to integrate CP strategies into teaching, and provided the trainers with insights on the training instructional design.

The qualitative and quantitative data were in a complementary nature (Woiceshyn & Daellenbach, 2018). To achieve a reasonable level of reliability and validity in the research design, the researchers took a number of measures, such as using a validated instrument, peer debriefing, seeking experts' opinions, member checking and deep engagement in the research process.

While collecting the quantitative data, the researchers simultaneously started qualitative analysis (Morrison et al., 2002). Following the content and thematic analysis, peer debriefing was carried out to ensure

credibility and trustworthiness (Creswell, 2002). Two researchers analyzed the lesson plans through the instruments while the other two were working on thematic analysis to unveil the themes in lesson plans, trainer feedback and open-ended responses from the training evaluation questionnaire. Member checking was done through sharing the findings with the teachers. It was seen that all results were congruent and consistent in terms of reflexivity.

In brief, multiple data collection instruments were administered to optimize the credibility and trustworthiness of the research. Triangulation of all three data sources enabled a clear focus on the research questions and the rejection/acceptance of the hypothesis. The cross-check was enabled through the alignment of the qualitative and quantitative analyses, which underlined the reliability of the findings in this study.

FINDINGS AND DISCUSSION

This section presents the discussions of the major findings of this study considering the research question in light of the related literature and the conclusions drawn. In addition to the participants' opinions gathered through the training evaluation questionnaire involving Likert-type and open-ended questions, the quantitative data was collected via the adapted CP instrument. CP instrument used when evaluating the lesson plans confirmed the findings of the qualitative data derived from the content analysis of the trainers' feedback and revised lesson plans. The analysis of all the data presented the themes emerged, as follows:

- The implementation of PIM regardless of levels, subjects, or topics,
- The exploitation of each phase in PIM,
- The underlying constructs of quality interaction, and
- The factors promoting deep learning in PIM.

Implementation of PIM Regardless of Levels, Subjects, or Topics

Defining CP as a manifestation of practical inquiry, Garrison et al. (2001) state that it is implemented through the practical inquiry process. Considering all the phases and basic foundations of this model, one can question whether this model is applicable in particular levels, subjects or topics only. However, Garrison et al. (2000) strongly argue that this model can be applied to all educational experiences. In line with Garrison's (2000) argument, the thorough analysis of the data in this study showed that PIM was implemented in all levels including four kindergarten, 11 elementary, 16 middle school, and 22 high school lessons. The trainers' assessment of the lesson plans (based on item 1 in CP instrument) showed the appropriateness of PIM to ensure CP in terms of instructional design in all levels with the overall score of 4.43/5.00. The level-wise scores were given, as follows: kindergarten 5.00, elementary school 4.54, middle school 4.31, and high school 3.90 out of 5.00.

Another striking point was the wide variety of the subjects at those levels. They were not limited to science or literature only. It was hard to miss how PIM was operationalized in almost all subjects including chemistry, biology, history, geography, language and social sciences, which naturally cover various topics such as electricity circuits, household waste and social life of first settlers. **Appendix A** displays the matrix of levels, subjects and topics analyzed in this research.

Exploitation of Each Phase in PIM

The close study on the 53 lesson plans verified that the teachers aimed to achieve the lesson objectives by implementing the strategies appropriate for each of the phases in PIM, in line with Garrison et al.'s (2000) statement that the instructional goal and challenge are to lead the inquiry process through all the four phases so as to establish a successful outcome. Despite with varying degrees as seen in **Table 3**, the quantitative assessment and trainers' written feedback showed that all the four phases of PIM created the backbone of the instructional experiences and were successfully carried out in the lesson plans.

All the data clearly showed that the first phase of CP, triggering event, which is a state of dissonance or feeling of unease resulting from an experience creating a sense of puzzlement (Garrison et al., 2000), was

Table 3. Trainers' rubric assessment of the phases

Phases of PIM	Kindergarten	Elementary school	Middle school	High school	Total (/5.00)
Triggering event	4.16	4.48	4.04	3.60	4.07
Exploration	4.58	4.15	3.85	3.81	4.10
Integration	4.50	4.18	3.87	3.90	4.11
Resolution	4.50	4.13	3.84	3.70	4.04
Total	4.43	4.23	3.90	3.75	4.08

successfully fulfilled in the lesson plans. The mean of the three items in CP instrument related to triggering event (items six, seven and eight) in all the lesson plans was 4.07 out of 5.00. The content analysis of the revised lesson plans also demonstrated that the teachers used various strategies to attract the students' attention and made them intrigued into the lesson. For example, a chemistry lesson (L43) started with an intriguing question of perfumes used every day; in a history lesson (L34), the students were shown an image of a community in the past and asked to brainstorm and make judgments about their social life and values. In a physics lesson (L36), they watched an Edpuzzle video on ocean waves with the question of what makes such waves that powerful. Before they started their mathematics lesson (L37), they played a game on Phet Simulations. Apart from attention-grabbing questions, images, videos and games, the teachers asked the students to complete a story (L17), make guesses what was in a box displayed on the screen (L33), play with QR-codes (L35), and decide on a given intriguing case (L38) in order to create a dissonance in this phase of PIM. The variety of strategies and the high statistical score were also confirmed by the trainers' feedback like "the triggering event was successfully presented to the students on Nearpod" (L10) and "the triggering events were presented to the students well through exploration" (L19).

The mean of the scores related to the second phase, exploration, obtained from CP instrument (items nine, ten, and eleven) was 4.10 out of 5.00. The detailed analysis of the revised lesson plans demonstrated that in this divergent phase, the students were involved in many different activities such as brainstorming, expressing their ideas, questioning, making justifications and voting, through various technologies like Flipgrid, Padlet, Mentimeter, Flipchart, Anatomy App, and Wordwall, which encouraged learners to research information, knowledge, and alternatives that helped them make sense of the given dissonance (Garrison et al., 2000). Thus, the data showed that this phase of PIM was also implemented satisfactorily.

The analysis of the revised lesson plans showed that the third phase, integration, was effectively operationalized in this study since the learners were encouraged to connect ideas and incorporate the information and knowledge into a coherent form (Garrison et al., 2000). For example, they were asked to work in groups and prepare a presentation on the orbit of the Earth (L32). In a language lesson (L5), as a group, they decided on a particular invention and gave the justification why that invention was more important. In a science lesson (L17), the students were asked to collaborate with each other and determine the steps that a scientist might follow when encountering a daily problem. The trainers also openly underscored the satisfactory implementation of this phase in their feedback such as "synthesizing the individual ideas into group work was very effective" (L38) and "the skill of transfer was promoted; and your learners were given the chance of implementing what they have learned in a new environment" (L46). The successful implementation of integration also reflected itself in the scores of CP instrument, which were 4.50 for kindergarten, 4.18 for elementary, 3.87 for middle, and 3.90 for high schools.

The fourth category, resolution, helped learners solve an issue or apply the ideas or solutions; however, the scores given by the trainers, their feedback and analysis of the revised lesson plans showed that this phase of PIM was the least fulfilled of all. The score of CP instrument was 4.04 for all the levels. In some lesson plans (e.g., L1), it was noticed that 'resolution' and 'after the lesson' were used like a collocation so this phase was assigned as homework like preparing a poster (L33), sharing a post on an online platform (L5), recording a video (L17), completing the given quizzes (L27), or online games (L39) outside the classroom. This was supported by Archer and Hughes' (2010) argument that many lessons generally reach the resolution phase offline. The result of this study is also upheld by many studies showing that students are usually engaged in the phases of triggering event and exploration rather than the resolution phase (Kanuka et al., 2007; Vaughan & Garrison, 2005). As a justification for that, in their study, Garrison et al. (2001) argued that the frequency of the participants' responses for integration and resolution in particular, was so little because the time required for reflection to synthesize information was not enough; and also, offering tentative solutions was challenging

for many learners. This situation is valid in this study as well since the students needed more time to apply what they had learned in the lesson such as drawing images by using the golden ratio spirals in a mathematics lesson (L9) and creating an online booklet on the via an app called Bookcreator in a social sciences lesson (L30). Additionally, coming up with solutions was not easy in particular lessons like making equations and drawing straight angles on a given platform (e.g., Desmos) in a mathematics lesson (L37) and preparing an animation showing the factors playing a role in how salt dissolves in water (L47). Garrison et al. (2001) claim that another reason behind weaker results in the resolution phase is related to the instructional design and facilitation, which means that it may not be the objective of the lesson to lend itself to advanced inquiry. This could be regarded as the case for particular lessons in this study since some lessons were delivered as a small part of a long chapter or unit, which guide the learners to advanced inquiry in the following lessons, not the one that was investigated in this research.

Another notable outcome of the study is related to the use of educational technologies in the implementation of PIM. The trainers' assessment of educational technology in CP instrument was given, as follows: kindergarten 3.50/5.00, elementary school 3.81/5.00, middle school, 3.43/5.00, and high school 3.90/5.00. Thus, the results clearly demonstrated that technology fostered CP of the learners at all the levels. However, the teachers were overambitious in the use of technologies, which was also openly stated many times in the trainers' feedback like "though the use of educational technology was appropriate, in order not to cause cognitive burden, please try to achieve maximum efficiency with fewer technologies" (L6). **Appendix B** lists some of the technologies that the teachers used in different phases of PIM.

Underlying Constructs of Quality Interaction

In addition to modeling how to create and maintain quality discourse when teaching and learning online, the crucial role of interaction in PIM was openly underscored in this study. There was also a particular item titled 'interaction' in CP instrument (item four). The teachers were provided with feedback on the interaction pattern they involved in their lesson plans. The trainers' assessment of interaction was, as follows: kindergarten 4.00/5.00, elementary school 3.72/5.00, middle school 3.12/5.00, and high school 3.38/5.00.

Markedly, the statistical data revealed a noteworthy point. The means were higher in lower levels (kindergarten and elementary school) compared to higher levels (middle school and high school). There was a decreasing trend when the levels increased, which might make one question whether there is an underlying element related to the age of the learners or the challenge level of the lessons. However, such conclusions are hard to draw and have no theoretical foundations. The data related to the interaction shed light on the reason why the scores got lower in middle and high schools. Noticeably, it is hard to miss that the higher scores of the implementation of PIM in the kindergarten and elementary school corresponded to the higher scores of the interaction in the middle and high schools. Likewise, there was a match in the lower scores of the middle and high schools in terms of the interaction and PIM. This result supports the argument that quality interaction is an indispensable dimension of CP (Garrison & Cleveland-Innes, 2005). Therefore, in this study, regardless of the levels of the learners or subjects or topics, the design and nature of the interaction, which was created and maintained in a lesson plan could reflect to what extent learners were mentally involved in their educational experience and how successfully PIM was carried out.

Another significant point underlined in this study is not to take interaction for granted. Sending students to breakout rooms or asking them to work in pairs or groups never guarantees that they really interact with each other; or the communication taking place is up to the cognitive level aimed to achieve. The quantity of the interaction is not important, either. Rather, the qualitative characteristics of interaction are the ones that matter most (Garrison & Cleveland-Innes, 2005). The close analysis of the interaction, which was created and maintained in the lesson plans unveiled the ten critical characteristics of quality interaction as seen in **Figure 1**.

In the lessons with the positive feedback from the trainers in terms of quality interaction, it was easy to notice that the discourse was systematic, critical and reflective (Garrison & Cleveland-Innes, 2005). The teachers especially in the middle and high school were also guided to increase the quality of discourse in their lessons with the feedback such as "the communication needs to involve student-to-student interaction apart from student-to-content and student-to-teacher" (L36), and "in order to enhance the in-class interaction, the students could have been asked to come up with a summary of what they had watched before the lesson"

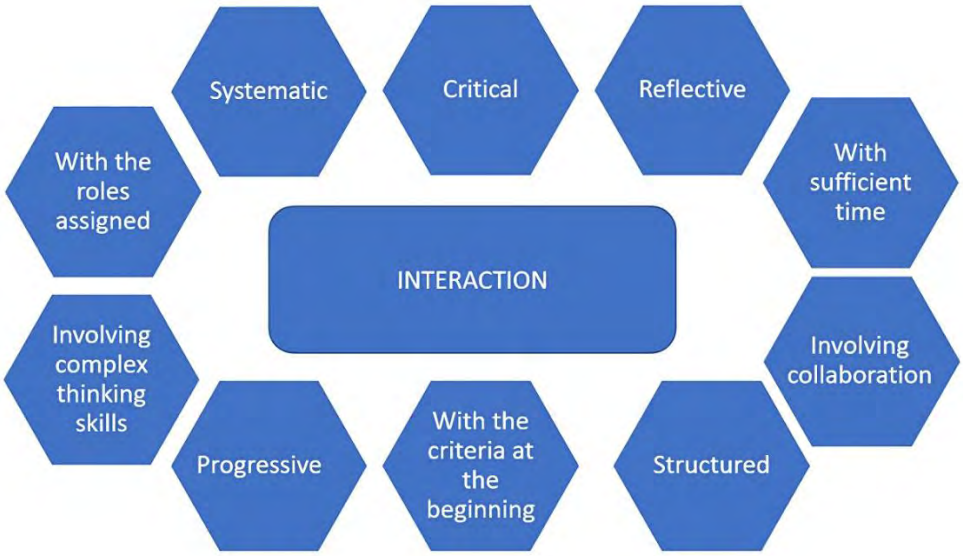

Figure 1. Key critical characteristics of quality interaction (Source: Authors)

(L16). The students were asked to reflect on the instructional videos and in-class discussions (L7) and on what they had learned by creating an infographic (L44), which encouraged them to have a critical and reflective lens while interacting with their peers as well as with the content (i.e., materials).

Structuring interaction also helped to accomplish the learning objectives as noted by Garrison and Cleveland-Innes (2005). For example, in a mathematics lesson (L9), before sending the students to breakout rooms, the teacher asked them three guiding questions to design their prototype rocket for SpaceX. This showed that the success of the quality discourse in many of the lessons depended on the design of the activities involving communication and higher order thinking skills strengthened with guided structuring.

In the lessons with a score of four and above in terms of interaction in CP instrument, it was easy to notice that the students were encouraged to work in pairs and groups, boosting cooperation and communication with their peers. Additionally, games and discussions/debates between groups fostered competition among the students. In line with this, Schrire (2004) argues that collaboration among learners is more effective compared to instructional tasks and experiences based on individual learning. That's why, when the trainers noticed a missed opportunity or lack of collaboration in the lesson plans, they gave such feedback: "in the design of the tasks, there needs to be changes in order to transform the individual work to group one" (L16).

As happens in all lessons, in this study, when the students were asked to work in breakout rooms, it was not possible for the teacher to keep track of every single group. In order to overcome this problem, instructors are advised to take an active role and assist, or guide, the discussions (Kanuka & Garrison, 2004). Thus, in some lessons (e.g., L32), the teachers gave particular roles to the students like moderator, presenter and writer, confirming that defining roles is another feature of well-designed interaction (Aviv et al., 2003). The trainers in their feedback also underlined the importance of assigning roles to the students like "before sending the students to breakout rooms, it is helpful to assign them such mini roles as group leader, group presenter, timekeeper in order to maintain the discourse even in the absence of the teacher" (L33).

The teachers were encouraged to involve their learners in the process of self and peer assessment through checklists and rubrics because they need to have the criteria at the very beginning for a quality discussion; thus, they can assess how well they have achieved the goal and develop their capacity to form deeper questions (Taylor et al., 2000). This will also contribute to structuring the interactions. In line with this, the students were given criteria before preparing their presentations; and they used the same criteria when evaluating their peers' presentations (L8, L47, and L48). When the trainers noticed such a gap in the lesson plans, they openly stated in their feedback "the learners could have been given a criteria or rubric to evaluate themselves or their peers when performing the given tasks" in their feedback (L32).

To ensure quality interaction, the teachers asked engaging questions, which constituted the focal point of the lesson and made the discourse progressive with sufficient time allocated (Kanuka & Garrison, 2004). This also enabled the teachers to link the triggering event to resolution phases together. For example, in a geography lesson (L32), a visual with the question of "why does the location of the sun in the sky change throughout a year?" was central throughout the lesson and the students could solve the puzzling question towards the end of the lesson after the exploration and integration phases built on the same intriguing question.

Factors Promoting Deep Learning in PIM

Resonating with Akyol and Garrison's (2011) statement that surface learning is characterized as reproductive and unreflective, this type of learning was avoided in this study since the students were not merely asked to complete the given tasks without digesting what they had learned. On the contrary, they were encouraged to use their higher order thinking skills to construct meaning and confirm their understanding, which amounts to deep learning. They were provided with opportunities not only to discuss what they had learned, but also apply them (Kanuka & Garrison, 2004). For example, the students were asked to measure the length of various objects at home with non-standardized measurement units (L1); in a two-month project, they were expected to calculate the shadow length every fortnight to see its relation to temperature (L32). As the flow of all the lesson plans showed, the goal was to take the learners from exploration to integration and then to resolution (Garrison & Anderson, 2003). The open-ended questions and tasks such as collaboratively defining the concepts of imagination (L12) and movement (L42) and describing the qualities of a scientist (L17) widened the variety and depth of the students' products. Therefore, the tasks particularly in the resolution phases resulted in qualitatively enhanced learning outcomes, which is another proof of deep learning (Akyol & Garrison, 2011). Marton (1988) argues 'what is learned (the outcome) and how it is learned (the process) are two inseparable aspects of learning' (p. 53). As seen in the tasks assigned to the students, the focus was not on the student products only but rather how to reach that point, which highlights the importance of process.

Collaborative constructivist assumptions, which are related to deep and meaningful approaches and learning outcomes (Garrison & Archer, 2000) are visible in this study as well. In order to achieve higher-level learning, there needs to be cognitive collaboration among students when interacting online so that they can integrate, synthesize and evaluate the ideas presented (Darabi et al., 2011). To ensure deep learning, the students were required to:

- think hypothetically: "If you were a poor teaseller in that period, what would you think about the royal family?" (L34),
- make justifications: "Why do you think the inventions you have selected as a group are more important than the others" (L5),
- make inferences based on a given case: "The result showed her BMD was -3.3. What would be a probable diagnosis to her condition?" (L38), and
- evaluate: "Evaluate your friends poster presentations" (L6).

In the present study, when the learners were provided with ill-structured problems, they created and justified their own arguments when there was no single solution (Jonassen, 1997) resonating with Johnson and Johnson (2000)'s argument that the debate strategy is linked to deeper understanding owing to the conflicting nature of the discourse**.** For example, in a biology lesson (L44), the students were divided into two groups, Lamarck and Darwin, and guided to have a discussion on the inheritance of traits. When the students saw their peers addressing the same problem or scenario with a different reasoning, their exposure to various perspectives increased their understanding of the given problem and facilitated their CP to resolve it (Darabi et al., 2011). Assigning roles in discussions and debates also resulted in constructing higher levels of knowledge (De Wever et al., 2010). In some lessons (e.g., L34), they were given particular roles in certain tasks. As Darabi et al. (2011) also confirms, one of the benefits of this strategy implemented in this study is that it helped learners to evaluate the world from the lens of the role they had and evaluated various perspectives of other roles.

The students in this research were encouraged to make a link between what they had learned and their own life as information needs to be contextualized and meaningful through reflecting on the relevance to one's world (Kanuka & Garrison, 2004; Rovai, 2007). For example, in a science lesson (L31), after learning the basics of kinetic energy, they were asked to explore the connection between mass and kinetic energy in their daily routine and prepare a poster presentation. The analysis of the revised lesson plans also verified that the learners were provided with resources, questions and tasks encouraging them to work individually and with their peers while making use of their own lives. To illustrate, in the triggering event of a language lesson (L16), they were asked to answer "what describes who and what you are"; in the exploration of an English lesson (L15), they brainstormed about their own rights as a child. In the integration phase of a social sciences lesson (L12), they collaboratively reflected on the points they needed to pay attention to for successful communication in their life. In the resolution phase of a language lesson (L13), they introduced themselves via a video in which they made the target sentences involving purpose, reason and condition. Thus, it is easy to interpret that the students' critical thinking was promoted by the successful integration of personalization in various phases of PIM, which could be regarded as a boost for deep learning.

In PIM, there is a perception-conception dimension, showing the continuum between the concrete and abstract worlds (Garrison et al., 2001), which was also operationalized in the revised lesson plans. For example, in a history lesson (L34), a photo depicting a community in the past functioned as a starting point to comprehend the social values and customs in the past. Also, in a physics lesson (L52), a video of Lebron James shooting a basket ignited the learners' perception of motion projectile. Thus, in the lesson plans studied in this research, it was obviously hard to miss such cognitive processes that link facts and ideas.

In addition to the revised lesson plan analysis, trainers' feedback and assessment via CP instrument, the successful implementation of PIM in all the levels, subjects and topics was confirmed by the participant teachers through the end of professional training evaluation. The overall result was 3.38/4.00. The level-wise scores were determined, as follows: kindergarten 3.66/4.00, elementary school 3.16/4.00, middle school 3.37/4.00, and high school 3.35/4.00. The teachers also made such positive and constructive comments as well:

- "Now I can check whether my students are cognitively with me" (high school-language).
- "What I have learned in this training has made a huge contribution to my teaching" (elementary school-math).
- "This training has made a huge change in the way I plan my lessons as it increased my awareness, knowledge and practice in CP" (elementary school-science).
- "This training made the key role of student-to-student interaction in online teaching crystal clear. I will plan my lessons accordingly" (elementary school-social science).
- "Working on good examples and lesson plans helped me a lot. I guess working on lesson plans with mistakes or defects and evaluating them according to the rubric could also have been useful" (elementary school-math).
- "Working collaboratively with the teachers of the same subject helped us all" (high school-language).
- "Now, I can involve my students into my lessons more and more; and I can make them more active than ever" (high school-math).
- "I will keep on designing lesson plans considering the phases of PIM and provide my learners with the chance of self-evaluation or peer evaluation" (kindergarten)

This online professional in-service training for K-12 teachers focusing on CP both modeled how to increase the quantity and quality of interaction among the participant teachers and encouraged them to enhance the discourse in their lessons. Throughout the training, the teachers interacted with the content, the tutors and their colleagues via various channels including synchronous meetings, asynchronous training videos, discussion threads, online classrooms, boards, posters, forums and questionnaires. The statement of "the more interactive the instruction, the more effective the outcome was likely to be" (Zirkin & Sumler, 1995, p. 100) is not inaccurate but missing because interactions consisting of mere information exchange or social talk do not reflect the quality of discourse or guarantee that learners are cognitively engaged in their educational

experience. To this end, the interaction in this professional training encouraged the participant teachers to use their higher order thinking skills such as analyzing what they had learned in groups, collaboratively creating new meaning of newly learned knowledge, evaluating their own teaching, assessing their colleagues' presentations and lessons. The quality discourse, which is at the core of CP was the key to the success of this professional training, which focused on CP.

CONCLUSION

The holistic analysis of the quantitative and qualitative data obtained from the study indicates that all four levels of PIM are successfully implemented to provide CP in the instructional designs in various subjects at all levels (kindergarten, elementary school, middle school, and high school). Another significant result of the study clearly reveals that the integration of educational technologies into the instructional design acts as a catalyst for facilitating CP. Lastly, as a result of the in-depth analysis of the lesson plans, ten critical characteristics of quality interaction have emerged in terms of building CP is significant. The approach to interaction in terms of quality rather than quantity by means of the systematicity in the course design manifested itself in the lesson plans leveraging CP of the participant teachers' students.

The results of the study have proved that it is achievable to provide in-service K-12 teachers with a professional training to boost their students' CP via following the phases of PIM. It has also been underscored that the key constructs of quality interaction are the key to achieving deep learning. The effectiveness of this training depends on certain facts. First, it was a needs-driven (Aydin et al., 2016) reflective practice in an authentic context (McNeil, 2013). Furthermore, the teachers always accessed the continuous support and timely guidance (Glazer et al., 2005) to assist them during the training (Keengwe & Onchwari, 2009). The close interaction between the trainers and teachers created a collaborative aura in this professional development (Darling-Hammond & Richardson, 2009). Additionally, it was based on first-hand experience through learning communities (Paulus et al., 2020).

As in other studies, this research also has its limitations. First of all, the validity of this study depends on the reliability of the instruments used. Another point is that the data were obtained from a single institution. Lastly, there was no control group in the study. Thus, the control group could be established in future research in order to compare the results. For future studies, the number of participants might also be increased to generalize a sample to the population more accurately. Another idea is focusing on one school level only like 'primary school teachers' to produce more confined and specific results. Last but not least, the specific role of utilizing digital learning tools and materials could be elaborated and studied in terms of both the teachers and the learners. Despite the limitations, this professional training could be regarded as a model that can be implemented in many different institutions. With the theoretical foundations, instructional design, clear stages to follow and online mode, this professional development sets itself as a model for any trainer and teacher who aim to improve their students' CP and achieve deep learning objectives.

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APPENDIX A

Table A1. Level-subject-topic matrix

No	Level	Subject	Topic
1	Kindergarten	Social life	Growing-up
2	Kindergarten	Mathematics	Numbers
3	Kindergarten	Science	Movements of the Earth
4	Kindergarten	Social life	Profiles of learners
5	Elementary school	English	Inventions
6	Elementary school	Social sciences	Natural beauties
7	Elementary school	Science	Inventions changing the World
8	Elementary school	Reading	Familiarize yourself with your book
9	Elementary school	Mathematics	Ratio
10	Elementary school	Mathematics	Triangles & quadrangles
11	Elementary school	Language	Loyalty
12	Elementary school	Social sciences	How to express ourselves
13	Elementary school	Language	Sentence meaning
14	Elementary school	Science	Where we are in place & time
15	Elementary school	English	Children's rights
16	Middle school	Language	Descriptive language
17	Middle school	Science	Literacy & ethics in science
18	Middle school	Science	Electricity circuits
19	Middle school	Social sciences	The life of the first settlers
20	Middle school	Language	The importance of words
21	Middle school	English	Comparatives & superlatives
22	Middle school	English	Describing people & objects
23	Middle school	Geography	First settlements
24	Middle school	English	Serendipitous discoveries
25	Middle school	Science	Household waste
26	Middle school	Social sciences	The Independence War
27	Middle school	Mathematics	Percentiles
28	Middle school	French	Who we are
29	Middle school	Mathematics	Patterns
30	Middle school	Social sciences	Culture & legacy
31	Middle school	Science	Kinetic energy
32	High school	Geography	The orbit of the Earth
33	High school	German	Past tense
34	High school	History	The Tulip Period
35	High school	Language & literature	Poetry
36	High school	Physics	Wave movements
37	High school	Mathematics	The graphics of functions
38	High school	Biology	Skeleton system
39	High school	Mathematics	Functions
40	High school	Language & literature	Literature & social events
41	High school	German	Making appointments
42	High school	Physics	Movements
43	High school	Chemistry	Gases
44	High school	Biology	Historical background of genetics
45	High school	History	WW I
46	High school	German	Sentence structure in the context of money
47	High school	Chemistry	Mixtures
48	High school	Biology	Cells
49	High school	Mathematics	Graphs of algorithms
50	High school	Physics	Liquid pressure
51	High school	Chemistry	Interactions among chemicals
52	High school	Physics	Projectile motion
53	High school	Language & literature	The link between literature & fine arts

APPENDIX B

Table B1. Technologies used in different phases of PIM

Triggering event	Exploration	Implementation	Resolution
Edpuzzle	Prezi	Padlet	Bookcreator
Nearpod	Google classroom	Breakoutrooms	Pivot animator
Google maps	QR Codes	Nearpod	Desmos
Phet Simulations	Phet simulations	Coggle	Quizziz
YouTube Videos	3D Bones and Organs	Google Forms	Google forms
Visme	Sebit V Cloud	Voki	Socrative
Flipgrid	Breakout rooms	Flipgrid	Plotagon
Khan Academy Videos	Thinglink	Phet Colorado	Powtoon
	Emaze	Educaplay	Issuu
	Wheelofnames		Playposit
	Notability		Quizlet
	Wordwall		Kahoot