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ROLE OF COLLABORATIVE INTERACTIONS BETWEEN MEMBERS OF A KNOWLEDGE COMMUNITY IN A TRIALOGICAL ENVIRONMENT

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ABSTRACT

The trialogical approach to learning offers a framework for fostering novelty and innovation. However, the framework lacks the details needed to guide practitioners. More studies should understand how it can be effectively adapted into instructional practices. This study addresses this gap by examining collaborative interactions' role in a trialogical learning environment. Through action research, this study analysed qualitative data collected from implementing an instruction that was designed using trialogical design principles. This instruction was implemented in a pre-university creative thinking module at a Malaysian private university. By analysing artefacts such as reflection and discussion logs, this study aimed to identify collaborative interactions and describe how they supported or hindered the participants' engagement with the trialogical-based learning activities of the implemented instruction. The findings suggest that effective collaborative interactions are essential for the students to successfully co-develop shared objects in a trialogical learning environment. Besides that, the findings suggest that the collaborative interactions must be epistemic, focusing on the exchange and co-construction of knowledge.

Keywords: *Trialogical learning, instructional design, action research, collaborative interactions, shared object.*

INTRODUCTION

Over the past decades, there has been a shift in our economic growth that saw increasing investments in intangible-based assets such as knowledge resources (OCED, 2022). This has also sparked the need for educators to prepare learners to pursue novelty and innovation rather than just routine skills (OCED, 2022; Paavola et al., 2004; Paavola and Hakkarainen, 2014; Riikonen et al., 2020). Several researchers, such as Lakkala et al. (2007), Ligorio et al. (2021), Sansone et al. (2021), Stefanova and Vasileva (2014) and Tammeorg et al. (2019) have adopted a trialogical approach to learning to address the need to equip the students for creative and innovative practices. Trialogical learning (TL) consists of 6 design principles to guide the instructional design and implementation process (Paavola & Hakkarainen, 2014). These design principles are broad, flexible guidelines rather than rigid rules for guiding instructional design (Paavola & Hakkarainen, 2014).

Due to the broad nature of the TL design principles, they can be interpreted in multiple ways, resulting in this characteristic being an area of criticism (Borchers, 2000; Mahemoff & Johnston, 1998; Paavola et al., 2011). Criticisms also cite that it is too difficult to interpret, leaving space for misinterpretation and requiring sophisticated interpretation (Paavola et al., 2011). Besides that, Paavola et al. (2011) also remarked that this could lead to loosely grounded pedagogical designs. As such, more details are needed by practitioners to adapt and apply the trialogical learning design principles (TLDP), especially in the

practice of instructional design. Details on how these design principles are interpreted for adaptations and applications will help instructional designers in the task analysis portion by allowing them to further understand and adapt the design principles for the tasks needed when designing the instruction (Morrison et al., 2019). To date, there have been several studies utilizing adapted versions of the TLDP for various purposes, such as assessment (Lakkala et al., 2012; Tammeorg et al., 2019) and learning activities (Ligorio et al., 2021; Sansone et al., 2021).

However, an aspect of adapting the TLDP for instruction that is not always discussed is the collaborative interactions among the knowledge community. Collaboration is at the core of the TLDP as it includes integrating, collaborative development and co-developing (Paavola & Hakkarainen, 2014). Collaboration in this context will include the shared efforts to co-develop the shared objects and the interaction of various knowledge brought forth by the knowledge community (Paavola et al. 2011). Many of these will require collaborative interactions, seen through externalizing and exchanging ideas, sharing thoughts, or communicating opinions amongst the knowledge community. Despite its crucial role in collaboration, in the trialogical approach, much of the interactions relating to the collaboration of participants are assumed as they engage with the design principles. This can be seen as the key studies discussing TLDP implementation do not explicitly discuss these collaborative interactions (Lakkala et al., 2007; Paavola et al., 2004; Paavola & Hakkarainen, 2014). The collaborative interactions discussed here relate to how the knowledge community engages with the collaborative aspects of the TLDP that are implemented as an instructional design. For the trialogical approach to be adapted into well-designed instruction, there needs to be more details on the role collaborative interactions amongst participants of the knowledge community play concerning their engagement with the design principles.

Currently, there is still a need for more literature discussing the details of the collaborative interactions amongst the knowledge community concerning adapting and implementing the TLDP into an instructional design. More specifically, more details are needed concerning the role of the interactions between the knowledge community concerning the collaborative elements of the instructional design. Due to these items that have been brought forward, this study aims to explore the role collaborative interactions amongst the knowledge community play in the engagement of the trialogical instructional design. The research questions that guided this study are:

1. What collaborative interactions occur in a learning environment designed based on trialogical learning principles?
2. How do these collaborative interactions support or hinder their engagement with these trialogical learning activities?

Trialogical Approach to Learning

The trialogical approach to learning is an addition to Sfard's (1998) conceptual metaphors to explain learning, i.e., the monological acquisitionist and the dialogical participationist metaphors. Trialogical learning emphasizes the creation and innovation of knowledge through collaborative efforts in co-developing shared objects (Paavola & Hakkarainen, 2009). Bereiter and Scardamalia's (2003) knowledge building, Engestrom's (1987) theory of expansive learning, and Nonaka and Takeuchi's (1996) theory of organizational knowledge creation (Paavola & Hakkarainen, 2009) are examples of concepts aligning with the trialogical learning approach.

A key characteristic of this approach is the collaborative efforts amongst individuals and communities to achieve novelty and innovation through the long-term and iterative co-development of shared objects (Paavola & Hakkarainen, 2014). The shared object, taking the form of knowledge artefacts, serves as an object of inquiry which anchors the collaborative efforts and drives its iterative development amongst the participants, also called the knowledge community (Paavola & Hakkarainen, 2014). Popper (1972) refers to this as "World 3" knowledge, where these shared objects become the materialization of a knowledge community's knowledge, taking the form of objects such as theories, works of art, and institutions. As proposed by Paavola and Hakkarainen (2014), these are the six design principles (DP) that guide its implementation:

1. DP1: Organizing activities around shared "objects"
   This DP focuses on a central object that the community collaboratively develops and innovates.

2. DP2: Supporting integration of personal and collective agency and work (through developing shared objects)
   This DP emphasizes the combination of individual learning and social interaction.

3. DP3: fostering long-term processes of knowledge advancement with shared objects
   Providing ample time for the knowledge community to iteratively develop new and novel objects, across different courses and by different people over time is the emphasis of this DP.

4. DP4: Emphasizing development and creativity on shared objects through transformations and reflection
   This DP emphasizes the development and knowledge creation through the interaction and transformation between different types of knowledge.

5. DP5: Promoting cross-fertilization of various knowledge practices and artifacts across communities and institutions
   The need for knowledge communities to cross boundaries between different knowledge disciplines, practices, education and professional industries is promoted through this DP.

6. DP6: Providing flexible tools for developing artifacts and practices
   Through this DP collaborative and mediating tools that are afforded by the advancement of web-based technology are used to support the collaborative development of the shared objects.

To engage with the activities of these design principles, collaborative interactions amongst the participants are crucial as it is needed to collaboratively develop the shared object as per DP 1, integrate the personal and collective agency and work as per DP 2, iteratively develop the shared object as per DP 3, foster the transformations and reflections as per DP 4, promote cross-fertilization across communities and institutions as per DP 5, and utilise the tools to collaborative development of the shared objects as per DP 6.

METHOD

This research intends to study the role of collaborative interactions in implementing the trialogical approach as an instructional design in an authentic environment. Action research was selected as a methodology to study this implementation as it is practitioner-based research that emphasizes taking purposeful action through implementing solutions or new practices and systematically documenting its application (McNiff, 2009). This study specifically intends to fill the gap by providing more details on the role collaborative interactions play amongst the knowledge community in their engagement with the TLDP. The systematic documentation of instructional design implementation can provide practitioners with details that could fill this study's gap. The following subsections describe the steps that were taken in this study.

Design of the Study

Adopting the action research methodology, the current instructional design in the module was reviewed and aspects for improvements were identified (McNiff, 2009). The focus was on a pre-university creative thinking module from a private university in Malaysia. The module assumed a largely monological approach, significantly emphasising the transmission of prescribed information. Per Paavolaa et al. (2004), approaches like this do not focus on innovation or creation, which was needed in the module. As such, this module was purposively selected as the site for this action research (McNiff, 2009; Merriam & Tisdell, 2016). The goal was to improve the instructional design, specifically focusing on collaborative interactions that foster knowledge creation and innovation. The first author, as the action researcher and lecturer of this module, uses this opportunity to improve the instructional approach to the course.

Based on the review and aspects identified, solutions informed by the literature were designed for implementation in the focused module (McNiff, 2009). The solution came as an instructional design adapted from the six design principles of the trialogical approach into key learning activities (KLA). The adaptation was done by operationalising the design principles into KLA, which students will engage with throughout the implementation. The approach was proposed as a suitable solution as it encourages innovation and collaborative knowledge creation (Paavola & Hakkarainen, 2014).

With students' collaborative interactions as the focus of this study, the students' engagement with the KLAs of DP1 and 2 was evaluated. These two DPs emphasised the collaborative efforts in developing a shared object and the collaborative integration of the collective agency and work. They collectively involve the knowledge community in the collaborative process of co-developing the shared object. These two principles serve as the foundation for the collaborative aspects present in the other design principles. Insights from a larger study, of which this research is a part, revealed that collaborative interactions were consistently linked to these two principles. With the emphasis on collaborative efforts in the first two DPs, this study focuses on them to identify and study the occurrences of collaborative interactions between members of the knowledge community. TLDP into KLAs operationalization is detailed in Table 1.

Table 1. *Operationalising Trialogical Design Principles (TLDP) to Key Learning Activities (KLA)*

Design Principle (TLDP)	Key Learning Activities (KLA)
DP 1 Organizing Activities Around Shared Objects	KLA 1.1 Students will work on a collaborative project to develop a creative solution for a practical problem [shared object]. Because of that, students will be grouped into knowledge communities of 5-6 members. KLA 1.2 During these projects, the students within the collaborative groups, will share their ideas for solving this problem
DP 2 Supporting Integration of Personal and Collective Agency and Work (Through Developing Shared Objects)	KLA 2.1 Each student will create a proposal for a creative solution intended to solve the practical problem [personal agency]. KLA 2.2 Each group will collectively review each proposal to select ideas that will be incorporated into their collective proposal [collective agency]. This process of proposing and reviewing will continue weekly as the visual identity system continues to be developed as per DP3.

The implementation of this adapted instruction was then evaluated and improved on (McNiff, 2009). This evaluation focuses on the role the knowledge community's collaborative interactions play concerning the TLDP. The evaluation and improvements from this stage will be discussed in the following sections of this study. The maximum variation sampling plan was adopted to analyse the widest range of data per the students' engagement with the KLA (Merriam & Tisdell, 2015). This was done by selecting the group that best represents the findings from the higher-performing groups and the group that best represents the findings from the weaker-performing student groups (Merriam & Tisdell, 2015).

The researcher was also involved in implementing the TL instructional design, playing the participant as an observer role (Merriam & Tisdell, 2015). Having the role of researcher and practitioner intertwined in this way is a characteristic of action research as it encourages the practitioner to systematically document improvements in their practices (McNiff, 2009).

This study employed qualitative data collection techniques and protocols from multiple sources to identify the incidences of students' collaborative interactions as they engage with the instructional design. With that intention, the data was primarily collected from the student reflection and group discussion logs: the artefacts produced as part of the instruction. In addition, semi-structured group interviews were conducted to get students to expand on the items written or discussed in their logs. The multiple data sources that included the artefacts produced by the students personally and as a group, as well as semi-structured interviews, provided clarity and triangulation (Merriam & Tisdell, 2016).

FINDINGS

This section will present the findings in themes from implementing the learning environment designed based on trialogical learning principles. Through the data collected, a few themes emerged concerning the knowledge community's collaborative interactions as they engaged with the KLAs of DP 1 and 2. These themes discuss the occurrence of collaborative interactions amongst the different groups and compare them. Out of these few themes, two themes that best represent the occurrences of collaborative interactions, and how they were able to support or hinder the students' engagement with these instruction's learning activities are discussed here. The comparison will be made between the collaborative interactions found in Groups A and B using the maximum variation sampling, as they both represent the interactions that occurred in higher-performing groups and the weaker-performing groups, respectively. The findings are contextual as this study takes place in a specific setting and collects qualitative data. References to the logs and interviews are tagged according to the group (A or B), the type of source (L for log and I for interview) and the line (A-L-3) as well as the time stamp (e.g., B-I-5:30)

Theme 1: Collective vs Divide and Conquer

This theme illuminates the fundamentally different ways Groups A and B handled interactions in their groups. Group A engaged in what can be described as collective interactions.

These interactions were characterised by a collective effort to engage with the KLAs as a group. In contrast, the interactions that occurred in Group B were almost entirely handled by what can be summarised as a "divide and conquer" approach. The interactions of Group B merely involved "dividing" tasks for the different group members to "conquer" separately.

As part of KLAs of DP 1, the students were briefed on a collaborative project to solve the practical problem of promoting a tiger-themed art exhibition. In response to this, groups of students will need to propose ideas in the form of a creative solution to promote that exhibition. For Arvind, Alice, Afrin, Ang, and Ali of Group A, collective interactions can be seen as they responded to this activity by proposing "whatever ideas" they had in an accessible shared digital board. Amongst the many ideas shared, Arvind proposed an idea to promote the art exhibition by "represent(ing) (the tiger's) resilience through a story" (A-L-11). Afrin also suggested that the promotion "needed to represent (the artists) in their process of growth" (A-L-12). Besides that, Afrin, Ali and Ang added visuals of tiger illustrations to visualise ideas to incorporate the tiger theme into the promotion. In these interactions, they were encouraged to "just throw (ideas out) there" (A-I-15:50) and "see whatever idea sticks" (A-I-15:30).

As the ideas were proposed, they collectively reviewed and evaluated each idea that was shared as per the KLAs of DP 2. Evident in the digital board, they evaluated every proposed idea by testing (A-L-29) and reviewing them. An example can be found in the entries of the log reviewing an idea proposed by Ang to execute promotional visuals using illustrations of tigers. This idea was tested and met with thoughts from fellow members, such as Afrin discussing the need to change "the colour used" to help illustrations "stand out" (A-L-97) and questions by Ali on "how does the chained tiger resemble the resilient tiger?" (A-L-97). Eventually, after the evaluation, Alice proposed an idea (A-I-15:40) to portray the tiger overcoming "obstacles that came its way" (A-L-28) stuck out. They used this idea "as a background" (A-L-28) on which other ideas were incorporated, as per KLA 2.2.

Arvind explained that around this idea, they were "sort(ing) out…" whatever ideas "work(ed) together" (A-I-15:57) to be incorporated. These interactions were handled collectively, responding to every idea proposed and involving every group member.

Bakri, Barry, Ben, Bulan, and Bala of Group B took a different approach as they "agreed" (B-I-19.44) on one proposed idea early in the project. The idea as proposed by Ben was to promote the exhibition by "represent(ing) (the) resilience of the tiger" and communicating "a pleasing atmosphere" through "mountains/tall places" (B-L-2-3). However, unlike group A, Bakri explained that they did not even "talk to each other" concerning their choice. He added that they kept to their "own business as if it was "not even a group project" (B-I-6.45). After Ben's idea was selected, Bulan described the process of "dividing" tasks where they "established" the "baseline of work" and everyone proceeded to "conquer" the tasks as they "just finish up... (their) work for... (their) assignments" (B-I-14.14). Unlike Group A's approach to encouraging the proposing of many ideas on a shared platform for evaluation and reviewing, they responded to the KLA of DP 1 hastily and settled on one idea. This was also the same for the KLA of DP 2, who accepted the idea without much evaluation and proceeded to work on executing the project themselves.

Group A's collective approach was characterised by how they freely proposed ideas, evaluated them together, and came to a collective agreement to select one idea on which they built. These interactions were collaborative as they supported their collective efforts in collaborating as per KLA 1.1, sharing their ideas as per KLA 1.2, and developing a collective proposal as per KLA 2.1 and 2.2. Conversely, the "Divide and Conquer" approach was not appropriate as it separated the members of Group B, hindered them from meaningfully collaborating as per KLA 1.1, as well as sharing their ideas as per KLA 1.2, and meaningfully developing a collective proposal as of KLA 2.1 and 2.2. This resulted in Group B producing an incoherent solution that failed to promote the exhibition, while Group A had a solution able to meaningfully and thematically promote the tiger-themed art exhibition.

Theme 2: Epistemic vs Task Oriented interactions

This theme highlights the contrasting directions the members of Groups A and B took to interact with each other. Group A's interactions were epistemically driven as their intention was to share and engage with ideas in the form of knowledge. However, Group B's interactions were merely task-driven with the goal of finishing the project. These interactions occurred as the groups progressed to proposing and reviewing their ideas for creative solutions to promote the art exhibition as per the KLAs of DP 2.

At this juncture in the project, Group A had just selected Alice's idea after much reviewing. The idea to promote the exhibition by reflecting the artists as the tiger that overcame obstacles (A-L-28) served as a "background" from which the group members will interact. To select and incorporate ideas into a collective proposal as per KLA 2.2, they built upon Alice's idea by sharing "thoughts on the idea and combin(ing) it"(A-L-29). Interactions during their "discussion time together" allowed them to be aware and foster a deeper understanding of the collective development of this central idea (A-L-29, 107-111, 150). Around this central idea, member interactions were directed to further develop Alice's idea to better suit the project brief. An example amongst the many interactions can be seen as Afrin tested and expanded the idea by creating promotional posters (A-L-129-130) while Ali discussed whether the "cool expression" of the tiger in the poster would communicate "resilience" to the audience.

By this stage, the members of Group B had already spent some time working on the tasks assigned to them, based on Ben's idea, which they had agreed upon. This idea took the form of a set of guidelines which included the use of "white and yellow" colours to "attract people", and "mountains with soft colours" to "represent calmness" (B-L-5-7). While the members of Group A used the central idea as a background to work off, the members of Group B merely saw these as requirements. This was evident as Group A's idea developed and evolved with discussion over time, while the guidelines remained the same throughout (B-L-5-7, 38-40, 68-70, 99-101). After the administered tasks, Ben recounted that there was a "lack of communication" as the members went about doing their "own thing" (B-I-18.35). Group A members were different, engaged and aware of the idea's progress.

The interactions that were epistemically driven, as displayed by Group A, supported the development of their creative solution. These collaborative interactions were anchored by a central idea, which acted as a collective proposal they incorporated ideas as per KLA 2.2.

Besides that, these interactions also promoted a deep understanding of this central idea. Group B's task-based interactions hindered the development of their creative solution as it limited their engagement with it. This also meant their engagements were functional and did not fail to support the integration of Group B's personal and collective agency.

DISCUSSION

As part of action research, the findings will need to inform the improvement of the instruction. The themes that were discussed revealed areas as well as opportunities for the instruction to be improved upon. This section will suggest ways of improving the instruction to adapt and implement the trialogical approach into an instructional design.

Collaborative Interactions Between Members of The Knowledge Community can't be Assumed and Need to be Guided

As presented in the findings, not all interactions are collaborative. To engage productively with the learning activities of the instruction, the interactions amongst the knowledge community must be collaborative. The co-developing of the shared objects, as per the intention of the trialogical approach, relies on innovations emerging from the interaction of different types of knowledge (Paavola & Hakkarainen, 2014). In this study, to implement the KLAs of DP 1, the students were tasked to develop a shared object that took the form of a creative solution to promote a tiger-themed art exhibition. As displayed by the members of Group A, these co-developments that take place during collaborative interactions include proposing ideas, evaluating them, and building on the ideas collectively.

In contrast, with interactions that were not collaborative, such as Group B's "divide and conquer" approach, the shared object was not meaningfully developed. This approach, which separated the group members to work on their parts of the project, limited their interactions with each other during the course of the project. Besides that, the approach displayed also limited the innovation and co-creation of knowledge. The resulting shared object was underdeveloped and incoherent, defeating the purpose of the trialogical approach where the co-development of a shared object was emphasised.

The findings suggest that in this study's implementation of the trialogical learning-based instruction, collaborative interactions were crucial in supporting the co-development of a shared object. This can be seen as these collaborative interactions handled collectively, as displayed by Group A, played a big role in supporting the students' engagement with the KLAs. To adapt the trialogical approach into an instructional design, elements that lead the knowledge community to interact collaboratively are crucial to support meaningful co-development of the shared object and knowledge. The current instructional design assumes that these collaborative interactions take place naturally. However, the "divide and conquer" approach to interacting, as displayed by Group B, reveals that this assumption is not true, and there is a need to guide these interactions.

Researchers such as Hmelo-Silver et al. (2007) and Puntambekar (2022) suggest that before students can achieve tasks like these, support from more knowledgeable individuals is crucial to provide guidance. Studies suggest that this support can be done by structuring the tasks unachievable by students (de Jong et al., 2024; Hmelo-Silver et al., 2007; Reiser, 2018). In the case of this instruction, structured guidance that gives the students steps to interact collaboratively can be used to support the instructional design. The approach to interacting, as displayed in Group A which collectively organised their interactions, can inform the type of guidance needed. A step-by-step guide on organising their interactions collectively can be integrated into the instruction. This guide will include steps on how to set up a shared board and steps to share their ideas using it. Besides that, these guides will include prompts on reviewing each other's ideas by testing, sharing thoughts and clarifying them. These guides can organise their interactions throughout the project, ensuring interactive collaboration.

Collaborative Interactions Need to be Directed to Be Epistemic in Nature

As discussed in the second theme, collaborative interactions that are epistemically driven are crucial for engaging with the KLAs of the implemented instruction. This is especially true for the KLAs of DP 2, as the task-oriented interactions displayed by Group B led them to treat the ideas as requirements to be followed. On the other hand, as Group A's collaborative interactions were epistemically driven, they engaged with the ideas as knowledge they needed to understand and develop. This interaction allowed for what Paavola and Hakkarainen (2014) described as integration between the members' personal and collective agency.

The instruction implemented in this study assumed that the students' interactions would be epistemically driven. As reported in the findings of this study, while higher-performing groups displayed epistemically driven collaborative interactions, weaker-performing groups interacted in a task-oriented manner. Due to this assumption, not much is discussed concerning directing these collaborative interactions to be epistemic in nature. Due to this, when adapting trialogical principles into instruction, guidance must be included to foster epistemically driven collaborative interactions.

This guidance can come in the form of cognitive modelling, as discussed by Dennen (2013) and Tharp and Gallimore (1991). Through cognitive modelling, the instructor can demonstrate appropriate collaborative interactions that are also epistemic. In the case of the interactions amongst Group B's task-oriented interactions, the instructor could demonstrate appropriate interactions that treat the ideas as knowledge to be understood and developed. Besides that, the instructor could also demonstrate interactions that involved responding and reviewing the knowledge shared to fine-tune the collective idea. This modelling can be done in a responsive and timely manner as the instructor observes the students' interactions. This could also mean that for groups that need it, the instructor could be more involved in the project, playing the role of a group member while demonstrating the appropriate interactions. The instructor can also eventually ease this involvement as the students can interact appropriately.

CONCLUSION

This study explored the role collaborative interactions play in the knowledge community's engagement in the trialogical instructional design. This was done by identifying the occurrence of collaborative interactions as they engaged in learning activities of the instruction. Besides that, this study also sought to describe how these collaborative interactions support or hinder their engagement with said activities. The findings from the implementation of this study indicated that interactions amongst the knowledge community that are not collaborative hindered their engagement with the KLAs of DP 1 and 2. As reported in the findings, the "divide and conquer" approach and the task-oriented interactions hindered their collaborations as per DP 1 and the integration of their personal and collective agency and work as per DP 2.

On the other hand, the findings indicate that the collaborative interactions amongst the students that were collective and epistemically driven were found to support their engagement with the activities of the instruction. From the findings, we can see that collaborative interactions play an important role in this implementation of the instruction. It is crucial to provide students with appropriate guidance to improve this instructional design. As discussed, two types of guidance should be incorporated: a step-by-step guide to help students organize their interactions collectively and guidance to foster epistemic interactions, delivered through responsive cognitive modelling by the instructor.

There were some limitations to this study as this was one-cycle action research. Due to this, the findings collected from this study were limited to the one implementing cycle. More details concerning the role collaborative interactions play can be revealed through iterative cycles of redesigning and implementing the instructional design. Besides that, another limitation was that the data was only collected and studied from the students' engagement with the KLA of the first two DPs. Including the other four DPs would provide more details and a full picture of the role of collaborative interactions. Being action research in a particular setting, the findings in this study are not generalizable but contextual in this study's settings.

With these limitations, future studies could include more cycles providing more emergent details on the role collaborative interactions play. Future studies could also study collaboration concerning their engagement with the KLA of the other four DPs. Finally, this study could be adapted and applied to different settings to further explore the role of collaborative interactions in different knowledge communities.

REFERENCES

Bereiter, C., & Scardamalia, M. (2003). Knowledge building environments: Extending the limits of the possible in education and knowledge work. *Encyclopedia of Distributed Learning*, 269-272.

Borchers, J. O. (2000). Interaction design patterns: Twelve theses. *Workshop, the Hague 2*(3).

De Jong, T., Lazonder, A. W., Chinn, C. A., Fischer, F., Gobert, J., Hmelo-Silver, C. E., Koedingerg, K. R., Krajcikh, J. S., Kyzai, E. A., Linnj M. C., Pedastek, M., Scheiter, K., & Zacharia, Z. C. (2024). Beyond inquiry or direct instruction: Pressing issues for designing impactful science learning opportunities. *Educational Research Review,* 100623.

Dennen, V. P. (2013). Cognitive apprenticeship in educational practice: Research on scaffolding, modeling, mentoring, and coaching as instructional strategies. In *Handbook of research on educational communications and technology* (pp. 804-819). Routledge.

Engestrom, Y. (1987). *Learning by expanding: An activity–theoretical approach to developmental research*. Orienta-Konsultit.

Hakkarainen, K., & Paavola, S. (2009). Toward a trialogical approach to learning. In Transformation of knowledge through classroom interaction (pp. 73-88). Routledge.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and. *Educational Psychologist, 42*(2), 99-107.

Lakkala, M., Ilomäki, L., Paavola, S., Kosonen, K., & Muukkonen, H. (2012). Using trialogical design principles to assess pedagogical practices in two higher education courses. In *Collaborative knowledge creation* (pp. 141-161). Brill.

Lakkala, M., Muukkonen, H., Paavola, S., & Rämö, E. (2007). Pedagogical design for trialogical approach on learning. In S. Schrire (Chair), *From dialogical learning to trialogical learning: Knowledge practices in higher education and teacher training* [Symposium]. 12th Biennial Conference for Research on Learning and Instruction (EARLI), Budapest, Hungary.

Ligorio, M. B., Amenduni, F., Sansone, N., & McLay, K. F. (2021). Designing blended university courses for transaction from academic learning to professional competences. In M. G. Di Gesú & M. F. González (Eds.), *Cultural views on online learning in higher education: A seemingly borderless class* (pp. 67-86). Springer Nature.

Mahemoff, M. J., & Johnston, L. J. (1998, November). Principles for a usability-oriented pattern language. In *Proceedings 1998 Australasian Computer Human Interaction Conference. OzCHI'98 (Cat. No. 98EX234)* (pp. 132-139). IEEE.

McNiff, J. (2009). *You and your action research project*. Routledge.

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation.* John Wiley & Sons.

Morrison, G. R., Ross, S. J., Morrison, J. R., & Kalman, H. K. (2019). *Designing effective instruction.* John Wiley & Sons.

Nonaka, L., Takeuchi, H., & Umemoto, K. (1996). A theory of organizational knowledge creation. *International Journal of Technology Management, 11*(7-8), 833-845.

OECD (2022), *Trends Shaping Education 2022.* OECD Publishing. https://doi.org/10.1787/6ae8771a-en

Paavola, S., & Hakkarainen, K. (2014). Trialogical approach for knowledge creation. In *Knowledge creation in education* (pp. 53-73). Springer Singapore.

Paavola, S., Lakkala, M., Muukkonen, H., Kosonen, K., & Karlgren, K. (2011). The roles and uses of design principles in a project on trialogical learning. *Research in Learning Technology*.

Paavola, S., Lipponen, L., & Hakkarainen, K. (2004). Models of innovative knowledge communities and three metaphors of learning. *Review of Educational Research, 74*(4), 557-576.

Popper, K. (1972). *Objective knowledge: An evolutionary approach.* Oxford University Press.

Puntambekar, S. (2022). Distributed scaffolding: Scaffolding students in classroom environments. *Educational Psychology Review, 34*(1), 451-472.

Reiser, B. J. (2018). Scaffolding complex learning: The mechanisms of structuring and problematizing student work. In *Scaffolding* (pp. 273-304). Psychology Press.

Riikonen, S., Seitamaa-Hakkarainen, P., & Hakkarainen, K. (2020). Bringing maker practices to school: Tracing discursive and materially mediated aspects of student teams' collaborative making processes. *International Journal of Computer-Supported Collaborative Learning, 15*, 319-349.

Sansone, N., Cesareni, D., Bortolotti, I., & McLay, K. F. (2021). The designing and re-designing of a blended university course based on the trialogical learning approach. *Education Sciences, 11*(10), 591. doi.org/10.3390/educsci11100591

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher, 27*(2), 4-13.

Stefanova, S., & Vasileva, T. (2014). Trialogical approach to knowledge practices in CAD education. *Annual Journal of Electronics, 8*, 150-153.

Tammeorg, P., Mykkänen, A., Rantamäki, T., Lakkala, M., & Muukkonen, H. (2019). Improving group work practices in teaching life sciences: trialogical learning. *Research in Science Education, 49,* 809-828.

Tharp, R. G., & Gallimore, R. (1991). *Rousing minds to life: Teaching, learning, and schooling in social context*. Cambridge University Press.