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THE DEVELOPMENT OF COLLABORATIVE MATHEMATICS LEARNING EMBEDDED WITH BALINESE CULTURAL PRINCIPLE

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ABSTRACT

Learning collaboratively has been proven to be beneficial in learning mathematics. Unfortunately, studies have elicited obstacles in implementing collaborative learning, such as students' behavior when engaging in collaborative learning. We address this problem by embedding local wisdom from Bali, namely Tri Hita Karana, within a learning handbook for studying polyhedron. Successful conceptual understanding after learning mathematics with the handbook showed potential merit of the handbook to be implemented in learning mathematics and students' behavior while doing collaborative works also showed that embedding cultural context in learning could foster students' collaboration skills.

ABSTRAK

Belajar secara kolaboratif telah terbukti bermanfaat dalam mempelajari matematika. Sayangnya, penelitian menunjukkan adanya hambatan-hambatan dalam meng-implementasikan pembelajaran kolaboratif misalnya perilaku siswa ketika sedang terlibat dalam pembelajaran kolaboratif. Kami mencoba mengatasi permasalahan ini dengan menanamkan kearifan lokal yang berasal dari kearifan lokal Bali yaitu Tri Hita Karana dalam panduan pembelajaran konsep bangun ruang sisi datar. Pemahaman konseptual yang tuntas setelah belajar matematika dengan panduan belajar yang dikembangkan menunjukkan potensi manfaat panduan belajar ini untuk dimplementasikan dalam pembelajaran matematika dan perbaikan sikap siswa ketika melaksanakan kegiatan kolaboratif juga menunjukkan bahwa menyertakan konteks kultural dalam media pembelajaran dapat membina keterampilan kolaborasi siswa.

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INTRODUCTION

Learning mathematics collaboratively is beneficial for mathematics education improvement because collaborative activity promotes students' conceptual knowledge acquisition (Mullins, Rummel, and Spada, 2011; Francisco, 2012). Improvement happens even when student start from a lower mathematical level (Dekker, Elshout-Mohr, and Wood, 2006) or having a negative perception of mathematics (Yackel, Cobb, and Wood, 1991). Abundant opportunities for students to reexamine their reasoning and to build refined forms of reasoning (Francisco, 2012) as well as continual process of offering ideas and innovation to build a collective understanding (see Martin and Towers, 2009), are what makes collaborative learning useful for learning mathematics. When teacher announced that students have to work collaboratively, students had no option but to actively generate ideas, discuss the idea, and answering questions collaboratively (see Elbers and Streefland, 2000). Moss and Beatty (2006) also suggested that when students face an increasingly difficult problem, it ignited their desire and commitment to offer detailed explanations as a member of the group.

Martin, Towers, and Pirie (2006) identified elements in the growth of collective mathematical understanding: (1) the presence of numerous potential pathways, (2) the development of a collective structure, and (3) the etiquette of emerging understanding and the importance of the group mind. When students work on mathematical problems collaboratively, they will firstly bring their own idea and understanding (*the presence of many potential pathways*). Unmatched or completely different ideas or understanding might occur in which they will analyze and implement available suggestions that the group collectively believe will produce an appropriate solution (*the development of*

collective structure). In the process of collectively understanding particular mathematical problems, students attentively listen to each other ideas and willing to abandon personal motivation which allows the emergence of a refined mathematical understanding from their engagement (*the etiquette of emerging and the importance of the group mind*). Dekker et al. (2006) study also showed that students' viewed collaboration as a responsibility, and they are continuously monitored and adjusting their approach: they were willing to exchange what they feel satisfying for an alternative that is more promising from a social interaction perspective, proving that they are willing to acknowledge the importance of group mind. Then, it can be surmised that willingness to accept other group member idea and acknowledge the merit of another person way of thinking or solution resulting from the collaboration is an attitude that the students must have to achieve fruitful collaboration and improve mathematical understanding (Yackel et al., 1991; Elbers and Streefland, 2000; Dekker et al., 2006; Moss and Beatty, 2006; Martin et al., 2006; Martin and Towers, 2009; Francisco, 2012).

Despite the prospective benefits of collaborative learning, studies have elicited obstacles in implementing collaborative learning. Study found that group functioning and learning were hampered when group members did not pay attention to others' opinions or blatantly rejected suggestions without adequate reasons (Barron, 2003). Le, Janssen, and Wubbels (2017) study also supported Barron's (2003) findings in which students still lack collaborative skills such as accepting opposing points of view prevented working productively in groups. Le et al. (2017) further found that insufficient efforts to complete the task and unbalanced work contribution negatively affected students' collaborative experiences. The social incident that disturbed the group's emotional balance will interfere with the group's keenness to work on the task (Jarvela, Volet, and Jarvenoja, 2010). Obstacles in working collaboratively originated from students' behavior and the teachers (Ruys, Van Keer, and Aelterman, 2012; Le et al., 2017), mainly in their inadequate efforts to organize collaborative works and facilitate collaborative activity. Therefore, the aim of our study was to address these problems in designing collaborative works.

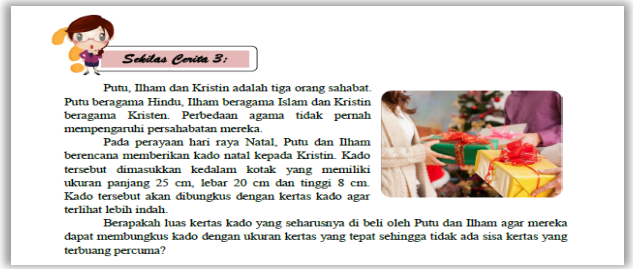
In addressing student behavior when working collaboratively, we embedded local wisdom from ancient Bali, namely Tri Hita Karana. The basic principles of Tri Hita Karana are that human being should live their life with a balance or harmony between man and God (Parahyangan), man and man (Pawongan), as well as man and his environment (Palemahan). When someone understands their role as being deeply connected with other beings or entities, problem behavior such as disrespecting other viewpoints can be reduced and propelled them to be a significant contributor in collaborative works. To facilitate collaborative activity embedded with Tri Hita Karana to improve mathematical conceptual understanding, we developed a learning handbook for teachers and students. Embedding local wisdom in improving students behavior when working collaboratively to understand a mathematical concept is currently limited in the literature, but embedding cultural context in mathematics is a notion that has stood in the test of time (see Bishop, 1988; Steffe, 1996; Bishop, 2002; Leung, Graf, and Lopez-Real,2006; Roth, 2012).

METHOD

The study was conducted in one of the public secondary schools in Kuta, Bali, Indonesia. Following Plomp and Nieveen (2013) development research model, we conducted preliminary research to determine mathematical concepts and problems, collaborative activity, and the congruent Tri Hita Karana principles that must be contained in the handbook. Preliminary results suggested that polyhedron should be the targeted concept of focus, and therefore, Tri Hita Karana principles were inserted into several math problems, stories, and motivational sentences. The handbook was evaluated based on validity, practicality, and effectiveness. Validity result for students' handbook was 3.43 and 3.33 for teachers' handbook. In terms of practicality, field tests (a limited preliminary test with 15 students as a sample and two medium-size sample field tests) showed that the developed handbook was practical. On average, the practicality score was 3.02 from three field test questionnaire to the students, 3.18 from validator, and 3.52 from teachers' questionnaire.

The handbook for learning polyhedron (see Table 1 for concepts, collaboration activity, and Tri Hita Karana principles embedded in the handbook) was implemented for eight consecutive weeks after deemed valid and practical. Students' conceptual understanding was evaluated in two implementation phases with 38 students (Class A,

Table 1. Concepts, Collaboration Activity, and Tri Hita Karana Principles Embedded in the Handbook

Concept	Collaboration Phase and Activity	Tri Hita Karana Principle
Cube, blocks, prism, and pyramids	 **Figure 1a.** An example of Brief Story containing Tri Hita Karana Principles and Polyhedron concepts. **Engagement Phase** The teacher engages students in exploring their initial knowledge of polyhedron. In the handbook, "Brief Story" was provided in which it contains Tri Hita Karana principles as a narrative for delivering mathematical problems. In one of the Brief Story (Figure 1a), we narrated that there were three best friends named Putu (a Hindus), Ilham (a Muslim), and Kristin (a Christian). Ilham and Putu wanted to give Kristin a Christmas gift. The gift will be put in a box of 25x20x8 cm (length x width x height). How much wrapping paper Putu and Ilham should buy to fully cover the box without making any wrapping leftover?	 **Figure 1b.** Tri Hita Karana Pawongan and Palemahan Embedded in The Handbook The Tri Hita Karana Principles embedded were Pawongan (man to man, how students can be respectful to their friends' religious belief) and Palemahan (man to the environment, how they can accurately and effectively use wrapping paper without making unnecessary leftover/waste). The principles were delivered through statements or sentences such as "Save on paper usage, save the forest. Do you know that paper is made from wood fiber? Behind the benefits of paper, trees in the forest were cut down. Therefore, use paper wisely. Do not throw it away easily, for millions of trees were cut down every day to meet human's paper needs" and "Respecting our friends' religious belief and uphold the value of friendship is a manifestation of fostering harmonious relationship among mankind (Pawongan)."
Cube, blocks, prism, and pyramids	**Exploration and Transformation Phase** Students were grouped into a group in which each group consisted of students with differing mathematical competence to facilitate knowledge transfer. Students were encouraged to actively exchange ideas or making questions to their peers when necessary.	The Tri Hita Karana Principles embedded were Pawongan (man to man, how students can be respectful to their friends' differing opinion in a discussion) and Parahyangan (man to God, self-awareness of one's ability and weaknesses) (Figure 1c). These were delivered through motivational sentences such as "A good discussion must be based on mutual respect and respecting other people's ideas or opinions (Pawongan)" and "If you do not understand something, do not be ashamed to ask for other people inputs. If you already understand something, don't hesitate to help other people. Try to understand your own ability and weaknesses so that you can improve your achievement (Parahyangan)".
Cube, blocks, prism, and pyramids	**Presentation** Students present the results of the discussion in front of the class. Each group presents various forms of spatial nets that they find in their group to increase the class knowledge about space-building nets. The benefit of presentation is twofold: building students' self-confidence when expressing their opinions in public and facilitating knowledge transfer.	The Tri Hita Karana Principles embedded were Pawongan (man to man, how students can be respectful to their friends' differing opinions in a discussion). The teacher serves as a facilitator.
Cube, blocks, prism, and pyramids	**Reflection** Students convey their experiences during learning and when they were engaged in a discussion. Teacher facilitates this phase by giving questions and arranging students' ideas into a concluding remark.	The Tri Hita Karana Principles embedded was Parahyangan (man to God, self-awareness of one's ability and weaknesses).

Implementation Phase I) and 36 students (Class B, Implementation Phase II) served as the sample. Student behavior (how respectful the students in the collaborative activity) were evaluated with self-assessment, peer, and observer assessment in a 4-scale questionnaire. The questionnaire consisted of 18 statements (positive-negative) such as "I maintain a good relationship with other students as fellow God's creations," "I appreciate other students' opinion during the discussion," or "I accept mutual agreement resulted from group discussion," as well as other questions related to how students see themselves in relationship with their God, peer, and surrounding. A higher score reflected a higher level of respectfulness in collaborative activity. Respectful behavior was evaluated at week three and after week eight to evaluate behavior improvement. Students' concepttual understanding was evaluated with a written test containing eight questions.

RESULTS AND DISCUSSION

After a series of testing and revision, mathematics handbook with collaborative activity embedded with Tri Hita Karana principle was implemented in the classroom. At first, students were confused on how to conduct collaborative activity in the handbook so that the teachers actively participate in initiating collaboration. Clashes of idea and opinion creates friction between members of the group and sometimes forces the teacher to act as a mediator. Staples (2007) also emphasize teacher's role in a collaborative learning which is to support the students in making contribution as well as establishing and monitoring the journey to find a common ground. Students' dissatisfaction with the collaborative activity is reflected by students' behavior assessment score (Table 1).

In Implementation Phase I and II, students evaluated his/herself as a more respectful collaborator than how peer or observer assess them to be. Peer assessment showed that students viewed his/her fellow collaborator as a good and respectful collaborator than how the observer (teachers) view them to be. Higher score in peer assessment was due to their tendency to assess their friend leniently and give higher score. This findings mimics Le at al. (2017) study that also found that the students tends to be more lenient in evaluating the role of their fellow group member in collaborative activity.

After implementing the handbook for eight weeks, behavior assessment showed improvement in how students respect each other when collaborating in a group. Although highest score was in self-assessment, near similar score assessment by peer and observer indicated that improve respectfulness in learning collaboratively did happen. Research by Tempelaar et al. (2013) stated that students have personal and social goals when learning and educational environment should be firmly rooted in collaborative focus on group learning to allow for social-directed goal setting. Differing idea or opinion still happen but did not creates friction as it initially do. Students already understand how to balance between personal goals with the group's goals. Even when students' feels that they have to communicate their differing opionion, the importance of considering other person point of view and maintaining positive group dynamic made them delivering the dissenting opinion in a respectful way. Therefore, social incident that dis-

Table 1. Students' Mathematical Conceptual Understanding and Behavior Assessment Results

Evaluation	N	Number of Students Reaching LAT (Score of 76 or above)	Conceptual understanding (Average ± SD)	Students' Behavior Assessment Score Average			
				Self	Peer	Observer	Overall
Implementation I (Week 3, Class A)	38	29	80.7	2.99	2.83	2.66	2.78
Implementation I (Week 8, Class A)	38	33		3.25	3.17	3.15	3.18
Implementation II (Week 3, Class B)	36	27	82.9	2.97	2.88	2.76	2.84
Implementation II (Week 8, Class B)	36	32		3.34	3.20	3.24	3.25

turbed the emotional balance within the group and will interfere with working to completing the task (Jarvela et al., 2010) could be avoided so that it did not hamper their activity in completing the task. The progression in respectful behavior when engaging in collaborative works indicated that collaborative skills progressed with time. Students' progress in creating productive relationships without teacher's assistance were also found in Yackel et al. (1991) study in which students became increasingly adept at working collaboratively as the school year progressed.

Average mathematical conceptual understanding was 80.7 in Implementation Phase I and 82.9 in Implementation Phase II which can be categorized as exceeding the Learning Achievement Threshold (LAT) of 76 is a proved that the students were deemed successful in learning. The nature of the study as preliminary study and have not implemented yet in a large scale experimental study with differing learning condition as control, made a clear inference on the effect of embedding cultural context within mathematical learning material and collaborative activity on mathematics conceptual understanding improvement cannot be made yet. Nevertheless, successful attainment of conceptual understanding after learning with the handbook showed potential merit of the handbook to be implemented in learning mathematics. Improvement in how students engage in doing collaborative works and when faced with conflict within the group also showed that embedding cultural context could foster students' collaboration skills.

CONCLUSION

Successful conceptual understanding after learning mathematics with the handbook showed potential merit of the handbook to be implemented in learning mathematics and students' behavior while doing collaborative works also showed that embedding cultural context in learning could foster students' collaborative skills. Further study and large scale implementation with consideration of learning factors for actual classroom implementtation is needed.

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