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Abstract

The exploratory sequential design was used in this study. The mixed methods design consisted of two modules: a qualitative module and a quantitative module. The qualitative module was used to code the data into categories and further into the structure in terms of Saldana's model. Based on the analysis of the interview transcripts, three themes were recognized to support the cooperative learning models. These three themes were Knowing by Undergone Events and Contexts (KUEC), Implementation and Action (I&A), and Opinions and Perceptions (OP). These three themes consisted of a Collaborative Learning Model describing and evaluating different topic patterns.

Keywords: cooperative learning, Bayesian network representation, Saldana's Coding Schemata, thematic coding, and mixed methods design

1. Introduction

This study was aimed at exploring the challenges educators faced in obtaining the support of cooperative learning strategies. The study examined how to plan appropriate cooperative lessons and attend professional development opportunities. Traditional pedagogy was not sufficiently effective in the digital era and required integration with technology to develop students' critical thinking and decision-making skills. Clearly, alternative pedagogical methods and strategies may improve students' learning. Cooperative learning was one of these effective learning and pedagogical strategies to transform and empower students' learning. This study used mixed methods to explore the interview data and establish the social interaction structure. A Bayesian network model was developed for researchers to further examine the teachers' interaction processes.

2. Theoretical Background

2.1 Cooperative Environment

The formation of cooperative learning environments helps students as passive knowledge receivers to be more active constructors. Altun (2015) believes that the learning environment provided opportunities for a student to work with other students, inspires motivation, and cooperatively work skills. The cooperative learning environment encourages students to develop their knowledge and problem-solving skills in the context of culture-based and social interactions. The cooperative learning environment empowers the students to be active in constructing their different strategies for solving learning problems. During the problem-solving processes, students present alternative problem-solving skills. Typically, these skills contain deep thinking and critical thinking skills. Therefore, students can elaborate, and peer-mentor other students. Through increased social interaction, students can affirm their own knowledge, yet extend and assist other students' knowledge. A cooperative learning environment fosters individualized thinking, self-expression and builds self-confidence. In other words, the instructor can build student learning models based on student learning experiences and small-group interaction patterns. This is a very effective strategy for the instructor to develop mastery learning based on students' cognitive trajectory. Therefore, cooperative learning provides a comprehensive environment, where both students and instructors develop their learning trajectories and pedagogical strategies.

2.2 Cooperative Learning Theories

Johnson and Johnson (1990c) present cooperative learning as "the instructional use of small groups so that students work together to maximize their own and one another's learning" (p.69). Sharan (1994) suggests that

cooperative learning should be student-centered learning, or the study should be organized in a small group. Sharan's perspectives are similar to Slavin's (2011) perspectives. Slavin (2011) refers to cooperative learning as a pedagogical method in which teachers organize students into small groups when they discuss the topics and seek possible problem-solving skills and strategies. The variations in the definitions and descriptions of cooperative learning do not block scholars to recognize the core meaning. In the cooperative learning environment, students become active constructors of knowledge instead of passive receivers of any given knowledge. Similarly, this social and verbal interaction builds knowledge, trust, and risk-taking in both students since their knowledge is valued and expressed. There are three main types of cooperative learning groups, namely informal cooperative learning groups, formal cooperative learning groups, and cooperative-based groups (Johnson & Johnson, 2008). However, the cooperative environment is the one of very important topics.

2.2.1 Constructivist Learning Theory

John Dewey's constructivist learning theory (Dat-Tran, 2013) indicates that learning takes place through social interactions creating new knowledge from previous knowledge. Learners reconstruct new ideas in their social environment.

For example, Piaget, Vygotsky, and Dewey (Dat-Tran, 2014) share their views on the cognitive theory which stresses that individuals develop, learn, assimilate, and accommodate due to each other's knowledge and skills taking place during cooperative learning activities among the group social interactions generating active learning. "Piaget's developmental theory emphasizes the involvement and participation of learners in the learning and thinking process. In the learning process, learners construct and reconstruct knowledge by themselves" (Dat-Tran, 2013, p. 106). Briefly, Vygotsky's view of cooperative activities promotes progress in learning.

2.2.2 The Constructivist Perspective of the Learning Theories

Bandura's social learning theory (Dat-Tran, 2013) indicates that individuals learn also by observing and reciprocating the behaviors of others in their own social environment causing retention of the skills being taught. Bandura proposes that social learning theory is derived from a combination of environmental and psychological factors, including retention, the ability to reproduce the behavior, and the motivation to adopt the behavior" (Tozer et al., 2011).

Piaget's constructivism is an epistemology or meaning-making theory, that offers an explanation of the nature of knowledge and how human beings work (Sjøberg, 2010), It states that people learn, create, and construct wisdom utilizing what they already know and integrate it with new knowledge to form new perspectives, ideas, and experiences.

Bruner's constructivist theory is that learners build new visions and beliefs by understanding them through similarities with previous information (O'Donovan, n.d.). This implies that learning is not about simply being exposed to new information but is an active process whereby learners examine, code, decode, and interpret new concepts and ideas.

2.2.3 Peer Cooperation

According to Baloche and Brody (2017), in 1949, Morton Deutsch held a study on the outcomes of peer cooperation and competition. "The findings from this study challenged the widely accepted belief that students who compete work better than students who cooperate to facilitate their own and each other's learning" (Baloche & Brody, 2017, p. 274). According to Baloche and Brody (2017), the "Results indicate that cooperative learning was not widely used and that the beliefs of the teachers, coupled with the perceived pressures of time and curriculum, were important determinants of usage.

Baloche and Brody (2017) suggest that supplying teachers with the tools, answers, and clarifications sustains a strong scholarship for them (p. 281). "Instead, they emphasize (a) examining beliefs; (b) identifying problems; utilizing research as a foundation for innovation; (d) understanding context and thinking incrementally; (e) building communities for inquiry, experimentation, and support; (f) being willing to fail; and (g) recognizing when something does not work" (Baloche & Brody, 2017, p. 281). Since these are some deep challenges, they may not always be easy to implement or learn.

3. Methods

3.1 Mixed Research Methods Related to the Study

There is a diversity of different mixed methods and data analysis models, which may be applied to different data. Creswell and Plano Clark (2018) introduced six mixed methods designs, which were applied to the research designs and data collections of the cognitively diagnostic assessment (Zhang, 2007a, 2007b): a) convergent

parallel design, b) explanatory sequential design, c) exploratory sequential design, d) embedded design, e) transformative design, and f) multiphase design (Zhang, 2007a; Zhang, 2007b; Zhang, 2022).

Among these mixed methods designs, the exploratory sequential design is the best candidate to apply to this study. The model consists of two modules: a qualitative module and a quantitative module. The qualitative module is to code the data into categories and further into the structure in terms of Saldana's model (2014).

3.2 Saldana's Coding Schemata

Codifying and Categorizing

To codify is to arrange things in a systematic order, and to make something part of a system or classification. (Miles, Huberman, & Saldana, 2014). When you apply and reapply codes to qualitative data, you are codifying – a process that permits data to be divided, grouped, reorganized, and linked in order to consolidate meaning and develop explanation (Grbich, 2013). Bernard (2011) succinctly states that analysis is "the search for patterns in data and for ideas that help explain why those patterns are there in the first place" (p. 338).

3.3 From Categories to the Themes

Morse (2008) commented on the categories and themes, and the comments are very remarkable:

"a category is a collection of similar data sorted into the same place, and this arrangement enables the researchers to identify and describe the characteristics of the category. This, in turn, enables the category itself to be defined and then compared and contrasted with other categories, or if broad in scope, to be divided into smaller categories, and its parts identified and described. A theme, on the other hand, is a meaningful "essence" that runs through the data. Just as a theme in opera occurs over and over again, sometimes in the foreground, sometimes in the background, and sometimes co-occurring with other tunes, so does the theme in our research." (p. 1)

3.4 From Themes to Theories

Morgan (2018) describes the relationships between the themes and theories as an analytic process and a series of activities which are coding, creating themes, and developing models and theories. Based on Morgan (2018), "themes convert codes into concepts representing important aspects of the results. Models connect themes to show the relationships between the themes and theories. Theories explain why these theories capture the data and are related in the ways the models show" (p. 339).

In this study, thematic coding suggested three themes that were Knowing by Undergone Events and Contexts (KUEC), Implementation and Action (I&A), and Opinions and Perceptions (OP). These three themes consisted of a Cooperative Learning Model. The selected phrases from the open coding consist of variables to support the themes with evidence.

4. Data Resources and Evidence

Data were from a small group of science teachers. The topic of the interview was cooperative learning and what aspects and elements consist of cooperative learning. Based on the analysis, twenty-five categorical evidence variables, and three thematic variables were found. The thematic variables are latent variables, which describe the construct of the theory. As shown in Figure 1, the model can be used to examine each participant's topic patterns, and then to better understand the opinions of these participants on the cooperative learning themes.

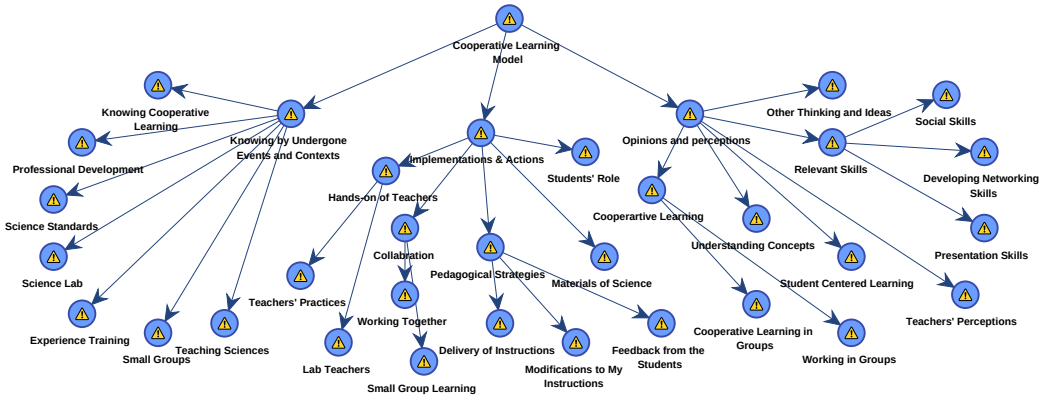

Figure 1. Cooperative Learning Model with Three Thematic Variables

5. Description and Analysis of the Findings

Several steps were needed in the analysis. The first step of the analysis was to code the data from the participants' interviews. The opening coding listed the frequencies of the words and phrases. The thematic topic of the study was cooperative learning and the author paid more attention to the words and phrases which are related to the topic. The judgments were mixed with subjective judgments and objective information. For example, the highest frequency was "science" occurring 61 times, which means the conversation and interactions between the interviewer and the interviewee focused on the keyword, science. The second highest frequency was "students," which occurred 39 times. This is a meaningful word, which implicitly means that cooperative learning was relevant to students. However, some words may not be reasonably recognized as meaningful one such as "using" occurring 15 times. Briefly, we've determined the topic ten important words: science, students, grade, learning, cooperative, teachers, teaching, group, training, and years. In addition, the author merged several words, such as teacher and teachers. Basically, we believe these two words are in the same group to represent the same concept, teacher, but the different contexts may request the singular or plural formats. The results were as shown in Table 1.

The second step was to examine the phrase, which consisted of two or two more words. The phrase indicated that there are certain relations between these words. The selections were more subjective rather than counting the frequencies. The top ten phrases are cooperative learning, science standards professional development, cooperative learning, cooperative groups, experience training, grade level, science lab, science training, small groups, and teaching science. The phrases of the opening coding provide the evidence to do further seeking the upper levels of themes, which request analysis of the sentences and relevant paragraphs to exact themes and upper levels of themes.

The third step was thematic coding. Thematic coding is a form of data analysis that involves identifying classes or patterns which help researchers to better understand the meaning of data. Caulfield (2022) suggests five steps to develop thematic coding: a) familiarization, b) coding, c) generating themes, d) reviewing themes, and e) defining themes.

Table 1. The Part of the Outputs of the Interview Data: Term and Phase Lists

Term and Phrase Lists

Term	Count
science	61
students	39
grade	35
learning	30
cooperative	26
th	25
5	23
training	23
years	21
teacher	18
teaching	18
groups	17
standards	15
learn	14
teachers	14
trainings	14
using	14

Phrase	Count
th grade	23
5 th grade	22
5 th	22
cooperative learning	19
grade teacher	8
science standards	8
5 th grade teacher	7
th grade teacher	7
professional development	7
cooperative groups	6
experience trainings	6
grade level	6
using cooperative	6
science lab	5
science training	5
small groups	5
teach science	5

6. Identified Themes & Relationship to Theories

When we finished the thematic coding, the next step was to establish the association between the themes and theories, which meant from categories to the themes and from the themes to the theories (Miles, Huberman, & Saldana, 2014; Morse, 2008). Morgan (2018) presented that, "themes convert codes into concepts representing

important aspects of the results. Models connect themes to show the relationships between the themes and theories. Theories explain why these theories capture the data and are related in the ways the models show" (p. 339). The theories are associated with the topic of the study. stated differently, the theoretic coding should support cooperative learning. the best way to represent an analysis result is to model the thematic patterns.

Thus, the next step was to develop a cooperative learning model based on the themes and thematic relations of these categories. Thematic coding suggested three themes that were Knowing by Undergone Events and Contexts (KUEC), Implementation and Action (I&A), and Opinions and Perceptions (OP). There are two latent variables belonging to Implementation and Action (I&A), and Opinions and Perceptions (OP). There were twenty-five evidence variables developed and selected from the term and phrase list. These evidence variables supported the latent variables.

These three themes plus Cooperative Learning consisted of the top of the Cooperative Learning Model. The selected terms and phrases from the open coding consisted of evidence variables and six lower-level latent variables to support the themes with evidence. As shown in Figure 1, the Cooperative Learning Model was represented in a Bayesian network (Conrady & Jouffe, 2022), which highlighted the quantitative characteristics of the data. Stated differently, the variables in this model were represented in probabilistic values dynamically.

7. Conclusions

This study examined the patterns of the interview topics on the cooperative learning of science education. Based on the analysis of the interview transcripts, three themes were recognized to support the cooperative learning models. These three themes were Knowing by Undergone Events and Contexts (KUEC), Implementation and Action (I&A), and Opinions and Perceptions (OP). These three themes consisted of a Cooperative Learning Model. These three themes are latent variables, which cannot be directly observed and they were evidentially supported by twenty-five evidence topics. Thus, a four-layer tree model was developed for both description and evaluation purposes.

8. Scholarly Significance of the Study

There are four aspects of the significance of the study. The first is that this study provided researchers with a mixed methods study to explore the interview data. The second is that this is the first time that Saldana's coding schemata/ model is combined with a quantitative representation. The third is that a model-based thematic structure can be used to be a descriptive structure of the cooperative learning topics. Finally, a model-based thematic structure can be used to be an assessment structure of the cooperative learning topics dynamically observe the participant's semantic trajectory.

9. Limitations

This study examines the cooperative learning model with a set of interview data. The findings and analyses have limited generalizations. We know that the cooperative learning model is developed in a specific group of data, so alternative cooperative learning models are possible.

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