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Enhancing Conceptual Understanding through Networked Collaborative Learning : A Study on Preservice Teacher

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ABSTRACT

The development of learning social network applications or features makes it possible to develop collaborative activities, making it easier for individuals in groups to communicate. NCL combines technology where social media and web technology are used to support relationships between learners, learning resources and learning communities. The purpose of this study was to determine the effect of NCL on concept understanding. The method used was descriptive quantitative approach with quasi experimental design. The sampling technique used purposive sampling with a total sample of 158 PGSD students at Tadulako University. Data collection techniques through tests in the form of pre-test and post-test statements of learning outcomes of concept understanding. The results of hypothesis testing showed that there was no significant difference in learning outcomes of concept understanding between the group taught with the networked collaborative learning strategy and the group that learned with discussion. The results of this study found that NCL applied did not affect the concept understanding of learners. Thus, NCL has not been proven to be more effective than conventional in the context of concept learning in this study.

Keywords: *Collaborative Learning, Concept Understanding, Online Learning*

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. Advances in technology have enabled greater connectivity among learners. In the age of social media, learners have an interest in collaborative learning, are passive during lectures, want information that can be received easily and individually, and always want a variety of learning materials that can be easily accessed through technological devices. Online learning is an increasingly common phenomenon across campuses with various forms such as MOOCs, *blended learning*, or online discussions. (Sobko et al., 2020). Online learning is experiential and more varied in its processes. Utilising technology while working together is an important part of learning social life, and applying technology in learning, such as computers, is part of the innovative and creative learning environment that leads to educational practice and research. (Pozzi et al., 2007).

Networked collaborative learning (NCL) is emerging as a promising pedagogical approach, utilising digital technologies to enhance engagement and interaction among students. NCL is used to provide connections: between learners and each other; between learners and learners; between learning communities and learning resources (Goodyear et al., 2005). In the process of NCL there is an integration of individual and collaborative learning. NCL not only indicates that the learning process is supported by ICT, but that the process is supported by, and conducted through, a network of reciprocal relationships among all those participating in the process: learners, learners, tutors, experts. These reciprocal relationships are intrinsic to collaboration in a group pursuing a common learning goal.(Trentin, 2010).

NCL can be implemented through the use of both synchronous and asynchronous methods, each of which presents a distinct set of advantages and challenges. Synchronous learning entails immediate, real-time engagement between learners and instructors, enabling swift feedback and active involvement. This is advantageous for involving pupils and improving their educational experience. Conversely, asynchronous learning provides flexibility and allows learners to interact with the content at their own speed, so fostering autonomy and reflective learning (Saxena & Carnewale, 2023). According to the study by Zou et al., (2024) in language learning and collaborative note-taking, which showed that it improves note quality and learning outcomes, this approach is particularly effective in situations where students are responsible for managing their own time. The COVID-19 pandemic has accelerated the adoption of both methods, blended learning combines the strengths of both synchronous and asynchronous learning to form a more comprehensive learning experience (Persada et al., 2022). Learning models that integrate synchronous and asynchronous elements have been shown to increase student motivation and engagement, as they enable direct interaction and flexible self-learning (Kholis, 2022).

The NCL model enables in-the-moment discussions and equalised understanding among students through collaborative learning, which emphasises self-regulated responsibility and knowledge acquisition. This approach differs from the traditional classroom, where the teacher mainly guides learning, students to engage in discussions thus improving conceptual understanding(Collerson et al., 2015). Furthermore, research shows that structured collaborative activities, such as problem sets, significantly increase student engagement and understanding, this is demonstrated by an increase in understanding and metacognitive strategies over time (Stokes, 2024). Furthermore, feedback and social regulation within collaborative learning environments supported by computers have been demonstrated to enhance group performance without increasing cognitive load, thereby supporting the efficacy of collaborative frameworks in higher education (Zheng et al., 2023).

NCL can facilitate deeper understanding by promoting collaborative processes that enable learners to construct and integrate knowledge effectively. The study conducted by (Freedman et al., 2024). Demonstrated a strong correlation between the use of concept maps in collaborative settings and individual student performance, indicating that collective understanding can enhance conceptual learning. Furthermore, the integration of NCL with digital tools has been shown to significantly enhance learners' conceptual understanding across various disciplines (Xu et al., 2023).

In higher education conceptual understanding is critical to the success of higher education, as it allows students to integrate and apply knowledge in complex situations thus encouraging critical and creative application of knowledge. Research Zou et al., (2024) showed that this understanding goes beyond mere memorisation, requiring critical thinking and the ability to form interconceptual relationships. Factors such as active engagement, collaboration, and feedback are critical to fostering concept understanding (Jere & Mpeta, 2024). NCL presents an innovative opportunity to enhance conceptual understanding by promoting dynamic and flexible interactions among students (Gatley, 2023). Jennifer, E., (2023) has researched and shown that interventions that focus on core concepts significantly improve students' ability to connect specific content to a broader context, thus deepening conceptual understanding. Thus, integrating digital approaches such as NCL can effectively overcome the limitations of traditional learning environments in developing students' conceptual understanding.

The relationship between NCL and students' conceptual understanding remains unexplored, although evidence suggests that NCL increases social engagement and interaction. In the context of programming (Liu et al., 2024) showed students with high collaborative perceptions had greater cognitive engagement and better learning outcomes. Studies conducted Freedman et al., (2024) showed that collaborative activities, such as concept mapping and peer discussion, can significantly improve students' understanding of complex concepts by encouraging critical examination of ideas and promoting metacognitive regulation during learning tasks. In addition (Chang et al., 2010) Yen et al. (2010) emphasised the role of scientific reasoning in conceptual change, suggesting that NCL can bridge gaps in understanding through adaptive learning environments. This underscores the need for further empirical studies to explore the specific effects of NCL across different disciplines and its comprehensive impact on conceptual understanding.

Understanding can significantly predict individual learner performance, suggesting that NCL can foster deeper conceptual insights (Freedman et al., 2024). Finally, the positive relationship between collaborative learning and practical skills is a potential for NCL to enhance conceptual understanding across disciplines. Thus, focused research is needed to determine the effect of NCL on conceptual understanding.

METHODS

This research is a quantitative research and *quasi-experimental* design with experimental group and control group. The research method used in this study is a quasi-experiment with a nonequivalent control group design (unequal pretest-postest) pattern. The description of the nonequivalent control group design is as follows,

O_1	X	O_2
O_3		O_4

Figure 1. Nonequivalent Control Group Design

Description:
O1 : Pre-test measurement of NCL group
O2 : Post test measurement of ncl group
X : Treatment
O3 : Conventional group pre-test measurement
O4 : Conventional group post-test measurement

This design was chosen to identify the effect of *networked collaborative learning* (NCL) on students' conceptual understanding. The experimental group received treatment with NCL, while the control group received conventional learning. This design allows a comparative analysis of the differences in conceptual understanding between students who participated in NCL and the group that was not given any treatment.

This study involved a total of 158 elementary school teacher education students at Tadulako University who were taking the Introduction to Education course. Furthermore, it was divided into 2 groups of conventional 76 people and NCL 82 people. In the NCL group consisted of 10 people of male gender and 72 women. The conventional group totalled 78 people who had a distribution of 8 men and 70 women. The research subjects have been assigned to certain groups that cannot be separated. The research conducted used quasi experiments or pseudo experiments where subjects were selected by "random assignment to treatment", the subject was determined according to the condition of the class. (Setyosari, 2013).

Table 1 distribution of research subjects

Group	**Number of students**	**Gender**	
		Male	Women
NCL	82	10	72
Conventional	78	8	70
total	160	18	142

The data collection technique used was conceptual understanding test. This test was given to both groups both before (pretest) and after (posttest) treatment. The test focuses on the concepts that have been taught in the Introduction to Education course and is designed to measure students' ability to understand and apply these concepts. The test was in the form of questions administered through google forms.

The data collected was analysed using the *independent sample t-test*. This test was used to determine whether there was a significant difference in the mean posttest results between the NCL group and the conventional group. This analysis aimed to identify the effect of NCL on students' conceptual understanding and ensure the differences found were statistically significant.

RESULT AND DISCUSSION

Learning outcomes of concept understanding in this study include the dependent variable. The questions distributed were not different between the *pre-test* and *post-test* questions, but the distribution of the question items was randomised, so that the research subjects did not recognise the question numbers that were done during the *pre-test*. The learning outcome test was given before and after learning in accordance with the research treatment, namely with *networked collaborative learning* strategy and conventional *learning* strategy.

The tests that have been conducted for concept understanding consist of *pre-test* and *post-test* given to both NCL and conventional groups. Referring to the *pre-test* data, the average value of the concept understanding test for the conventional group was 62, 27 with a standard deviation of 13.81 and NCL was 56, 45 with a standard deviation of 13.45 (table 2).

Table 2 Description of pre-test results of concept understanding

Pre-test group	N	Mean	Std. Deviation
NCL	82	56, 45	13.45
Conventional	78	62.27	13.81

The results of this *post-test* data for the experimental and control groups after receiving treatment, showed that the average value of the concept understanding test scores increased compared to the pre-test. The complete results of the *post-test* after treatment in the research group are described in table 3

Table 3 Description of post-test results of concept understanding

Post-test group	*N*	*Mean*	*Std. Deviation*
NCL	82	72, 39	13, 32
Conventional	78	74, 36	12, 74

The results in table 3 can describe the *post-test* results of learners who are grouped as NCL groups show an average of 72, 39 while the average in the conventional group shows an average of 74, 36. the average learning outcome or mean pre-test is 66.34 and the average value of the post-test is 81.78 which means the average learning outcome of the pre-test is 66.34 < post-test 81.78. So descriptively there is a difference in the average pre-test and post-test learning outcomes, which can be seen in table 4 to clarify the difference.

Table 4 Average Pre-test and Post-test

Group	Mean	
	Pre-Test	Post-test
NCL	56, 45	72, 39
Discussion	62.27	74, 36

Analysis of the difference test using the *independent sample t-test*, before carrying out the analysis stage, a prerequisite test is required, namely the normality test and homogeneity test. The aim is to test the hypothesis whether it can be continued or not, analysis of variance requires that data derived from the population must be normally distributed and the groups being compared must be homogeneous. So, analysis of variance requires a test of normality and homogeneity of data. The normality test uses a one-sample Kolmogorov-Smirnov test model, while the homogeneity test model. The results of the data normality test can be seen in table 5.

Table 5 Shapiro-wilk normality test

	Group	Shapiro-Wilk		
		Statistic	**Df**	**Sig**
Pretest	NCL	.970	82	.052
	Conventional	.969	78	.052
Posttest	NCL	.970	82	.052
	Conventional	.969	78	.055

Normality testing using the Shapiro-Wilk test on pre-test concept understanding data obtained a significance value in the experimental group of 0.052 and the control group of 0.052, then on post-test concept understanding data obtained a significance value in the experimental group of 0.052 and the control group of 0.055. These results indicate that the pre-test and post-test concept understanding data have a significance value of more than 0.05 so that the data is normally distributed.

Testing is done using the Levene test with the provision that if the significance value is more than 0.05 then the variance between groups is homogeneous.

Table 6 Homogeneity Test Results

	Levene Statistic	df1	df2	Sig.
Conceptual understanding. pretest	.099	1	158	.754
Conceptual understanding.posttest	.052	1	158	.820

Testing the homogeneity of variance using the Levene test obtained a significance value of the pre-test concept understanding data of 0.754 and post-test of 0.820. The homogeneity test results show that the concept understanding data has a significance value of more than 0.05, causing the variety between groups to be homogeneous.

After normality and homogeneity, the next hypothesis test was carried out using the independent sample t-test where H_0 : there is no difference in learning outcomes of concept understanding between groups taught using *networked collaborative* learning and conventional models and H_1 : there is a difference in learning outcomes of concept understanding between groups taught using *networked collaborative learning* and conventional.

The null hypothesis (H0) is that there is no difference in learning outcomes of concept understanding between groups taught using the *networked collaborative learning* model and conventional. While the alternative hypothesis (Ha) there is a difference in learning outcomes of concept understanding between groups taught using *networked collaborative learning* and conventional models.

Table 7 *independent sample t-test* results

From the data in table 7 Cohen's d measures the magnitude of the mean difference

Independent Samples Effect Sizes

		Standardiser[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
Understanding. Post-test	Cohen's d	13.03694	-.151	-.461	.159
	Hedges' correction	13.09923	-.151	-.459	.159
	Glass's delta	12.73715	-.155	-.465	.157

between the two groups in units of combined standard deviations. A value of **-0.151** indicates a **very small** effect (effects below 0.2 are generally considered very small or even practically meaningless). The confidence interval [-0.461, 0.159] includes 0, suggesting that the mean difference may not be practically significant.

Hedges' g is an effect size similar to Cohen's d, but uses a correction for smaller sample sizes. A value very close to Cohen's d (due to the relatively large sample), and the same conclusion: the effect is very small and not practically significant. Glass's delta uses the standard deviation of the control group to calculate the effect size, suitable if the variance between the groups is different. The value of -0.155 also indicates a very small and insignificant effect. All effect sizes showed very small values (around -0.151 to -0.155), indicating that the mean difference between the experimental and control groups on the Comprehension.post variable had almost no practical significance. nConfidence intervals that include 0 indicate that these results cannot be confidently regarded as real differences.

Although there was a mean difference, the effect size indicated that the effect of the treatment or intervention on the experimental group was very small and insignificant both statistically and practically. The two independent samples T-test analysis showed that there was no statistically significant difference between the experimental group (M = 72.39, SD = 13.32) and the control group (M = 74.36, SD = 12.74) on the post-test comprehension variable, **t(158) = -0.957**, p = 0.340**.** A p value greater than 0.05 indicates that accepting the null hypothesis, which means that the intervention in the experimental group did not produce a significant difference. The effect size, Cohen's d = -0.151, indicates that the mean difference is very small and not practically significant. Therefore, these results suggest that the intervention provided to the experimental group may not have had a considerable impact on participants' comprehension.

The result illustrates that the significance value is higher than 0.05 ($p > 0.05$) meaning that NCL has no significant effect on concept understanding or the alternative hypothesis is rejected and H_0 is accepted. Based on this, it can be concluded that the learning outcomes of concept understanding in the NCL and conventional groups are not different, or the NCL strategy has no effect on the learning outcomes of learners' concept understanding.

DISCUSSION

The results of hypothesis testing showed that there was no significant difference in learning outcomes of concept understanding between the group taught with networked collaborative learning strategy and the group that learned with conventional learning. The results of this study found that NCL applied did not affect the concept understanding of learners.

Networked learning is a new form of CSCL that uses connections, which helps collaboration between groups of learners, learners and learners, educators, learning communities and learning resources. (Issa et al., 2014). *Networked Collaborative Learning* is learning in a computer network-based learning environment where two or more than two learners communicate, coordinate, co-operate with colleagues, support each other in learning, and construct knowledge (Zhou, 2011)Therefore, the network environment can assist learners in expanding and developing their abilities and understanding as expected. (Goodyear et al., 2004).

Online discussion is described as a text-based learning activity where learners interact with each other to discuss a particular topic without being limited by time and place. (Foon et al., 2010). Learning strategies that use meaningful peer interaction, facilitated discourse, and direct instruction rather than conventional question and answer methods, learners gain a deeper understanding of the content (Bangert, 2008). When learners gain deeper conceptual understanding, they learn facts and procedures in a much more useful and profound way that transfers to the real world (Sawyer, 2014). (Sawyer, 2014).

Research conducted Junus & Andula (2020) by implementing collaborative learning through LMS Moodle and the results of collaborative learning had no effect in improving learners' understanding. However, there are other research findings that are not in accordance with the findings of this study, namely the study conducted by Aminoto & Dani (2018) developed a discussion model through whatapps in order to improve student understanding and the results showed that student understanding increased with the model. Collaborative learning can improve learners' understanding. Zhu, (2012) Collaborative learning improves comprehension learning outcomes, motivation and interpersonal relationships compared to conventional learning.

Other researchers have found that in conventional unstructured online discussions, learners generally post messages that mostly demonstrate understanding of the topic and sharing and comparing information, all in the low-level cognitive category. (Darabi & Jin, 2013). In addition Garrison & Anderson (2001) conducted a study in which graduate students engaged in online discussions intended to foster critical thinking, only about 13% of the learners' posts showed creativity and only 4% showed critical appraisal of concepts and solutions (evaluation).

Research has found that learners prefer to share and compare available information rather than continuing to construct new knowledge during collaborative discussions. (MA, 2009). It shows that learners tend to quickly interact in discussions and accept peer opinions that other learners may not necessarily agree with in order to speed up discussions (Rimor et al., 2010).Therefore, the concept understanding of learners is low.

Online collaborative learning allows discussions to occur at a deeper depth where knowledge can be built remotely. However learners were found to build knowledge at a low level where learners discuss by sharing and comparing opinions; it is not adequate for the creation of new knowledge. (Shukor et al., 2014). This research confirms that working on practice questions using concept mapping found significant results in improving student learning outcomes.(Ulfa & Fatawi, 2020).

The ability to understand concepts between learners who are treated with hybrid learning models and conventional learning models through direct delivery of learning materials or face-to-face lectures shows significant differences. Furthermore, the use of hybrid learning model Type 2 (asynchronous plus virtual classroom) is significantly superior to hybrid learning model Type 1 (asynchronous plus face-to-face classroom), in understanding the concepts of science learning courses in elementary school teacher education. (Rorimpandeya et al., 2019)

This study reaffirms that the implementation of Networked Collaborative Learning (NCL) did not produce a statistically significant difference in conceptual understanding compared to conventional learning approaches. While previous studies frequently report positive effects of collaborative and network-based learning on conceptual development (Zhu, 2012; Freedman et al., 2024; Xu et al., 2023), the present findings indicate that such outcomes are not automatically guaranteed across contexts.

The novelty of this research lies in its empirical evidence demonstrating that NCL, when implemented in an Introduction to Education course with preservice elementary teachers, does not necessarily yield superior conceptual understanding compared to structured conventional discussion. Unlike studies that highlight significant improvements in conceptual gains through structured collaborative interventions (Bangert, 2008; Stokes, 2024), this study suggests that the effectiveness of NCL is highly dependent on instructional design quality, facilitation structure, and learner readiness.

The findings are consistent with Junus & Andula (2020), who reported that collaborative learning through Moodle in a blended environment did not significantly improve conceptual understanding. Similarly, Darabi & Jin (2013) and Shukor et al. (2014) found that online collaborative discussions often remain at lower cognitive levels, focusing on sharing and comparing information rather than deep knowledge construction. These similarities may be attributed to insufficient scaffolding, limited cognitive regulation, or lack of structured knowledge-building prompts.

However, the results differ from studies such as Aminoto & Dani (2018), Zhu (2012), and Rorimpandeya et al. (2019), which demonstrated significant improvements in conceptual understanding through collaborative or hybrid models. These differences may be influenced by variations in instructional design, integration of structured concept mapping, level of instructor facilitation, technological familiarity, or learner characteristics. For example, Freedman et al. (2024) emphasize that collaborative learning enhances conceptual performance when structured through concept mapping frameworks, suggesting that the absence of structured knowledge visualization tools in the present study may have limited deeper conceptual integration.

Therefore, the theoretical contribution of this research is its clarification that NCL effectiveness is not inherently determined by technological networking alone, but rather by pedagogical structuring, cognitive scaffolding, and learner readiness. This study contributes to the growing discourse on networked learning (Goodyear et al., 2004; Trentin, 2010) by providing evidence that technological connectivity must be aligned with cognitive engagement strategies to impact conceptual understanding significantly. From a practical perspective, the findings suggest that higher education instructors should not assume that integrating network-based collaborative tools automatically enhances conceptual understanding. Effective NCL implementation requires structured guidance, clearly defined cognitive tasks, metacognitive scaffolding, and possibly integration with tools such as concept mapping or structured problem-solving activities.

Academically, this study contributes to the refinement of Networked Collaborative Learning theory by emphasizing the importance of instructional design variables as mediating factors. It highlights the need to integrate cognitive presence principles (Garrison & Anderson, 2001) and structured engagement strategies to ensure deeper conceptual construction rather than superficial interaction. From a policy standpoint, institutions implementing digital transformation in learning should consider investing not only in technological infrastructure but also in pedagogical training for instructors. Professional development programs focusing on collaborative learning facilitation and digital pedagogy design are essential to maximize the impact of NCL on higher-order learning outcomes.

This study has several limitations. First, the research employed a quasi-experimental design with non-randomized intact classes, which may limit internal validity. Second, the intervention duration may not have been sufficient to produce measurable conceptual transformation. Third, students' familiarity with digital collaborative platforms was relatively limited, which may have influenced engagement quality. Fourth, the study focused solely on conceptual understanding without examining mediating variables such as cognitive engagement, self-regulated learning, or social presence. Additionally, the absence of structured scaffolding tools such as guided concept mapping or sequential collaborative scripts may have restricted higher-order knowledge construction processes.

Future studies should explore the moderating and mediating variables that may influence the effectiveness of NCL, such as digital literacy, cognitive engagement levels, self-regulated learning skills, and instructional scaffolding models. Experimental designs incorporating structured collaborative scripts, concept mapping integration, or adaptive feedback systems may provide deeper insight into how NCL can meaningfully enhance conceptual understanding. Longitudinal research is also recommended to examine whether sustained exposure to structured NCL environments produces cumulative conceptual gains over time. Furthermore, mixed-method approaches incorporating discourse analysis could provide richer explanations of how knowledge construction unfolds within networked collaborative settings. Future researchers are encouraged to investigate different disciplinary contexts and learner populations to determine whether NCL effectiveness varies across subject domains or academic levels. Exploring hybrid models that combine asynchronous networking with synchronous guided facilitation may also offer promising directions for optimizing conceptual learning outcomes.

CONCLUSION

In research on the effect of NCL on concept understanding. The study used 2 (two) groups, namely groups that used NCL and conventional. The findings of this study the significance value is higher than 0.05 ($p > 0.05$) meaning that NCL has no significant effect on concept understanding or the alternative hypothesis is rejected and H_0 is accepted. it shows the learning outcomes of concept understanding in NCL and conventional groups are not different, or NCL has no effect on learning outcomes of concept understanding. Thus, NCL has not been proven to be more effective than conventional discussion in the context of concept learning in this study. The weakness of this study is not familiar with the use of digital platforms so that future researchers can consider these factors and moderator variables that may support the improvement of concept understanding.

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