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THE EFFECTS OF A COOPERATIVE LEARNING METHOD ON PRE-SERVICE TEACHERS' MATHEMATICS KNOWLEDGE

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Abstract

This study sought to determine how a cooperative learning technique affects pre-service teachers' mathematical understanding of word problems in quadratic equations. The study used a quasi-experimental research design. A sample of 120 aspiring teachers was used in the study. Two colleges in the Upper West Region were chosen by the use of purposeful sampling. Data were gathered using mathematics achievement test and questionnaire from two intact classes: one treatment group and the other control. The independent sample t-test, paired sample t-test, and percentages were used to analyse the data. According to the findings, cooperative learning improved pre-service teachers' understanding of word problems involving quadratic equations. The findings also highlighted pre-service instructors' challenges when trying to understand, interpret, and translate word problems. The survey also showed that pre-service teachers generally approved the cooperative learning approach, with a majority recognising benefits in social support, learning, and skill development. According to the pre-service teachers, the cooperative learning approach improved communication abilities, inspired them, and aided understanding.

Keywords: *Cooperative Learning, Pre-service Teachers, Mathematics Achievement, Word Problems, Quadratic Equations*

Background to the study

Mathematics is crucial for society's advancement and welfare, as it affects economic, political, educational, technological, and economic growth. Mathematical literacy is essential for meeting fundamental human needs and enhancing the quality of life. The world's developed economies have excellent educational systems (Wokocha, 2011). In Ghana, science and math instruction was first introduced in the 1960s, but it does not seem like much has changed since then (Akyeampong, 2010). The issue of students' lack of interest in mathematics continues to exist despite the efforts of the numerous involved parties in the educational field (Akyeampong, 2010). Despite the fact that mathematics is becoming more and more important in all facets of life and in every civilization, students' interest in the subject has been dropping (Entwistle & Ramsden, 2015). According to Coughlan (2015), Ghana's GDP may increase by 38 times if its 15-year-olds have fundamental mathematics and science skills. Mathematics is a crucial subject in Ghana, but students' performance has been inconsistent across all levels of education. To improve learning, educators are exploring cooperative learning strategies, which promote active learning, discussion, and problem-solving. Cooperative learning (CL) has been studied for three decades to improve students' social and academic performance in small groups. However, many educators and students still struggle with effectively applying CL, and focusing solely on success may not improve teachers' comprehension of CL and its use (Ashman, 2014). Cooperative learning research has shifted from determining whether it accelerates student achievement to determining the circumstances in which it performs best. Understanding the

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elements that influence its success can be done through two approaches: comparing findings using different techniques or comparing various cooperative learning formats (Alkali 2013). Factors such as technology, globalization, and economic competitiveness have affected sociocultural contexts and economic systems in the 20th and 21st centuries. To improve cooperative learning, it is essential to change the context, content, and methods used. Regular teacher training and education programs focusing on collaborative and cooperative teaching methods can shift from a teacher-centered to a student-centered approach, supported by advancements in teaching and learning theories. Experts and educational leaders emphasize the importance of adopting new instructional strategies, such as cooperative learning, rather than relying on direct instruction (Giilies 2014).

Research at an eastern Saudi high school suggests teachers should implement cooperative learning groups as evidence-based teaching strategies to adapt to the changing educational landscape and increase accountability for student learning. University Kebangsaan Malaysia's Faculty of Engineering and Built Environment has implemented CL in Engineering Mathematics courses.

The study aims to investigate the effect of the cooperative learning method on pre-service teachers' mathematics achievement and to find out the perception pre-service teachers have/hold about the effectiveness of the cooperative learning method

Problem Statement

All continue to be quite concerned about the enduring issue of pre-service teachers' poor mathematics performance. The performance of pre-service teachers in mathematics has remained subpar despite the introduction and implementation of various teaching methods/strategies recommended by researchers (e.g. Qayyum, Liaquat, Asif & Muhammad, 2014), necessitating the investigation of alternative pedagogical stances. There are several causes for the low accomplishment in mathematics, but experts say that the primary one is that the subject is still largely taught using autocratic methods (the conventional lecture approach). Adopting the optimal teaching strategy is the only way to increase achievement (Roig, 2008). Anamuah-Mensah, Mereku, and Ghartey-Ampiah (2008) claim that there appears to be general haste to cover topics in Ghana without providing students with the chance to have a deeper understanding of any given issue. These circumstances could be the root of our schools' pervasive failure. Ghanaians' performance on the TIMSS 2011 test shows us that our mathematics pedagogy and methodology need to be altered in order to allow students opportunities for active engagement in mathematics learning in the classroom (Fredua-Kwarteng, 2005). For over 20 years, scholars, parents, and educational authorities have emphasized improving student success, but little research on instructional strategies and frequency in Ghana. An analysis of pre-service teachers' proficiency in mathematics using cooperative learning is needed to improve social support, positive attitudes, and academic skills development (Gyimah, 2011).

Purpose of the study

The purpose of the study was to investigate the effect of the cooperative learning method on pre-service teachers' mathematics achievement and to find out the perception pre-service teachers have/hold about the effectiveness of the cooperative learning method.

Research Questions

1. What effect does the cooperative learning method have on pre-service teachers' mathematics achievement in word problems in quadratic equations?
2. What perception do pre-service teachers have/hold about the effectiveness of cooperative learning methods for mathematics learning?

Review of related literature

Theoretical Framework of the Study

This study is supported by the social-constructivist theory of instruction. This article is about a theory of knowing that contends that human beings produce knowledge and meaning through the interaction of their thoughts and experiences. Greater (2010). The history of mathematics, psychology, sociology, and education have all been influenced by this idea. According to Piaget and Vygotsky's theories of cognitive development, this is actually the main dependent variable fostering conceptual change (Moreno, 2010). According to Moreno (2010), Vygotsky emphasises the need to analyze the child's zone of proximal development (ZPD) in order to navigate with scaffolding, while Piaget maintains that cognitive development can be encouraged by equilibration or fostering cognitive conflict. Piaget also believed that the three processes of assimilation, accommodation, and equilibration were crucial to cognitive development. Assimilation is the process through which a kid adapts previously learned concepts to new situations (Knauer, 2015).

Vygotsky prioritised social interaction, in contrast to Piaget. Development is the conversion of social interactions into cognitive processes. Learning and growth, according to Vygotsky, are distinct processes. Each academic subject has a unique relationship to a kid's development, which changes as the child progresses through different stages (Knauer, 2015). Solving challenges is crucial for advancing talents and acquiring the necessary knowledge and skills. Learning involves developing specialized thinking skills and general thinking capacity through social interactions. Reception and discovery learning involve independent agents presenting concepts and prepositions to the learner in their ultimate form.

Effects of cooperative learning on pre-service teachers' Achievement

Cooperative learning has recently been shown to improve academic performance in a variety of areas, including mathematics (Gambari, 2010; Kumara & D' Souza, 2011; Ning & Hornby, 2010). Ajaja and Eravwoke (2010), Daud and Abidin (2013), as well as Gupta and Pasrija (2012), and Ajaja and Eravwoke (2010), came to the same conclusion that the cooperative learning strategy is superior to the traditional teaching method in terms of the academic accomplishment of pre-service teachers. It has been demonstrated that employing a cooperative learning technique while learning a new topic increases students' accomplishment in a variety of subject areas across a wide range of skills, grade levels, and ethnicities. Cooperative learning tactics can boost student achievement, but they should arouse their interests and intrinsic motivation (Law, 2011) p. 419. Educators must select cooperative learning techniques based on subject matter, students' interests, and preferred methods. A study in Hong Kong found that Jigsaw techniques improved fifth graders' aspirations, motivation, and reading ability, outperforming drama and control groups. Cooperative learning principles promote social and intellectual

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benefits in students through interaction, fostering reciprocity, and fostering learning communities. Implementing these principles can lead to significant academic and social advantages. (Idowu, 2013; Johnson et al., 2010). Cooperative learning techniques emphasize the importance of learners' engagement and interaction, promoting learning from one another. Studies show that active participation in-group exercises, preparedness, constructive feedback, and teamwork improve academic achievement among undergraduate students. Cooperative learning is a successful method for students to acquire conceptual content and develop collaborative skills. High-test scores indicate engagement, but superior knowledge does not necessarily indicate superior knowledge. Studies show that students who learn in cooperative learning contexts master more material and retain material longer than those taught using traditional methods retain. However, knowledge retention rates do not differ between traditional and cooperative learning methods. Meta-analysis research is crucial for comprehensive evaluations and focusing on the overall impact of cooperative learning on students' achievement (Bukunola & Idowu, 2012; Tran, 2014).

Students' Perceptions of the Effectiveness of cooperative learning

Upper primary students prefer cooperative small-group learning over other methods, with diverse perspectives and group dynamics. African American students prioritize diversity and social engagement over individualistic or competitive learning. (Johnson, 2006). American elementary students of diverse ethnic backgrounds prefer cooperative learning to competitive and individualistic learning. African students are more inclined to cooperate, and cooperative teaching can scaffold academic progress and social skills. Studies show that 92% of students cite achievement advantages in small groups, but social relationships are only included in less than half. Comparisons between student and teacher perspectives on cooperative learning's effects are investigated (Ellison, Boykin, Tyler, and Dillihunt 2005).

Devine (1993) study on students' perceptions of small group participation found that over 90% of participants had no challenges, and some felt they were placed in the wrong group. The majority wanted to be placed in a more advanced group, giving them confidence and superiority. Students in the lowest group expressed dissatisfaction with group-specific teaching strategies, preferring whole-class instruction to one-on-one or small-group instruction. This highlights the diverse forms of instruction and activities in different groups. Cooperative learning in mixed-ability and mixed-gender groups helps elementary children achieve greater academic and cognitive goals. Social aspects, sharing, and a lack of defensive attitudes are key to efficient cooperation. Greater achievers emphasize the importance of social variables for teamwork, with female students more frequently recognizing this component.

Research design

As the framework for research, research design serves as the connecting thread between all of the project's components (Trochin, 2000). The study is a quasi-experiment with a control group and treatment group, aiming to assess the effects of factors on participants. A positivistic paradigm is used, with a pre-and-posttest with treatment and group comparisons. The study includes two whole classes of level 100 pre-service teachers from colleges of education.

Population

According to Trochim (2006), a research population is typically a sizable collection of people or things to which researchers occasionally extrapolate their findings. All level 100 colleges of education from the Upper West made up the population. All of Ghana's colleges of education use the same curriculum. Therefore, regardless of the college they attend, pre-service teachers are taught similar/same material. Cohen et al. (2004) define the target population as specific criteria-fitting elements for generalization in a study. In the area, there are three public colleges of education. There are 430 men and 270 women among the three colleges' level 100 pre-service teachers.

Sample and Sampling Techniques

Whether or not it is representative, a population's component might be considered a sample (George & Mensah, 2012). According to Alhassan (2006), sampling is the process of choosing a subset of the population to represent the full population. Purposive sampling and simple random sampling were used in conjunction with the study's sample methodologies. When researchers construct a sample that is likely to meet certain specific goals, they utilise the non-probability method known as "purposive sampling" (Cohen et al., 2004). On the other hand, simple random sampling is a method of choosing a sample from a population where each person has an equal probability of being included in the sample (Opoku, 2005). 120 participants served as the study's sample size. Cohen, Manion, and Morrison (2008) state that "a sample size of 30 is held by many to be the minimum number of cases if researchers plan to use some form of statistical analysis on their data" (p. 101). The sample size is representative, allowing for reliable judgments. However, purposeful sampling may limit the sample's representation. The study selected Upper West and two colleges of education, followed by simple random sampling to ensure equal probability of class selection.

Research Instruments

Research instruments, according to Wilkinson and Birmingham (2003), are merely tools for gathering data that is important to certain research activities. Tests, questionnaires, and interviews are some of them. They counter that there is not a single research tool that is acknowledged as the industry standard. Because of this, no research tool is more appropriate than another. Achievement tests and a questionnaire served as the primary study tools

Achievement Test Items

The pre-test consists of 10 quadratic word problems that include proportion, area, integer, and digit issues. These questions are based on goals 2 and 3 of the FDC112 syllabus for basic algebra and numbers (College of Education 2012). The test involved 40-minute time limits for each group of students, with 10 items on the same subject. Post-test items were evaluated using pre-test criteria. The cooperative learning method was applied if significant differences were observed from the control group.

Questionnaire

Baxter and Jack (2008) list various benefits of using a questionnaire, including making data collection easier, making it simple to verify data for validity and reliability, and taking less time than an interview or an observation. Additionally, it protects the respondents' responses and responses privacy and confidentiality. According to Hannan (2007), questionnaires are written questions that must be answered by checking or circling the

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right box. They are effective methods for gathering information. The Likert scale is currently the most frequently used method of scaling adopted in questionnaires in the social sciences. Questionnaires are also used as tools to gather information about people's opinions. Respondents are frequently asked to indicate how strongly they agree or disagree with a statement. The study used a questionnaire with closed-ended inquiries to gather respondents' responses. This method was chosen for its uniformity, accuracy, and objectivity. Closed-ended questions are easy to construct, compile, and don't discriminate based on response articulateness (Cohen, Manion & Morrison, 2013). They expedite data gathering and analysis, and computer programs like SPSS and Excel make data entry and tabulation simple.

Validity and Reliability

This required using research techniques that improve the study's data's usefulness and quality. As a result, it improves the validity and reliability of research findings. Different kinds of triangulations were used in the study to accomplish this. Triangulation, according to Sarantakos (2005), is the practice of using multiple instruments as part of a single study design. In a qualitative study, triangulation serves a variety of functions. It is helpful for confirming the study's methods, outcomes, and conclusions. Researchers can address all potential aspects of a phenomenon using the triangulation strategy, gather enough data to advance knowledge, and solve the drawbacks of employing a single technique for data gathering (Flick, 2000). Contextually, methodological, data and respondent triangulation were used to ensure the validity of this study. The use of these validity and reliability methodologies allows for the efficient review and presentation-level authentication of data.

Intervention

In February 2019, an intervention was initiated in level 100 general classes, involving lessons on word problems. The experimental group was put into groups of six, while the control group received conventional instruction. The intervention lasted for four weeks, with a post-intervention evaluation involving parallel test questions and questionnaires. The study aimed to assess the effectiveness of cooperative learning and the pre-service teachers' understanding of the subject matter and the challenges they face when solving word problems.

Data collection procedure

The researcher started by obtaining permission from the Principal and Head of the department of mathematics to use the pre-service teachers of the College. The researcher of the intervention conducted a pre-test personally. After that a four-week period of intervention was carried out where the experimental group was taught using a cooperative learning strategy and the control group taught using the traditional methods of the researcher. The researcher himself will then administer a post-test interview and questionnaire.

Data Analysis

The results of the pre-test and post-test will be analyzed using the independent t-test whiles the questionnaire will be analyzed using descriptive and inferential statistics. All the results will be analyzed with the help of SPSS version 20. Data analysis using statistics will display the frequency, percentage, deviation, and mean. The statistics also reflect the difficulties the respondents encountered in translating and solving word problems. Inferential statistics used in this study is the t-test, which is a powerful statistic that enables the researcher to determine whether the differences obtained between the two groups are statistically significant. The independent-groups t-test is appropriate when different participants have performed in each of the different conditions (Coakes, 2012).

Results and Discussions

Research question one: What is the effect of using a cooperative learning strategy on pre-service teachers' achievement in word problems*?*

The researcher determined the effect of cooperative learning strategy on pre-service teachers' mathematics achievement in word problems involving quadratic equations by comparing the scores of both groups in the pre-test and post-test using the independent t-test and paired samples t-tests. Within the experimental group, the results showed significant improvement in students' mathematics achievement in the post-test. The mean score of students in the pre-test was 21.10 while that of the post-test was 69.95, an increase of 48.85. This is an indication that, in the post-test, every pre-service teacher's performance had increased in the experimental group. This great improvement might be due to the effect of the use of cooperative learning as well as other factors such as the teacher factor. The independent samples t-test also found it to be not significant as t (59) = 2.141, p = 0.036. The results of the independent samples t-test on the two groups' scores in the pre-test are presented in Table 1.

Table 1. Independent Samples t-test for the experimental and control groups pre-test

Test	Groups	N	Mean	SD	t-value	p-value
	Experimental	60	21.10	8.953		
Pre-test					2.141	0.036
	Control	60	24.32	8.951		

Table 1 shows the pre-test mean scores of the treatment and control groups. The results indicate that the mean score for the treatment group was 21.10 with a standard deviation of 8.953 and that of the control group was 24.32 with a standard deviation of 8.951. The results indicate that the difference between the achievement mean scores for the treatment and control groups was not significant (p = 0.036 > 0.05). This, therefore, means that the treatment and the control groups were at the same entry behaviors, level, strength, and achievement at the start of the study. The same independent sample t-test inferential statistics analysis was used to analyze the post-test scores and the results are displayed in Table 2.

Table 2: Independent Sample T-test for Experimental and Control Groups Post-test scores

Test	Group	N	Mean	SD	t-value	p-value
	Experimental	60	69.95	12.134		
Post-test					-19.314	0.000
	Control	60	39.97	6.131		

The post-test results indicated that the mean scores for the treatment group (M = 69.95, SD = 12.134) were significantly

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higher than the scores of the Control group (M = 39.97, SD = 6.131), and independent samples t-test found the post-test results of the treatment group to be significant t(59) = -19.314, p-value = 0.000 < 0.05. This shows remarkable improvement in the achievement of students in the experimental group. The results also affirm that there is a significant difference between the mean achievement scores of students taught using the Cooperative learning strategy and those taught using the traditional method. The results of the post-test and pre-test of the experimental group only and that of the control group only were separately analyzed using paired sample t-test. The results indicated that the mean score for the experimental group was significantly higher (M = 69.95, SD = 12.134) than that of the pre-test (M = 21.10, SD = 8.953), and paired samples t-test also found this to be significant, t(59) = -25.054, p-value = 0.000 < 0.05. The means and standard deviation differences are -48.850 and 15.103 respectively and that of the Control group are -15.650 and 1.258. This shows that the Cooperative learning strategy has increased students' achievement in the experimental group more than the traditional method in the Control group.

Table 3: Paired Sample T-test for Experiment Group and Control Group

Group	Test	N	M	SD	Paired Mean difference	t-value	p-value
Experimental	Post-test	60	69.95	12.134	-48.850	-25.054	0.000
	Pre-test	60	21.10	8.953			
Control	Post-test	60	39.97	6.131	-15.650	-12.437	0.000
	Pre-test	60	24.32	8.951			

Table 3 above shows the results of the paired samples t-test conducted between the means of both experimental and control groups. The pre-test and the post-test differences were found to be statistically significant in both cases at p-value = 0.000 < 0.05. However, the paired mean difference for the experimental and the control groups was found to be -48.850 and -15.650 respectively. The paired mean difference of both the experimental and control groups suggests that the Cooperative learning strategy is more effective than the Traditional method of teaching.

Discussion of research question 1

The study shows that cooperative learning significantly improves students' mathematics achievement and attitudes, with the experimental group showing a significant improvement compared to the control group. This aligns with Zakaria et al.'s (2010) findings but differs from Ismail's (2000) findings, which found no significant difference in attitudes between the experimental and control groups. Cooperative learning has been shown to positively influence students' performance in mathematics and attitudes toward mathematics. It allows students to confidently translate and solve word problems involving quadratic equations, enabling them to acquire appropriate problem-solving techniques. The study found that those exposed to cooperative strategies had more interest in mathematics and performed better than those not exposed to cooperative strategies perform. This finding aligns with previous research by Odoh (2013) and Okebukola (2005), who found that cooperative learning strategies are essential tools for boosting students' achievement in mathematics. Cooperative learning strategies significantly improve student interest in mathematics and academic achievement in social psychology lessons. These strategies involve active interaction, cognitive conflict, social construction, and meta-cognitive processes. Teachers should incorporate cooperative learning strategies to prepare students for future academic success.

Research question two: What perception do pre-service teachers have about the effectiveness of cooperative learning strategy?

Research question 2 aimed to understand pre-service teachers' perceptions of cooperative learning strategies in solving word problems. 11 open-ended items were administered, categorizing positive and negative responses. Results are presented in Table 4.

Table 4: Pre-service teachers' perception of the effectiveness of cooperative learning in solving word problems (n = 60).

Perception about the effectiveness of cooperative learning	Agreement N (%)	Disagreement N (%)	Mean	SD
11. l often acquire valuable information through this approach	60(100)	0(0)	3.40	0.494
12. I often share information and ideas with other students through this approach	60(100)	0(0)	3.92	0.279
13. I often engage in critical thinking (evaluating ideas and opinions, solving problems through this approach	60(100)	0(0)	3.02	0.129
14. I often listen to the thoughts and opinions of my classmates through this approach	60(100)	0(0)	1.98	0.129
15. I often practice skills of listening, sharing and giving encouragement to classmates through this approach	60(100)	0(0)	3.48	0.504

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16. I feel actively involved in these activities	59(98.3)	1(1.7)	3.40	0.494
17. I get frustrated or impatient in these activities	5(8.3)	55(91.7)	1.23	0.427
18. I feel intellectually challenged in these activities	54(90)	6(10)	1.93	0.252
19. I feel closer to my classmates in these activities	58(96.7)	2(3.3)	3.33	0.475
20. Most of my classmates participated actively in these activities	60(100)	0(0)	3.93	0.252

Table 4 shows pre-service teachers benefit from cooperative learning strategies for solving quadratic equations, gaining valuable information, critical thinking, listening, sharing, and feeling closer to their students. Participants disagreed with confusion and intellectual challenges in cooperative learning activities. Most associate cooperative learning with positive benefits, including acquiring valuable information, sharing ideas, critical thinking, listening, practicing listening, reviewing, actively participating, and feeling closer to classmates.

Discussion of research question 2

The next discussion focuses on student perceptions of cooperative learning. The findings show that students love cooperative learning because it allows them to: 1) Exchange opinions with friends without fear, 2) Can make friends as a place to ask, 3) Enjoy learning in groups rather than individually, 4) quickly understand when a friend explains, 5) is not afraid of doing mistakes, 6) Enthusiastic and motivated. This is proven by the study of Slavin (2011) which says that cooperative learning methods as a whole require the collaboration of students in the learning process and they are responsible for the learning of their teammates as well as their own learning. Students dislike cooperative learning due to factors like friends' unwillingness to share, non-focused discussions, and communication difficulties. Teachers divide groups based on values, causing communication and problem-solving issues. Students find cooperative learning beneficial due to repetition, individual study, and discussions. Vygotsky's "Zone of Proximal Development" construct supports this process. Cooperative learning offers numerous opportunities for success, relaxing students and promoting effective learning. (Ahmad and Mahmood, 2010).

Summary of Findings

The research examines the impact of cooperative learning strategy on pre-service teachers' mathematics achievement in solving quadratic equations and their perception of its effectiveness. The study analyzes descriptive and inferential statistics and the major findings are summarized as follows.

1. Cooperative learning significantly improved pre-service teachers' mathematics achievement in solving quadratic equation word problems, with higher mean scores in the Experimental Group compared to the Control Group.
2. Students enjoy cooperative learning for its ability to exchange opinions, make friends, enjoy group learning, understand explanations, and be enthusiastic and motivated.

Conclusion

The study found that cooperative learning positively affected pre-service teachers' mathematics achievement in quadratic equations. It allowed teachers to exchange opinions without fear, enjoy group learning, quickly understand explanations, and be enthusiastic and motivated. This approach improved in-depth knowledge of the content area, enabling students to select, organize, recognize, and interpret their thoughts. The study emphasizes the importance of separating the influences of good teaching and good teaching methods. Cooperative learning led to deeper understanding, control of mathematical anxieties, motivation, and social and collaborative skills.

Recommendations

This study recommends exposing pre-service teachers to cooperative learning strategies to promote social interaction, active learning, discovery learning, motivation, and learning by doing. Government, educational agencies, NGOs, UNICEF, and UNESCO should organize workshops on cooperative learning strategies. This research benefits mathematics tutors and pre-service teachers in developing countries like Ghana, contributing to educational pedagogy knowledge. Improving teacher education programs in Ghana tertiary institutions will prepare teachers to apply innovative teaching approaches.

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