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Effects of problem-solving and cooperative learning in mathematics on students' higher levels of cognitive learning domains: The case of high school students, Awi-zone, Ethiopia

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The purpose of this study was to look into students' higher-level reasoning skills in a high school mathematics class through cooperative problem-solving learning activities. The participants were fifty-five students in the experimental group and fifty-five students in the control group. The study included a pretest to find out students' reasoning skills before the new teaching strategy. The experimental group encountered cooperative problem-solving learning and higher-level questions over six-weeks period. The changes were directed at helping them reach higher levels of Bloom's Taxonomy. The control group received conventional teaching style. At the end of the six weeks, students in both groups were given a post-test to find out if they could answer higher-level questions. Analysis of paired t-test was employed to determine the results, which were substantial and establishing that the experimental group achieved at higher levels of Bloom's Taxonomy than the control group. It is recommended for schools to incorporate the higher levels of Bloom's Taxonomy on a more frequent basis so that students will improve higher reasoning skills.

Keywords: bloom's taxonomy, cooperative learning, problem-solving, traditional methods

The most usual instructional instrument utilized by almost all teachers are questions Gegen (2003). According to McCarthy, Sithole, McCarthy, Cho, and Gyan (2016) teachers distinguish both efficient and inefficient querying methods in their mathematical classroom discussion through an analysis of questions they inquire and the feedback they get from their students during mathematical discourse. Structuring the style of questioning is one of the guarantees that make students to participate, for students to be pliable and their non-judgmental answers (Shahrill, 2013).

Contribution of this paper to the literature

- Cooperative problem-solving approach resulted in a statistically significant difference on the mean scores of students' higher levels of cognitive learning domains in mathematics.
- The methodology adopted the combination of cooperative problem-solving and Bloom's Taxonomy of cognitive domains in enhancing critical thinking.
- Cooperative problem-solving learning would increase students' active master of higher-level domain knowledge and hence solving trending issues.

Three-fifth of the questions that teachers inquire are recalling, comprehension and applications, the remaining two-fifth are equally shared between operational and higher-level questions (Cotton, 1988). Recognizing these data, it is crucial to think about the questions mostly asked in a mathematics classroom and their effect on student reasoning skills.

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According to Piscopo (2019), ask students "formative open questions" rather than questioning the correct answer, for instance, it is better to ask as follows:

- What does this problem make you think of?
- In doing this problem, which reasoning strategy you can utilize?
- In doing this problem, where shall be the beginning stage?
- In doing this problem, do you know more than one solution method(s)?

These types of questioning calls for all students to take part in classroom discourse because everybody realizes some part of the problem.

Bloom's taxonomy (Bloom, 1956) is a formal and scientific method of classifying questions based on the level of cognitive reasoning skills.

If questions are at low-level reasoning skills of Bloom's Taxonomy, students do not have to necessarily employ prior knowledge to answer almost all of the questions (Bell & Fogler, 1995). Students do not have to be involved to propose alternative solutions and find new patterns, make predictions based on previous knowledge, or defend opinions and make judgments or conclusions and defend their solutions. Haghparast et al. (2014) explained that students should be able to distinguish problems, assess possible evidence, differentiate information, and depict conclusions. Once used the right way, Dwyer, Hogan, and Stewart (2014) announced critical thinking skills enhance the likelihoods resulting in a coherent inference and conclusion reacting to a particular debate or a problem. The uplifting enlightenment of critical thinking is crucial for booming completion of degree programs in higher education (Fell & Lukianova, 2015). Critical thinking is the updating of knowledge, investigation of differences, observation of cause-effect relationships, extraction of ideas from real-case scenarios, the support of ideas with evidence-based metaphors, and the evaluation of data established on multiple views (Florea & Hurjui, 2015).

Teachers have been cognizant of Bloom's Taxonomy since 1956 (Huitt, 2004). If teachers know the cognitive levels encouraged by higher-level questions, they should necessarily practice in the classrooms. However, in our country, teachers do not know the cognitive levels of questioning as it is seen from classroom observations. If teachers do not ask higher-level questions, learners may not find out to think at higher levels. Bloom's Cognitive Domains of the six levels of reasoning skill are Knowledge (Recalling), Comprehension, Application, Analysis, Synthesis and Evaluation in order of their levels.

Review of literature

Theoretical/conceptual framework

This study draws its theoretical framework from constructivism which has two belief systems: radical constructivism and social constructivism. Formalization of the theory of radical constructivism, according to Glasersfeld (1990) is generally attributed to Jean Piaget (1896-1980). According to Glasersfeld (1990), Piaget suggested that through processes of accommodation and assimilation, individuals construct new knowledge from their experiences. Radical constructivists view learning as a process in which the learner actively constructs or builds new ideas or concepts based upon current and past knowledge experience.

In terms of psychology, recognition for the further development of radical constructivism in regard to classrooms and learners can be given to (Dewey, 1859-1952; Piaget, 1896-1980; Vygotsky, 1978).

Social constructivism is considered as an extension of the traditional focus on individual learning in addressing cooperative and social dimensions of learning. Social constructivists state that knowledge is constructed when individuals engage socially in talk and activity about shared problems or tasks (Jones, 1996) and that knowledge is interwoven with culture and society (Ernest, 1992).

The Taxonomy of Educational Objectives is a conceptual framework for classifying statements of what we expect or intend students to learn as a result of instruction. The six levels of the cognitive domain of Bloom's Taxonomy are knowledge, comprehension, application, analysis, synthesis, and evaluation. The Taxonomy of Educational Objectives is a scheme for classifying educational goals, objectives, and, most recently, standards. Fig.1 shows the conceptual framework of the study.

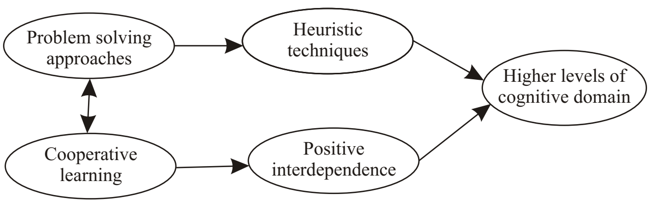

Fig.1: Conceptual framework of the study

Method

Participants

Participants in this study were grade 11 high school students enrolled in the school. In the control group, there were fifty- five participants, also in the experimental group; there were fifty-five participants. Non-equivalent quazi-experimental research design is used. Pretest-intervention- posttest. Cooperative problem-solving integrated with Bloom's Taxonomy of cognitive levels of reasoning used as an intervention.

Methods of assuring validity, reliability and trustworthiness

Two groups of grades 11 students (one for the control and the other for the experimental group) will be randomly selected to reduce threats to external validity. Similarly, schools were selected randomly. In addition, threats to internal validity were controlled: the content validity of test items were determined by preparing a chart/table of specification (a table which can be used to identify the achievement domains being measured & to ensure a fair & representative sample of questions), and expertise commented on it.

To test for reliability, the study used the internal consistency technique by employing Cronbach's Coefficient Alpha test for testing the research instruments, the pretest and the posttest. Internal consistency of data was determined by correlating the scores obtained with scores obtained from other times in the research instruments. The Cronbach's Coefficient Alpha was 0.78. According to Mugenda and Mugenda (2003), indicating a high consistency among the variables.

Students' cognitive abilities for solving mathematics problems were evaluated with a pretest to determine their skill levels prior to any changes in instruction. Each pretest and posttest consisted of eighteen questions demanding various cognitive levels of reasoning skills (three questions at each level). The questions covered lessons that the students would be learning over a six-week period. The researchers monitored students' possession of mental qualitiesvia class observations, their accomplishment on home take exams and problems designed to encourage reasoning skills critically and answering various levels of questions according to Bloom's Taxonomy. Questions were asked through cooperative-problem-solving approach, where students were grouped in mixed abilities. In order for students to answer questions at various cognitive levels, sometimes quizzes and assignments were designed out of their textbook. Students should use a variety of problem-solving strategies such as guess, drawing a graph, using a pattern, creating equations, working backwards, making predictions, etc. to overcome the problems. After interventions were accomplished, students were given a posttest, which was similar to the Pre-test. During this intervention, it was presumed that the students would become more beneficial in problem-solving, critical reasoning skills and cooperative learning and hence their performance in higher levels (Analysis, Synthesis, & Evaluation) of reasoning skills in mathematics increases.

Results

Effects of problem-solving and cooperative learning on students' higher level (Analysis, Synthesis, & Evaluation) reasoning skills in mathematics achievement: To determine the effects of problem-solving and cooperative learning on students' achievement, the analysis of students' pre-test for experimental and control groups mean scores of all levels of reasoning skills was carried out.

To decide if treatment was in effect, comparison of posttest scores between experimental and control group was made using paired t-test.

Table 1 shows the pre-test scores of the experimental and the control groups. The results indicate that the mean score for the experimental group was 27.05 with a standard deviation of 2.07and that of the control group was 26.87with a standard deviation of 1.26. The results also indicate that the difference between the achievement mean scores of experimental and control groups t (54) = -0.769 and p = 0.445 are not significant at the alpha level of 0.05. The difference, the effect size (d = 0.1036), is much smaller than typical (negligible) using Cohen's (1988) guidelines.

This, therefore, means that the experimental and control groups were at the same level of achievement at the start of the study.

Table 1: Pre-test and the achievement mean scores of the experimental control group of all levels of reasoning skills

Groups	N	Mean	SD	t-value	df	p-value
Experimental	55	27.05	2.07	-0.769	54	0.445
Control	55	26.87	1.26			

Table 2 shows the post-test achievement mean scores of the experimental and the control groups of all the six levels of reasoning skills. The results indicate that the mean score for the experimental group was 36.49 and that of the control group was 27.29. The results also indicate that the difference between the achievement mean scores for the experimental and the control groups t(54) = -27.994 and p =.000 is significant at the alpha level of 0.05. The difference, the effect size (d = 3.775), is much larger than typical using Cohen's (1988) guidelines.

Table 2: Post-test achievement mean scores of the experimental and the control group of all levels of reasoning skills

Groups	N	Mean	SD	t-value	df	p-value
Experimental	55	36.49	1.12	-27.99354	54	0.000
Control	55	27.29	2.32			

Table 3 shows that the pre-test achievements mean scores of the experimental and the control groups of higher levels (Analysis, Synthesis & Evaluation) of reasoning skills. The results indicate that the mean score for the experimental group was 6.53 with standard deviation 2.09 and that of the control group mean score was 7.07 with standard deviation 2.54. The results also indicate that the difference between the achievement mean scores for the experimental and the control groups t(54) = -1.396 and p = .169 is not significant at the alpha level of 0.05. The difference, the effect size (d = 0.188), is much smaller than typical using Cohen's (1988) guidelines.

Table 3: The pre-test scores of the experimental and the control groups for higher levels of reasoning skills

Groups	N	Mean	SD	t-value	df	p-value
Experimental	55	6.53	2.09	-1.396	54	0.169
Control	55	7.07	2.54			

Table 4 shows the post-test achievement mean scores of the experimental and the control groups of higher levels (Analysis, Synthesis & Evaluation) of reasoning skills. The results indicate that the mean score for the experimental group was 16.12 and that of the control group was 6.33. The results also indicate that the difference between the achievement mean scores for experimental and control groups t(54) = -25.099 and p = .000 is significant at the alpha level of 0.05. The difference, the effect size (d = 3.38), is much larger than typical using Cohen's (1988) guidelines.

Table 4: The post-test scores of the experimental and the control groups for higher levels

Groups	N	Mean	SD	t-value	df	p-value
Experimental	55	16.12	2.19	-25.099	54	0.000
Control	55	6.33	1.64			

Discussion

Results from the data propose that by integrating higher levels of Bloom's Taxonomy through problem-solving and cooperative learning, questioning and activities, students will score higher on tests, thus making them better problem solvers and critical thinkers. Results showed significance when incorporating the higher levels of Bloom's Taxonomy. More students in the experimental group than the control group showed growth in their higher levels of cognitive abilities from the pretest results to the post test results. The reason for the increase in students' achievement could be caused by the students' involvement in explaining and receiving explanation in which the concepts can be easily understood. Problem-solving and cooperative learning give more space and opportunities for students to discuss, explore and solve problems, create solutions, provide ideas and help each other. Furthermore, as table 2 and 4 shows, the post-test scores of all the six levels and higher levels (Analysis, Synthesis & Evaluation) are respectively 36.49 and 16.12 which means students have scored less when they are required a high level of reasoning skills. The results were also in line with previous studies, as reported by some researchers such as Esan (2015) who showed that there was a significant main effect of treatment on students learning outcomes in achievement towards algebraic word problems and Poore (2008) discovered that cooperative learning has a positive impact on students' abilities in problem-solving and their overall impression of mathematics and group work. Zakaria, Chin, and Daud (2010) described that conventional way of teaching is teacher-center, hence a very few chance to students to discuss, to be involved in critical thinking and work in a group.

Conclusion

Student-centered approaches such as cooperative problem-solving learning improve the students' high-level reasoning skills in mathematics achievement. Therefore, teachers in high schools need to be cognizant of the gains and usage of problem-solving and cooperative learning and thus changing the culture of lecture method to active teaching methods. There are promising changes taking place when teachers change their style of discourse towards a more group work critical thinking reasoning skill approach. Teachers must surmount the subject matter and plan different strategies in carrying out cooperative -problem-solving learning better. Problem-solving with Polya's four-step method and cooperative learning strategy in which small groups of learners with different levels of ability work together to accomplish a shared learning goal should be employed. Furthermore, the results showed that cooperative problem-solving learning have a better result on the establishment of a more positive opinion towards mathematics due to the students' positive interdependence among students. However, attitude is very difficult to change in short period of time. This study only lasted for six weeks. This means that students are exposed to learning in a very short period. Therefore, a similar research should be given at least a semester so that the study could be more validated. Therefore, teachers are encouraged to practice these methods regularly and effectively.

Recommendations

Future research could look at incorporating Bloom's Taxonomy for a lengthier period of time. A researcher could look at the long effect on students' cognitive abilities due to the internalization of Bloom's Taxonomy. Students in this research study showed short term growth; however, they did not have an opportunity to show long-term retention or application of the information presented in the six weeks.

Research findings in this study should influence the researcher, as well as other educators, to incorporate the higher levels of Bloom's Taxonomy on a more frequent basis. Even though long-term results were not shown in this study, the short-term results are very beneficial.

By incorporating Bloom's Taxonomy more often, students do become better problem solvers and critical thinkers, as shown here proving that Bloom's Taxonomy is here to stay and that it influences students' scores on tests and students' confidence in math.

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References

Bell, J., & Fogler, H. (1995). *The investigation and application of virtual reality as an educational tool.* Retrieved August 10, 2005, from http://www.vrupl.evl.uic.edu/vrichel/Papers/aseepap2.pdf

Bloom, B. (1956). *Bloom's taxonomy of measurable verbs.* Verbs that demonstrate Critical Thinking.

Cotton, K. (1988). *Classroom questioning.* Retrieved Oct 14, 2005, from <http://www.learner.org/channel/workshops/socialstudies/pdf/session6/6.Classroom>Questioning.pdf

Dwyer, C. P., Hogan, M. J., & Stewart, I. (2014). An integrated critical thinking framework for the 21st century. *Thinking Skills and Creativity, 12*, 43-52. https://doi.org/10.1016/j.tsc.2013.12.004

Dewey, J. (1859-1952). *Constructivism (learning theory).* https://education.stateuniversity.com

Eison, J. (2006). *Learning to use questions and using questions to learn.* Retrieved January 15, 2006, from <http://tlc.geneseo.edu/?pg=resources/toolbox/wait-time>.

Ernest, P. (1992). *Social constructivism as a philosophy of mathematics: Radical constructivism rehabilitated?* Retrieved from http/www. ex.ac.uk/

Evan, R., & Lappin, G. (1994). Constructing meaningful understanding of mathematics content. In D. Aichele and A. Coxford (Eds.), Professional development for teachers of mathematics (pp. 128-143). Reston, Virginia: NCTM.

Esan, F. (2015). *Cooperative problem-solving strategy and students' learning outcomes in algebraic word problems: A Nigerian case.* doi: 10.20533/iji.1742.4712.2015.0116

Fell, E.V., & Lukianova, N.A. (2015). British universities: International students' alleged lack of critical thinking. *Procedia-Social and Behavioral Sciences, 215*, 2-8. https://doi.org/10.1016/j.sbspro.2015.11.565

Florea, N. M., & Hurjui, E. (2015). Critical thinking in elementary school children. *Procedia-Social and Behavioral Sciences, 180*, 565-572. https://doi.org/10.1016/j.sbspro.2015.02.161

Gegen, S.E. (2003). *The effects of higher-level questioning in a high school mathematics classroom.* Master's thesis, Wichita University.

Haghparast, M., Nasaruddin, F. H., & Abdullah, N. (2014). Cultivating critical thinking through e-learning environment and tools: A review. *Procedia-Social and Behavioral Sciences, 129*, 527-535. https://doi.org/10.1016/j.sbspro.2014.03.710

Huitt, W. (2004). *Bloom et al.'s taxonomy of the cognitive domain.* Educational Psychology Interactive, Retrieved August 12, 2005, from <http://chiron.valdosta.edu/whuitt/col/cogsys/bloom.html>.

Jones, G. (1996). The constructivist leader. In J. Rhoton and P. Bower (Eds.), *Issues in science education* (pp. 140-141). USA: National Science Teachers Association.

Mugenda, O., & Mugenda, A.G. (2003). *Research methods: Quantitative and qualitative approaches.* Nairobi, Kenya: Acts Press, ISBN 9966411070.

McCarthy, P., Sithole, A., McCarthy, P., Cho, J., & Jyan, E. (2016).*Teacher questioning strategies in mathematical classroom discourse: A case study of two grade eight teachers in Tennessee, USA.* Published 2016.

Piaget, J. (1896-1980). *Piaget's constructivism.* Papert's Constructionism: What's the difference?

Piscopo, S. (2019). *Questioning Strategies that invite math participation.* Retrieved March 13.

Poore, S. (2008). *Cooperative learning in relation to problem solving in the mathematics classroom.* Action Research Projects. 44. https://digitalcommons.unl.edu/mathmidactionresearch/44

Shahrill, M. (2013). Review of effective teacher questioning in mathematics classrooms. *International Journal of Humanities and Social Science, 13*(17), 224-231.

Von Glasersfeld, E. (1990). An exposition of constructivism: Why some like it radical. In R.B. Davis, C.A. Maher, and N. Noddings (Eds.), *Constructivist views on the teaching and learning of mathematics* (pp 19-29). Reston, Virginia: National Council of Teachers of Mathematics.

Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes.* Cambridge: HarvardUniversity Press.

Zakaria, E. L. C. C., & M. Y. D. (2010). The effects of cooperative learning on students ' mathematics achievement and attitude towards mathematics Effandi Zakaria, Lu Chung Chin and Md. Yusoff Daud Department of Methodology and Educational Practice, Faculty of Education, University Kebangsa. *Journal of Social Sciences*, *6*(2), 272-275.