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EFFECTS OF GROUP BASED LEARNING APPROACH IN PROBLEM SOLVING FOR OLYMPIAD IN INFORMATICS COMPETITION ON SECONDARY SCHOOL STUDENTS

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ABSTRACT

The need to prepare students for better performance in Olympiad in Informatics competition necessitated this study. The study investigated the strength of group based computational thinking in problem solving. Two research questions guided the study and two null hypotheses were tested at 0.05 level of significance. The study adopted a pre-test post-test quasi-experiment research design. The population of the study consists of 50 students that qualified for the third round of Nigeria Olympiad in Informatics competition, it is an annual competition organized by National Mathematical Centre, Abuja for secondary school students. The instrument used for data collection was computational thinking test assessment. The research questions were answered using mean and standard deviations. Paired-sample t-test was also used to determine whether there were significant changes in terms of their average test scores. The t-value of 2.48, p(t) = 0.017 which is less than 0.05 significance level, there is significant difference between the pre-test and post-test assessments which indicate that group learning help the students develop computational thinking in problem solving. Accordingly, the research results encourage group learning in computational thinking for students. The results demonstrated that integrating computational thinking with the group based approach into educational learning can effectively improve the students' understanding of Olympiad in Informatics. Based on the findings, the researchers recommend that computational thinking should be included in teaching and learning for programming competitions.

Keywords: computational thinking, *group learning, informatics olympiad competition.*

Introduction

Computational thinking include understanding of the concepts and solving problem approaches, Wing (2008) viewed computational thinking as the procedures and the logic rather than programming with the multi steps of abstraction, techniques in computational thinking and the impacts in problem solving. It has been an area of educational research, the development of computational thinking concepts with the theory, knowledge and improvement in

critical thinking. Cuny et al. (2010) stated computational thinking as thought processes used to define problems, analyze and find their respective solutions; the solutions are represented in procedures which can be implemented on information processing systems. The computational thinking is an approach that does not necessarily need programming with computers, but rather is an approach to problem solving that uses algorithms and strategies with the ability to think computationally which is essential to conceptual understanding of the problems. The steps of algorithmic thinking, problem solving and incorporating computational thinking in computer education as well as other science subjects. (Yadav, Zhou, Mayfield, Hambrusch & Korb, 2014).

Voogt et al (2015) argued that computational thinking goes beyond typical human computer interactions in which humans initiate the actions that are then computed by the machine. There is focus on problem solving through algorithmic approaches to problems with view of the different levels of abstraction and representation. In Barr & Stephenson (2011) study showed there was the need to incorporate their knowledge of computational thinking for the educators, logical reasoning in the academic environment, curricular review and policy formulation. There are relationships between computational thinking and science subjects especially in problem solving. The concepts should be integrated in the teaching of computer science.

Nigerian Olympiad in Informatics is an annual competition that secondary schools students participate; the first and second rounds of the competition are conducted in various schools in the thirty six states and the FCT. Students participate to broaden their algorithmic and problem solving skills of problem analysis, design of algorithms, data structure, testing and coding in programming competitions. Nigeria Olympiad in Informatics (NOI) is organized by National Mathematical Centre, Abuja which is an annual competition for secondary school students that tests and prepare students for problem solving in programming, qualified students would represent Nigeria at the International Olympiad in Informatics (IOI). Computational thinking is an important skill in problem solving for students for Olympiad in Informatics competition. The rise of programming competitions lead to principles of assessment of computational thinking used to interpret the abstraction, problem analysis, the steps of problem solving in tasks. Secondary school students has improved on general computer studies knowledge but there are still shortcomings in constructing problem solving strategies for Nigeria Olympiad in Informatics competition. An approach is the teaching and learning of computational thinking in group based educational environment. The group approach would encourage students to share different perspectives, solve more problems than they could on their own. The students learnt the computational thinking modules in the training. There are intuition to evaluate logical patterns, model complex systems and their solution representation. The importance in group learning of computational thinking for programming competitions provide different approaches in problem solving. Currently computational thinking is not

taught as a course in Computer Studies or ICT in secondary schools.

Computational thinking (CT) has been the focus of several studies and reports in years. Wing (2006) presented computational thinking as a set of intellectual and reasoning skills that people relate and learn through problem solving. Computational thinking incorporates critical skills which also include mathematical aspects to problem solving. The design of algorithms contain set of conditional logic and instructions to solve a complex problem in a step-by-step approach, the use of models for implementing the algorithm considered with different test scenarios. Allan et al (2010) contributed to the discussion about computational thinking for the youths with the use of examples from their various projects to describe strategies to engage youths in computational thinking, modeling, simulation and design of system through interacting components. Computational thinking has the prospect to improve students' problem-solving skills and abilities as they begin to think differently. Lu and Fletcher (2009) suggested that students need to learn computational thinking in their schools with emphases on the processes, knowledge in abstraction and representation. Computational thinking is independent of any programming language and should be included not only in computer science study but other science subjects. It comprise of problem solving, systems design, thinking computationally with the use of processes like algorithms, models, heuristics, designs to solve problems and representation of the solutions.

Kalelioğlu et al (2016) explored framework of computational thinking, the concepts to different age groups and inductive qualitative content analysis were conducted on literatures and research papers. The study consist of activities in use of computers or unplugged for problem solving and encouraged teaching of computational thinking in schools. Hemmendinger (2010) argued that the goal of teaching and learning computational thinking is for the students being able to solve the problems, think widely in other subject areas, identify problems and discover new questions. Good et al (2017) study contributed in the theory, the use of computational thinking in secondary schools, examined computational thinking concepts and its applications in the classrooms. The use of qualitative interviews with teachers on how computational thinking are taught and how the curriculum could be better structured. Bundy (2007) suggested problem solving techniques in other disciplines, the ability to think computationally is essential in other disciplines.

Mannix & Neale (2005) explained that members' attitude, behavior had impacts on a team therefore it was necessary to ensure diversity which increase variety of ideas, perspectives and approaches to solve problems. Knowledge sharing would lead to greater creativity and teams' performance. Burke (2011) described the benefits of collaborative learning in group discussions, ability to develop skills like communication within the groups. Monitoring, evaluation of groups in a recursive process with techniques that were beneficial for the students. The group work helped the students involved in

the activities. In National Survey of Student Engagement (2006), grouped students are more involved than working individually, there would be creativity, knowledge sharing and improvement in student learning. Although studies on computational thinking are encouraging, it was important that the training modules provided conceptual knowledge while supporting and encouraging students' learning of computational thinking through the group approach with clear definitions, computational thinking components for problem solving which would improve their computational thinking skills.

Computational Thinking in problem solving

Many studies in computational thinking and problem-solving processes have been done, there can be several ways to solve a problem and the one chosen will depend on the type of the task problem. The training modules comprise of computational thinking concepts of problem identification, abstraction, algorithms for solving tasks in programming competitions. This involves problem identification and formulation; a breakdown process which is the decomposition, the process of pattern matching and recognition; with several processes of abstraction, evaluation and algorithmic thinking. Computational thinking has structured, conceptual, strategic way of thought process and problem solving. Decomposing a problem constitute of manageable steps, related and the whole problem. (Barr & Stephenson, 2011). The decomposition process are designed by modeling and iterating to find solution. Abstraction is a concept of reality used to represent an aspect of a problem so that the students can better understand the problem. The variables in abstraction represent discrete values or intermediate values. It is used to create lower-level abstractions with component parts of the tasks, focus on each part of the problem and solve problems discarding unimportant details. Algorithms are the sequence of steps or processes to solve problems, the steps of an algorithm should be consistent for different tasks and the order of steps to reach the solution. The process of designing algorithms help to build foundation in logical thinking, algorithmic thinking which cut across different disciplines. Algorithm should solve a general, well-specified problem. The Olympiad in Informatics has algorithmic problems by describing the set of cases it must work on and its expected output. This distinction between a problem and an instance of the problem is important, there are different algorithms for solving the problem. The use of group based strategies and heuristics in problem solving; the heuristic process create strategies to solve a problem, conditional logic strategy such as an "if-then-else" construct are also used to solve problems. (Skiena, 2008)

Computational thinking in group learning

Group based learning is an organized training approach that encourages student learning, knowledge acquisition and skills. Groups are structured which enables a hands-on approach of activities that provide students the avenue to examine tasks, learn by discussions and illustrations (Race, 2000). The potential learning benefits of group work are significant, though assigning group tasks

is no guarantee that objectives will be achieved but there is need to plan, supervise and to assess the groups. The size of the groups depend on the number of students, groups of four-five people tend to have diversity, active participation and results. The number of groups created was based on the number of students which was fifty. We created ten groups consisting of five students for each group which increase active participation. The assigned groups encourage overall involvement and interdependence for the students.

1. The identification of the tasks objectives and how to solve them in the groups. The activities help the students to learn in their groups to complete the tasks. Roberson and Franchini (2014) emphasize that for group learning to be effective, students need to appreciate discipline, group work expectations and thought processes in solving problems.

2. Computational thinking involves use of abstraction, logic reasoning and problem solving. The educators explained how to better understand problem statements and representation of computational thinking processes. The students applied concepts, abstraction to develop models and practical sessions to present their solutions. The solutions were analyzed for their efficacy and correctness.

3. The computational techniques and strategies. The students created models in computational designs and solutions which were evaluated for the groups. The students showed proposed solution to a problem, correct errors when it arises and present their solutions for assessment. Innovations occur when people work together or collaboratively can often achieve more than individuals working alone. The grouped students were given number of tasks, the study of problems using test cases. They worked together in solving problems. The tasks were mostly from Olympiad in Informatics competition. By sharing their knowledge and ideas, groups of students can develop a more pronounce outputs than they could as individuals.

4. The students shared information among themselves, with practice of computational thinking modules to solve the problems. The students selected one or two people from their group to speak on their behalf. They also assign different roles to group members so that they are all involved in the process.

5. The grouped students explained their choice of computational methods and designs. The interactions within the groups involved oral, written descriptions of computational analysis, visualizations and graphs. The students had personal responsibility for the success of their groups and their individual skills helped in the group's success on solving tasks.

From the tasks provided during the training, there were application of abstractions, patterns, trends and representations to solve the problem. The tasks were solvable though challenges of understanding the underlying tasks properly but with ideas in the group,

they would not only focus on the task processes but also on the design of the solution. The problems are defined, problem statements understandable, ability to identify patterns, design of new algorithms that solve the given problems. It allow for cases of normal, extreme outcomes for unusual solutions based on improved algorithm. The grouped students developed their skills in problem solving. The students were provided with problems or tasks, the emphasis was on the algorithmic, computational thinking scenarios and the accompanying approaches for the implementation of the tasks. The students improved their knowledge for problem solving, the activities included creating of learning scenarios and illustrations.

For this purpose, the training modules was designed which include the concepts of Computational thinking were taught such as the algorithm, problem identification, abstraction, analysis decomposition; its perspectives and effects for patterns, problems solving, real life scenarios. In the illustrations, the grouped students used representation in tables, graphs and visual presentation and assessment of their solutions.

In their practice sessions were Olympiad in Informatics tasks. The problems included break down of tasks into parts, refinement through explanation and discussions which develop stronger communication skills. For the perspectives, it expanded on analysis of the tasks which involves, to understand the data and identify patterns to solve the problems. The students demonstrated the ability to identify a problem, break it down into manageable steps, work out the important details or patterns and present their solutions. The tasks strengthen their skills. In the time given, there were assessment of their solutions for correctness and robustness. Students share group perspectives, collaborative efforts, solve more complex problems than they could on their own. The learning benefits of group work are numerous that encourage meaningful teamwork that leads to solving problems.

The Training Activities

The innovation for Nigeria Olympiad in Informatics training is to improve the learning of computational thinking by the use of creative thinking, algorithmic design and programming. The training lasted for eight weeks. The student groups received the modules for the training which included lectures on cognitive processes such as critical thinking and problem solving. The training classes include the use of abstractions, create and apply algorithms for any particular problem; evaluate an algorithm on the specifications and criteria used; apply computational thinking methods to problems. The exercises develop creativity by engaging thought process, combine both individual and group efforts to solve problems. The students in their group provided analysis which promoted both computational thinking skills and its application in programming. There were guidelines for the group activities

developed to enable students to learn problem solving skills.

The educators discussed and illustrated the following:

1) The introduction of computational thinking based on the research literatures.
2) The modules of concepts, perspectives, illustrations and practice sessions in computational thinking, how it improves problem solving in programming competitions.
3) The group learning approach with exercises, descriptions of the tasks which benefited students in communication and knowledge sharing to solve problems.
4) The initial and the final assessment of the students on the group learning approach from 50

respondents comprising of 5 students for each group.

In the groups, they work together to identify, analyze problems, provide abstractions, create ideas, apply computational thinking techniques to creatively solve problems and presentation of their solutions. The grouped students were expected to use applicable techniques to develop algorithmic and computational methods. At the end of task activities, the groups showcase their solutions through presentations. The groups work together to identify relevant data and different ways of solving problems. The project tasks were of National Olympiad in Informatics (NOI) and International Olympiad in Informatics (IOI) exercises. The project activities had an overall guiding question and sub-questions that drove the learning objectives. Students' demonstrated creativity, identified previously unnoticed facts and presented in understandable forms with the use of visualization tools like tables and graphs. They also applied problem solving when the tasks has multiple possible outcomes. In the illustrations, it gave the groups opportunity for representation which depicts and organize data in appropriate graphs or images. The grouped students would extract relevant information, similarities and patterns. It showed ways of recognizing patterns in tasks based on previous solutions, the strategies to solve tasks and building on prior experience. The use of models help to better understand concepts, there were presentations of oral and written descriptions of analysis and representations of the solutions.

In IOI 2017 question, a task of spatial orientation in routing an agent through the maze. The goal for the students is to develop algorithms and implement a way out of the maze with series of commands to be executed with the aim to solve the tasks. The practice on the concepts of movement from left or right, up or down and back or forth. The use of abstraction, decomposition condition component of IF part and an action component THEN part. The m × n grid are known and defined, the cells traversed with the random cells blocked. Some of the tasks were on the concepts of binary search, merge sort. Search tasks with the lookup for information like in IOI 2017 the big price question in which binary search, merge sort, their time complexity calculated and takes several comparison checks.

These scenarios given are for the students to better understand the concepts in

computational thinking. The researchers also illustrated data organization concepts like last in–first out, stacks, queues and graphs. The training sessions demonstrated the application of computational thinking in programming competitions. Computational thinking in teaching and learning encourage creativity and problem solving which is important in programming competitions. The grouped student methods on tasks required well thought-out procedures for solving the problem. The training also presented information on how computational thinking concepts could be implemented in other science areas through interactions with different scenarios.

Research Questions

1. What is the effect of group based learning on students' understanding of computational thinking in Informatics competition with regards to the analysis of their pretest and post-test mean scores?

2. Does teaching students' the computational thinking modules have effect on their problem solving skills towards problem solving in Olympiad in Informatics competitions?

Hypotheses

Ho1: There is no significant effect of group based learning on students' understanding of computational thinking in Informatics competition with regards to the analysis of their pretest and post-test mean scores.

Ho2: There is no significant effect of computational thinking modules on problem solving skills towards problem solving in Olympiad in Informatics competitions.

Research Method

The researchers utilized pre-test post-test design for the training to access the students understanding of computational thinking. The groups completed varieties of computational thinking tasks over a period of eight weeks. The pre-test was given during the first week and the posttest in the last week, to evaluate impact of the training on grouped students understanding of computational thinking and their attitude towards Nigeria in Olympiad in Informatics competition. To demonstrate if there is improvement by the students was statistically significant, t-test for paired samples using a 95% confidence level ($\alpha = 0.05$) were used for our statistical decisions. The data analysis include descriptive statistics, mean, standard deviation and paired sample t-test were applied.

Methods of Analysis and Discussion

The study is to determine the effects of group-based learning approach of computational thinking on students that qualified in the third round of Nigeria Olympiad in Informatics. The computational

thinking assessment tests was carried out to answer the research questions and the results demonstrated knowledge gained on computational and programming concepts, the procedure of combining computational thinking concepts, perspectives and practices. Computational thinking Assessment test measure the level of computational thinking concepts using constructs of sequences, loops, functions and iteration. The scores obtained from the pre-test and post-test were analyzed using mean, standard deviation and sample t test. While mean was used to answer the research questions, standard deviation was used to determine the homogeneity of the mean scores, the sample t test was used to test the hypotheses at 0.5 level of significance.

Tables for measures 1 and 2

1. What is the effect of group based learning on students' understanding of computational thinking in Informatics competition with regards to the analysis of their pretest and post-test mean scores?

Table 1: Mean and Standard Deviation for pretest and post-test mean scores

Variables	No	Mean	SD
Pretest	50	35.18	7.86
Posttest	50	36.72	8.32

Table 1 shows paired sample means for pretest of 35.18. The posttest mean score of 36.72. It shows an improved effect of group based learning on students' level of understanding in computational thinking for solving tasks in Olympiad in Informatics competition. It is more representative of the true mean of the participants.

2. Does teaching students' Computational thinking modules have effect on their problem solving skills towards problem solving in Olympiad in Informatics competitions?

The paired sample t-test was applied to determine the difference between levels of students' computational thinking abilities towards problem solving before and after teaching of computational thinking modules with the results in Table 2. The results of the matched group t-test showed that when the students' computational thinking skills before and after the training were examined, there is a significant difference.

Table 2: Paired Sample t-test of the scores with group learning approach

Variables	Mean	SD	S.E Mean	t	df	p
Pretest Posttest	1.54	4.40	.62	2.48	49	.017

The results of the *t*-test for paired data are shown in Table 2 of the paired sample test differences. The mean of the difference was 1.54 with Standard Deviation = 4.40. The data was subjected to paired-samples t-test indicating that the mean of the difference is statistically significantly greater than zero. As t-value is 2.48, p(t) = 0.017 < 0.05, the null hypothesis is rejected therefore there are significant difference between the pre-test and post-test assessments which indicates that group learning improved students computational thinking in problem solving. The training improved the students acquired knowledge of computational thinking for problem solving than before the training program. It showed with t = 2.48, p = .017, that the training improved their marks.

The findings showed that eight-week training of the group-based approach in learning computational thinking positively affected the students' levels for problem solving thinking skills in programming competitions. The evaluation results found that after completing the training exercises, processing skills learned was associated with computational thinking as measured by tasks provided. Overall, these results support the effectiveness of computational thinking through group learning method. In the training, there was a significant improvement in students computational thinking by the group learning approach, there is need for educators to teach computational thinking concepts in the classroom.

Conclusion

Developments in computing and the drive for cognitive thinking have far-reaching implications on the students' academic performance. The group learning approach for students to develop and share ideas to solve tasks improved their problem solving skills. The study showed how the students using the training modules and practical sessions in computational thinking concepts improved their knowledge and better understand ways to solve tasks in Nigeria Olympiad in Informatics competition. Computational thinking modules increase creativity in the classroom, exposed the students to problem solving and how to apply the training program in their academic activities. The use of group work is beneficial and the problem analysis can be applied in another disciplines. Some disciplines and research has shown that it is often better to learn with others in groups.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. These types of training programs should be continual to improve critical thinking among

students, computational thinking in a group based approach can be integrated into teaching and learning for Nigeria Olympiad in Informatics competition, programming competitions and Computer Science.

2. Group based learning approach for students would enable them learn how strategies in problem solving can improve their academic performance in others subjects.
3. Secondary school students should be enlightened on participation for Olympiad in Informatics competition which is an annual competition where the qualified student would participate in International Olympiad in Informatics competition.

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