African Journal of Educational Studies in Mathematics and Sciences Vol. 13, 2017

Effect of multimedia courseware with cooperative learning on senior high school students' proficiency in solving linear equation word problems

E. [1]Adu, D. K. [2]Mereku, [3] C. K. Assuah, & C. A. [4]Okpoti

Abstract

This study investigated the effect of two teaching methods (i.e. multimedia courseware with cooperative learning and cooperative learning) on Senior High School students' proficiency in solving linear equation word problems and their engagement in learning mathematics. A nonequivalent pretest-posttest control group design with three intact classes comprising 124 students (i.e. control group, n_1=45, cooperative learning only group, n_2=40, and multimedia with cooperative learning only group, n_3=39) was used for the study. Pre-test, post-test, and questionnaire were used to collect data. The pre-test and post-test result indicated that the use of multimedia courseware with cooperative learning had positive impact on the students' proficiency in solving linear equation word problems. The result from the post-test on students' proficiency in solving linear equation word problems were found to be statistically significantly different among the groups $F(2,121) = 107.63$, $p < .05$. The means of the experimental groups (cooperative learning only group and multimedia with cooperative learning only group) were higher than that of the control group. Also, the results from the questionnaire on students' self-engagement in learning mathematics indicated a statistically significantly difference between the groups $F(2,105) = 4.903$, $p = .009$. The implication of the study is that technology use and cooperative learning in mathematics classroom really improve students' performance in solving linear equation word problems.

Keywords multimedia courseware; cooperative learning; proficiency in solving linear equation word problems; engagement in learning mathematics

Introduction

Adequate understanding of mathematics and its subsequent applications is important in many technically oriented work sectors. This is because mathematics forms the basis of analytical and logical problem solving that is often necessary in many field of work. In Ghanaian Senior High School (SHS), there are about eight content domains of mathematics that are taught to the students as core mathematics. Algebra is one of these content domains and is taught to students at the Junior High School (JHS) before reaching SHS. The knowledge of algebra is so important that its utility is needed by all. In school, algebra is needed as a foundation for further studies in other branches of mathematics. Students without good knowledge in algebra would be seriously challenged when

[1]ElizabethAdu is a reader at the Department of Mathematics Education, University of Education, Winneba, Winneba, Ghana. Email: elizabethadu21@yahoo.com.
[2]Dr. Damian Kofi Mereku is an Associate Professor in the Department of Mathematics Education, University of Education, Winneba, Winneba, Ghana.
[3]Dr. Charles Assuah is a senior lecturer in the Department of Mathematics Education, University of Education, Winneba, Winneba, Ghana.
[4]Dr. Chriss A. Okpoti is also an Associate Professor in the Department of Mathematics Education, University of Education, Winneba ,Winneba, Ghana.

studying calculus, geometry, statistics and probability. In the domain of algebra there are many concepts that are taught to students in our Ghanaian classroom. Linear equation word problems (LEWPs), is a topic that Ghanaian Senior High School students learn at the Junior High School level. Objective 2.4.1 of the Junior High School (JHS) syllabus, requires that students are taught how to solve linear equations using three methods – graphs, flag diagrams and balancing methods – as well as translate linear equations word problems into standard linear equations and solve them (Ministry of Education, 2012). Even though this concept is taught at the JHS many students at the SHS cannot solve simple mechanical linear equations, let alone the word problem. Project reports in the Department of Mathematics Education, University of Education, Winneba, has also shown similar results (Adu, 2013; Issaku, 2012). Research by Adu, Assuah and Asiedu-Addo (2015) have also shown that students make several errors in solving LEWPs.

Literature Review

In the last eight years, the West Africa Senior School Certificate Examination (WASSCE) mathematics chief examiner's reports have indicated that average Senior High School students who sat for the WASSCE did not performed well (WAEC, 2008, 2011). The reports further stated that for candidates who sat for the exam, majority of them did not tackle problems involving linear equation word problems and that the few who made an attempt did not arrived at the correct answer (WAEC, 2008, 2011). The studies of Norasiah (2002) and Rahim (1997) have indicated that students' failure in LEWPs may be caused by lack of emphasis by teachers on understanding the language of mathematics and the skills needed by the students. This may also result from the failure or inability of teachers to teach them with the right method and also ensure that every student masters the basic skills before moving to new topics.

In light of this, new approach in teaching method need to be identified to ensure these students acquire the understanding of mathematics and LEWPs. Some educators suggest technology to supplement learning while others promote team learning in learning mathematics (Waycaster 2001; Clark, 1998; Idris, 1999). Teamwork is always at the heart of great achievement. If students are teamed to work in classrooms it will possibly stimulate students' interest which will eventually lead to great achievement. The introduction of teamwork brings on board the engagement of students in class. If teachers exempt from the use of teacher-centered approach of teaching and rely on student-centered it will lead to students' involvement and participation in teaching and learning. Maxwell (2008) suggested teamwork not only in learning but encompassing many other endeavors since teamwork divides the effort and multiplies the effect. The use of collaborative learning method (teamwork) has also been tested to improve mathematics learning (Felder & Brent, 2004). Other research has shown that team-working is favoured by many students and that students like to learn with team mates of similar interests (Atkinson, 1999; Dillenbourg, 1999; Morell, Buxeda, Orenga, & Sanchez, 2001).

Also, there is evidence from research that ICT can help students to learn and teachers to teach effectively and that technology plays essential role in the teaching and learning of mathematics as it influences the mathematics that is taught and enhances students' learning (NTCM, 2000). However there is not a simple message in such evidence that ICT will make a difference simply by being used. Findings suggest that although ICT can improve learning there are a number of issues that need to be considered if such technology is going to make a difference. In addition if ICT is targeted at specific areas of learning, with a clear rationale for its use from a broad research base (about ICT, about pedagogy and about professional development) it can have a positive effect on students' achievement. In another study by (Waycaster, 2001; Mays, 2001; Salwa, 2003), they discovered significant differences in classroom instruction by the technology used. Mohd and Maizam's (2010) study also showed that the use of interactive courseware and cooperative learning among students improved their algebraic learning.

Teachers have been required to implement problem solving into the teaching and learning of mathematics for some time. The Ghanaian mathematics syllabus stated clearly that the primary aim of the mathematical curriculum is to enable pupils to develop their ability in mathematical problem solving (Ministry of Education, 2007, 2012). Nevertheless, recent evidence provided in national assessment reports generally suggest basic school students cannot solve problems. For instance, the Ghanaian students who participated in the 2003 Trends in International Mathematics and Science Study (TIMSS) performed poorly because of their weak problem solving abilities and their inability to comprehend the language of test (Anamuah-Mensah & Mereku, 2005). The poor problem solving abilities and weak performance in LEWPs observed in Ghanaian students are due largely to teachers over reliance of using one method of teaching, weak teacher content knowledge, teachers' use of ineffective mathematics teaching practices, and inadequate supply of mathematics teaching/learning materials (MOE, 2014b).

In response to this concern the aim of this study is to determine the effect of multimedia supported courseware with cooperative learning (MC-CL) on Senior High school students' proficiency in solving linear equation word problems and their engagement in learning mathematics. The engagement in this study complements students' involvement, participation and presentation in mathematics classroom. This study looked at one concept of algebra which is Linear Equation Word Problems (LEWPs) and the objective of this paper is to understand whether multimedia and cooperative learning can facilitate LEWPs in a context where students exhibit shortcomings in this type of mathematical tasks, and answers the following crucial questions: (a) What is the effect of multimedia supported courseware with cooperative learning on students' proficiency in solving linear equation word problem? (b) What is the effect of multimedia courseware with cooperative learning on students' engagement in learning mathematics?

Method

Design

A nonequivalent pretest-posttest control group design was used for the study. The main independent variable observed was the teaching method (Multimedia Courseware with Cooperative Learning (MC), Cooperative Learning (CL), and Traditional method).

Participants

Three intact-classes of 124 Senior High School students were purposively sampled from two programmes (Home-Economics and General Arts) in a SHS in the Agona Municipality. The three intact classes were labelled: Cooperative learning only group, Multimedia courseware with cooperative learning group, and Control group.

Procedure

Permission letter was sent to the headmaster of the above SHS to seek his approval and consent to allow teachers of the various classes, the ICT department and students to participate in the study. The treatment (1) MC was developed in English by merging Microsoft PowerPoint slides with audio to produce a video using the Camtasia software. The animation and other features were very clear and understandable to students after the courseware had been thoroughly vetted by experts in the field. The materials used were computers, flash drives, CD, papers, textbooks, pens and calculators. The content of the courseware was limited to finding solutions to given equations in one variable (first and second lessons) and word problems based on them (third and fourth lessons). Examples of such tasks are: Find the solution set: $3(x + 2) = (x - 2)$, and, the sum of two consecutive odd numbers is 57, find the numbers. These tasks were set from the core mathematics syllabus, students answered these questions in the ICT Lab. The developed courseware was put on a CD and was also put on the computers. Day students were given copies of the CD to watch in their various homes before implementing the intervention. Papers and pens were provided to the students to work alongside with their calculators. The video was put into sections to allow students time to pause to work examples on their own as they worked in groups of 2 and 3 to a computer. The teacher went round to assist the students. Exercises and homework were provided at the end of each topic (e.g. Kwesi, Ama and Adwoa shared GH¢720.00. Ama received twice as much as Adwoa and Kwesi received three times as much as Ama. How much did each receive**?).** Students in groups presented their answers to the whole class for students and teacher to make their inputs and corrections and corrections.

The CL group (treatment 2) consisted of students of mixed-ability group of 4 or 5 who worked together to maximize every student's learning potential. These students were put into groups after they have been introduced to the topic. Tasks were given to these groups to brainstorm, solve and present their answers to the class. The control group (no treatment) received their lesson through the traditional method of teaching. The CL and the control groups took their lesson in the normal classroom. Pens, papers and textbooks were provided, after which exercise and homework were given. The study took a period of four weeks in the third term of the academic year. In the first week, a pre –test (first achievement test) and a questionnaire were administered personally to the students in each of the three groups. This test helped the teacher to describe the difficulties and errors the students made in solving linear equation word problems and to compare the various groups prior to the study. The means scores of the groups were calculated and the group with the highest mean was assigned the control group and the others assigned the experimental groups. In the second and third weeks, the concept of linear equation i.e. finding the solution set of given equations in one variable, were taught to the three groups (CL, both MC-CL and control) in two lessons. Each lesson took three periods for 40 minutes each in conformity with what the SHS time table describes. In addition, the third week lessons focusing on solving word problems in linear equation in one variable were also taught to all groups in two lessons, using lesson notes designed for each group. The post-test was administered to all groups in the fourth week (after intervention).

Instrumentation

Achievement Tests (Pre-Test and Post-Test)

The pre and post-test consisted of 10 linear equation word problems consisting of age problems, consecutive integer problems, digit problems, geometry word problems and fraction and proportion problems. Students from each group were given 40 minutes to complete each test. A collective marking scheme for scoring the test was drawn for both the pre and post-test.

Questionnaire

Nineteen (19) closed-ended questions consisting of both positive and negative worded items, and assessing students' engagement (participation and involvement) in teaching and learning mathematics were used. The items (e.g. We are given the opportunity to present our work to the class, We work in groups in class and Teacher lectures throughout the lesson) required students in both groups to choose from the options provided on a 3-point Likert scale (1 = never, 2 = Sometimes; = and 3 = Often). The questionnaire was administered before and after the treatment. The data were organized and analyzed using descriptive and inferential statistics.

Validity and Reliability of Instruments

The Content validity of MC, test and questionnaire items were vetted and processed by the senior lecturers of department of mathematics education, University of Education, Winneba. Also to determine the reliability of the instrument a pilot study was conducted. The teacher piloted the instrument on a small sample of 20 form 1 SHS students that is comparable to the students in the study. The reliability (Cronbach's Alpha value) for the instrument was 0.783, indicating a high degree of reliability of the items in the questionnaire.

Results

In the pre-test, 60% of the students attempted all the items and out of this percentage, only 2% arrived at the correct answer. But in the post-test an overwhelming majority (90%) attempted all the items and 40% arrived at the correct answer. On all the post-test items the students did far better on each item than in the pre-test. The result of the post-test revealed after using the teaching methods that, majority (72%) of students could read, understand, transform the statement to algebraic form and solve the LEWPs. These possibly made them to score higher marks during the post-test leading to their improved performance. Table 1 and Figure 2 show the percentages, descriptive statistics and cumulative frequency curve of students' scores on the pre and post-tests.

Table 1: Descriptive statistics of students' scores in the pre-test and post-test

	N	Min.	Max.	Mean	Std. Dev.	Mode	Median
Pre-test percent score	124	0	73	8	18.55	1	4
Post-test percent score	124	1	99	67	26.7	93	71

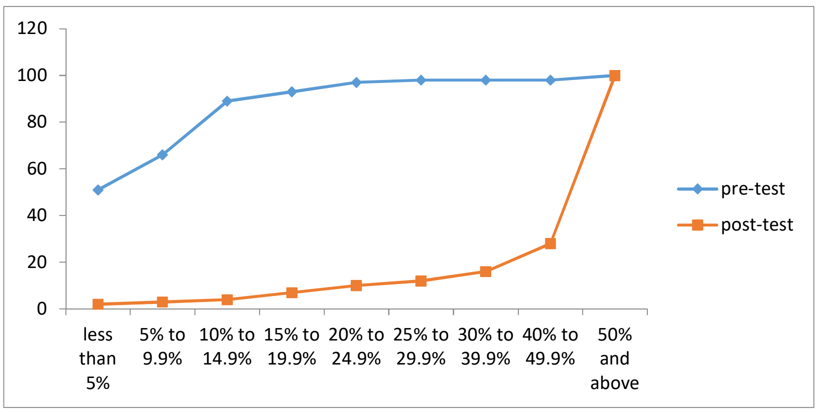

Figure 1 Cumulative percentage frequency curve of students' pre and post-test

From Table 1, the pre-test highest score on all the ten questions was 73% and the least score was 0%, whereas the post-test highest and least scores were 99% and 1% respectively. Even though the maximum score on the pre-test is 73% it was only one students who scored this mark. The mode and the median scores in the post-test were 93% and 71% respectively, as compared to 1% and 4% respectively in the pre-test making the distribution of the post-test scores moderately negatively skewed (skewness = -0.6), with only 28% of the students scoring less than 50% (Figure 1), and that of the pre-test scores highly positively skewed (skewness = + 3.9) with nearly 99% of the students scoring less than 50% of the total scores. Table 2 shows the descriptive statistics on students' gain score in the three groups (i.e. MC-CL only group, CL only group, and Control only group) on the post-test. The results indicated that Group 1 (MC-CL group) had the highest mean whereas the Group 3 (Control group) had the least mean. Table 3 reports the One-way Anova test comparing the means of the three groups. The results indicated a statistically significant difference among the means ($p < 0.01$).

Table 2: Descriptive statistics of students gain score by the treatment groups

	N	Mean	Std. Dev.	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Min	Max
Both multimedia and cooperative group	39	57.05	9.63	1.54	53.92	60.17	39.00	69.00
Cooperative learning group	45	56.65	11.59	1.73	53.16	60.13	29.00	69.00
Control group	40	24.98	12.43	1.97	20.99	28.95	1.00	47.00
Total	124	46.56	18.69	1.678	43.23	49.88	1.00	69.00

Table 3: Results of the one-way analysis of variance (ANOVA) comparing the means of each group

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Between groups	27505.42	2	13752.71	107.63	.000
Within groups	15461.18	121	127.78		
Total	42966.61	123			

In Table 3, the results indicated a statistically significantly difference among the groups ($F\ (2,121) = 107.63$, $p < .05$). Post-hoc multiple comparison (using Tukey's test), indicated that the mean of Group 1 ($M = 57.05$, $SD = 9.63$) was highly statistically significantly different from Group 3 ($M = 24.98$, $SD = 12.43$, $P < .05$) and mean of Group 2 ($M = 56.65$, $SD = 11.59$) was also highly statistically significantly different from Group 3 ($M = 24.98$, $SD = 12.43$, $P < .05$). Results of the effect of the two teaching approaches on the students' engagement in learning mathematics were examined by analyzing the scores obtained on the questionnaire by the students before and after the treatment period to rate how often they were involved in teaching activities that ensured engagement in mathematics lessons. The comparison of the pre and post questionnaire responses revealed that students in the experimental groups were fully involved in the mathematics lesson. Some items that involved students' participation and technology use in class were rated highly as compared to before the experiment. The students' mean rating of their involvement in the engagement of teaching activities were further analyzed using One-way Anova test to determine whether or not there were differences between the groups in their mean rating of their involvement in the engagement teaching activities as a result of the experiment.

Table 5 reports the One-way ANOVA test. The results indicated that there was statistically significantly difference among the means ($p < 0.05$). A Post hoc multiple comparison test further showed that was carried out to compare the means using the Tukey's test. Table 4 shows the descriptive statistics on groups responses (i.e. MC-CL group, CL only group, and control group) on the post questionnaire.

Table 4: Descriptive statistics of students' responses from the questionnaire

	N	Mean	Std. Dev.	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Min	Max
Both multimedia and Cooperative	34	2.29	0.27	0.05	2.20	2.38	1.68	2.79
Cooperative learning group	44	2.39	0.23	0.03	2.32	2.46	1.74	2.89
Control group	30	2.17	0.41	0.08	2.02	2.32	1.00	3.00
Total	108	2.30	0.31	0.03	2.24	2.36	1.00	3.00

Table 5 Results of the one-way analysis of variance (ANOVA) comparing each group's mean rating of engagement

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square Error	F	Sig
Between Groups	.886	2	.443	4.903	.009
Within Groups	9.482	105	.090		
Total	10.367	107			

The results in Table 5 indicated a statistically significantly difference between the groups $F(2,105) = 4.903$, $p < .01$. The post-hoc multiple comparison test revealed that the mean of Group 2 ($M = 2.39$, $SD = 0.23$) was statistically significantly different from Group 3 ($M = 2.17$, $SD = 0.41$, $P < .05$). However there was no statistically difference between Group 2 ($M = 2.39$, $SD = 0.23$) and Group 1 ($M = 2.29$, $SD = 0.27$, $P > .05$).

Discussion

An observation worth mentioning is that the teaching methods led to an improvement in the proficiency of the experimental groups in solving LEWPs. This improvement is indicative of the fact that teaching with technology comes with several advantages. It enables students to explore and experience real-case algebraic examples with animations. These results are consistent with Morell et al.'s (2001) study which showed that technology improves learning when students work as a team to function actively in the classroom. The results also demonstrate that learning outcomes resulting from using technology supported collaborative learning leads to more students' interactions as compared to the traditional method. Learning with technology also produces superior problem solving performance when compared to the collaborative learning (CL) and the control group (Mohd et al., 2010). This study has clearly demonstrated that the MC-CL group benefited because of the contents of the design involving adequate practice of mathematical facts and good animations which helped in simplifying students' understanding in doing the LEWPs solving. Students' engagement for the CL and MC-CL groups were equal. Technology use did not enhance the students' engagement, enthusiasm and interest. However, students' engagement at the control group was at its lowest ebb due to lack of cooperative learning and technology use. The results showed that the students' preparedness, participation and involvement in class led to improvement in their performance (Mohd et al. ,2010) Also, the interactions the teacher had with the students revealed that the students really love to learn in groups and share ideas with colleagues of different abilities as well as learning mathematics with technology.

Conclusion and Recommendations

The study revealed that the use of multimedia courseware with cooperative learning can positively influence students' learning of linear equation word problems. Students can solve LEWPs through technology with cooperative learning as they complement the use of technology because they had not had the opportunity to use computer laboratory since they came to the school. Students learn to relate to their peers and other learners as they work together in groups. They also benefited from structured interactions with others as their attitude towards making of presentations and asking questions in class was boosted. During the small-group interactions, they find many opportunities to reflect upon and reply to the diverse responses fellow students bring to the questions raised. In addition, it was revealed that students were highly engaged in the use of technology with cooperative learning in teaching and learning of LEWPs. The closed-ended questions indicated that students have a positive perception about the teaching methods and usefulness of technology with cooperative learning and easy use in teaching and learning of LEWPs. The study therefore recommends that teachers should take time to engage students in team work and language work (i.e. reading and comprehension activities during mathematics lessons). Again, teachers should be supported to develop multimedia courseware and integrate it effectively in their teaching. It is therefore suggested that the study should be replicated in many more schools to obtain the general picture of how multimedia courseware with cooperative learning can improve students' learning of linear equations word problems in Ghana. It is also suggested that this study could be replicated for pre-service teachers in other subject areas in universities and other teacher training institutions. This would provide a basis for more generalization of conclusions to be arrived at about the effect of multimedia courseware with cooperative learning use in teaching and learning.

References

Adu, E. (2013). Swedru School of Business Students' difficulties in solving linear equation word problems. Unpublished BSc Ed Thesis, University of Education, Winneba, Mathematics Department, Winneba.

Adu, E., Assuah, C. K., & Asiedu-Addo, S. (2015). Students' Errors in Solving Linear Equation Word Problems: Case Study of Ghanaian Senior High School. African Journal of Educational Studies in Mathematics and Sciences, 11, 17-30.

Anamuah-Mensah, J., & Mereku, D. K. (2005). Ghanaian JSS2 students' abysmal mathematics achievement. Journal for Science and Mathematics, 73-82.

Atkinson, S. (1999). Key Factors Influencing Pupil Motivation in Design and Technology. Journal of Technology Education, 10 (2), 4-26.

Clark, W. M. (1998). Using Multimedia and Cooperative Learning in and out of class. Worcester: Worcester Polytechnic Institute.

Dillenbourg, P. (1999). What Do You Mean by Collaborative Learning? In D. (Eds), Collaborative –learning: Cognitive and Computational Approaches (pp. 1-19).

Felder, R. M., & Brent. (2004). Notes on Co-Operative Learning. Skudai: UTM.

Idris, N. (1999). Linguistic Aspects of Mathematical Education: How precise do teachers need to be? Proceeding of the 4th Annual Conference of the Department of Science and Mathematics Education: Cultural and Language Aspects of Science, Mathematics and Technical Education (pp. 281-288). Brunei Darussalam: Universiti Brunei Darussalam.

Issaku, I. F. (2012). Using modeling technique to help students overcome their difficulties in word problems on linear equations in Tamale Business Senior High School. Unpublished MEd Thesis, University of Education, Winneba, Department of Mathematics Education,

Maxwell, J. C. (2008). Teamwork 101 – What Every Leader Needs To Know. Nashville, Tennessee: Thomas Nelson.

Mays, H. (2001). An Intelligent Diagnostic System for Algebra Based in a Taxonomy of Errors and a Computational Model of Mathematical Problem Solving. Australia: Unpublished Ph.D Thesis, University of Ballarat.

Ministry of Education. (2007). National Syllabus for Junior High School Mathematics. Accra: Ministry of education.

Ministry of Education. (2012). National Syllabus for Junior High School Mathematics. Accra: Ministry of Education.

Ministry of Education. (2010). Teaching Syllabus for Core mathematics (Senior High School 1-3). Accra: Ministry of Education.

Mohd, S. k., & Maizam, A. (2010). Effect of collaborative computer aided learning on problem solving skills in algebra among polytechnic students. Malaysia: Universiti Tun Hussein Onn.

Morell, L; Buxeda, R; Orenga, M; Sanchez, A. (2001). After so much effort: Is faculty using cooperative learning in the classroom? Journal of Engineering Education, 357-362.

NCTM. (2000). Curiculum and Evaluation Standards for School Mathematics. Reston. V A: National Council of Teachers of Mathematics.

Norasiah, A. (2002). Diagnosis jenis kesilapan dalam hierarki Pembelajaran Serentak. [Error type diagnin learning simultaneous equation]. Master of Education Research Project. Malaysia: Universiti Kebangsaan .

Rahim, M. N. (1997). Problem solving skills among Lower Secondary School students, Master of Education Research Project. Malaysia: Universiti Kebangsaan.

Salwa, A. B. (2003). Pembinaan dan Penilaian perisian pembelajaran pecahan berasaskan anilisis kesilapan. Malaysia: Ph.D Thesis, Universiti Teknologi.

Waycaster, P. (2001). A Study of Success in Developmental Mathematics Classes. Inquiry, 6 (1): Virginia Community College System.

West Africa Examination Council. (2008). West Africa Senior School Certificate Examination, Chief Examiners Report. Accra: West Africa Examination Council.

West Africa Examination Council. (2011). West Africa Senior School Certificate Examination, Chief Examiners' Report. Accra: West African Examination Council.