

The Effect of Think-pair-share Learning on Junior High School Students' Achievement in Algebraic Expressions: Pre-test-Post-test Non-equivalent Control Group Design

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Authors' contributions

This work was carried out in collaboration among all authors. Author CKA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors GKM and LO managed the analyses of the study. Author LO managed the literature searches. All authors read and approved the final manuscript.

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Abstract

This study explores the effect of think-pair-share learning on junior high school students' achievement in algebraic expressions. The study used the pre-test-post-test non-equivalent control group design. The participants were selected from two intact classes (already-formed groups) and received either an intervention (the treatment group) or not an intervention (the control group). The control group received the conventional learning method often used in the classroom. The participants consisted of hundred (100) third year junior high school students of equal mathematics ability (control group = 54 students; experimental group = 46 students) from a junior high school in the central region of Ghana. For the pre-test and post-test scores, the Shapiro-Wilk had a p -value greater than .05 ($p > .05$) for each statistic, indicating that both the pre-test and post-test scores were normally distributed, before and after the intervention. The results of the independent samples t -test before the intervention, indicated a non-statistically significant difference between the experimental and control pre-test scores ($t = -.48$, $p > .05$, $C. I = [-1.78, 1.08]$). A one-way ANOVA after the intervention, indicated that the effect of the method of instruction was significant for student scores, $F(1, 98) = 353.98$, $p < .05$. Also, the paired-sample t -test for the pre-test and post-test scores indicated the students' post-test scores were statistically higher than their pre-test scores ($t(98) = -8.44$, $p < .05$). Further, the results of the independent samples t -test for the post-test also indicated statistically significant differences between

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the experimental and control post-test scores ($t = -22.68, p < .05, C. I = [-24.29, -20.40]$). The implications of this study are that, through think-pair-share learning, students gain leadership and decision-making skills, enhance their communication skills, develop confidence in their problem-solving abilities, nurture positive attitudes toward their colleagues and take personal responsibility. The study concludes that the think-pair-share learning has a positive effect on junior high students' achievement in algebraic expressions.

Keywords: Algebraic expressions; the pre-test-post-test non-equivalent control group design; intervention; think-pair-share learning; intact classes.

1 Introduction

Mathematics teachers often face many challenges in choosing the appropriate and effective instructional method to improve student mathematics achievement. Sometimes, a particular instructional method alone may not be enough to improve student mathematics achievement, a combination of some of these instructional methods and their usage in the classroom could render them very beneficial to enhance student mathematics learning and achievement. These innovative instructional methods and techniques should be effectively developed to ensure that students become successful learners. Teachers must, therefore, use effective instructional methods for students to attain high mathematics achievement [1]. These instructional methods provide a systematic process and a framework for teachers to plan, develop, and adapt mathematics instruction [2]. "Aside from these instructional methods that could improve student mathematics learning, demographic, social, economic, and educational factors affect student mathematics achievement" [3,4,5]. Other factors such as gender, family structure, parents' educational level, socio-economic status, parent and student attitudes toward school, and parent involvement [5,6], are known to improve student mathematics achievement.

2 Literature Review

Students' educational success depends strongly on their parents' social-economic [6]. A student's parental socioeconomic status (SES) explains a lot of the variation in achievement among students [7]. [8] contend that students whose parents are socially, educationally, and economically advantaged, always have high achievement levels. Teachers' training background and quality professional development improve student achievement [9]. Further, the quality of teaching and learning, which enhances academic achievement is dependent on teaching and learning materials. A strong relationship exists between the use of recommended textbooks and academic achievement [10].

Students' levels of engagement and beliefs about their competence and expectations, successfully promote or interfere with their ability to succeed academically [11]. Student engagement predicts their academic achievement [12-14]. Therefore, the relationship between student engagement and academic achievement has been studied widely [15,16]. There is a correlation between cognitive engagement and student achievement [17]. Many studies have indicated that student learning strategies about cognitive engagement are related to achievement [18]. There is also a correlation between behavioural engagement and academic achievement [19,20]. For example, diligence, which pertains to behavioural engagement, affects academic achievement [21]. Diligent students always improve their academic achievement because they do their assignments and are attentive in class [22]. Cognitive engagement correlates more strongly with achievement than behavioural and affective engagement [22]. Student affective engagement significantly correlates with academic achievement [23]. Thus, students who interact well with their teachers obtain better results than students who do not [24]. Additionally, students' interest in mathematics enables them to obtain high achievement in mathematics.

Research findings indicate that teachers' mathematics knowledge and beliefs are linked to their instructional choices [25,26,27,28,29,30]. These teachers need to be experts in their fields to apply their philosophy in teaching. They need adequate knowledge to prepare their students for challenging work in school [31]. Aside from the knowledge they need of a particular subject matter, they also need to have good pedagogical knowledge [32]. Their knowledge and skills related to these areas are linked closely to student thinking, understanding, and learning of mathematics. Students' mathematics achievement improves if teachers are knowledgeable in the subject they teach [33,34]. In spite of this content knowledge, teachers should be

competent in the pedagogical content knowledge to enable them teach their students. The students, in this context, had a lot of challenges in understanding algebraic expression, having been exposed to the conventional teaching method. Hence, grounded on data from previous research, the following research question was set: Are there statistically significant differences in scores between the post-test and pre-test in students' achievement in algebraic expressions after using the think-pair-share learning, as an intervention?

3 Materials and Methods

3.1 Design

The study used the pre-test-post-test non-equivalent control group design. For this design, the participants were selected from two intact classes (already-formed groups) and received either an intervention (the treatment group) or not an intervention (the control group). The outcome of interest was measured twice, once before the treatment group received the intervention, the pre-test, and once after the post-test. The objective was to measure the effect of the intervention, by using the think-pair-share model in teaching algebraic expressions. This design had three major characteristics: The participants were not randomly assigned to either the treatment or the control group, and both groups were exposed to the same conditions except for the intervention: The treatment group received the intervention, whereas the control group received the conventional method often used in class. The outcome was measured simultaneously for both groups at two points in time-the pre-test and the post-test. The pre-test-post-test non-equivalent control group design is illustrated in Fig. 1.

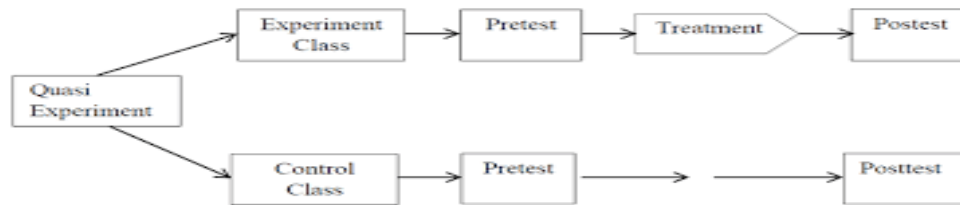


Fig. 1. The pre-test-post-test non-equivalent control group design

3.2 Participants

The participants were one hundred (100) third year junior high school students of equal ability in mathematics (control group = 54 students; experimental group = 46 students) from a junior high school in the central region of Ghana. There were one hundred and sixty (160) form three students in the school. The average age of the participants was fifteen years and two months.

3.3 Intervention

“Think-pair-share is a form of cooperative learning, where students work together in pairs to achieve a common objective. With this approach, a teacher poses a question during a lecture, asks students to think about the topic individually, and then has them discuss their conclusions in pairs. The use of think-pair-share learning results in increased participation, improved retention of information, and higher levels of student confidence” [35].” Most people know from experience that a powerful way to learn the material at a deep level is to teach it to others” [36].

“When pairs of students work together to solve mathematical problems, they represent the most effective form of interaction” [37]. “When students work in pairs, one person listens while the other partner discusses the question under investigation. Both are developing valuable problem-solving skills by formulating their ideas, discussing them, receiving immediate feedback, and responding to questions and comments from their partner” [37]. “During learning, students may or may not be involved by listening to the lecturer or taking notes” [38]. This practice falls within the larger domain of cooperative learning where students work together in small groups to achieve learning goals [39]. [39] emphasise five attributes of think-pair-share: a common task or

learning opportunity suitable for group work, small-group learning, cooperative behaviour, interdependence, and, individual accountability and responsibility.

The think-pair-share learning provides many advantages to teachers and students. Many of these advantages arise from the intrinsic motivational strengths of think-pair-share learning and the extent to which it fosters student interest, behavioural and attitudinal change, and opportunities for success. Cooperative learning, which includes think-share-pair learning, is an umbrella term for a variety of educational approaches involving a joint intellectual effort by students and lecturers together. Usually, students work in groups of two or more, mutually searching for understanding, solutions, or meanings in mathematics or creating a product. In this study, the lecturer met the students and advised them to participate actively in the learning process. Four important principles of active learning were demonstrated in the lecturer-student interactions. The students (1) constructed their learning (2) built new learning on their prior knowledge (3) enhanced learning through social interaction with their peers, and (4) developed learning by solving authentic tasks [40].

3.4 Pre-test and post-test

The pre-test consisted of twenty (20) questions covering the entire algebraic expressions syllabus. These questions were administered to the students to ascertain their achievement in algebraic expressions before the intervention. Similarly, the post-test contained twenty (20) questions which were not the same as those in the pre-test. Some variations were made in the questions; however, the focus was not much different from the pre-test. The post-test was administered to the students after the intervention had taken place. The intervention took five hours to complete.

4 Results

Table 1. Tests of Normality for the Pre-test and Post-test

	Group	Shapiro-Wilk		
		Statistic	df	Sig.
Pre-test	Control	.97	54	.12
	Experimental	.96	46	.21
Post-test	Control	.98	54	.14
	Experimental	.95	46	.23

Table 1 shows the tests of normality for the pre-test and post-test scores. For the pre-test and post-test scores, the Shapiro-Wilk had a p-value greater than .05 ($p > .05$) for each statistic, indicating that both the pre-test and post-test scores were normally distributed. Table 2 shows the independent samples t-test for the pre-test scores.

Table 2. Independent samples t-test for the pre-test scores

		Levene's test for equality of variances		t-test for equality of means				95% C.I.		
		F	Sig.	t	df	Sig. (2 tailed)	Mean difference	Std. difference	Lower	Upper
Pre-test	Equal variances assumed	1.11	.30	-.20	98	.84	-.14	.71	-1.55	1.27
	Equal variances not assumed			-.20	91.40	.85	-.14	.72	-1.56	1.28

Table 2 shows the independent samples t-test for the pre-test scores. Levene's test for equality of variances shows that the equal variance assumption is upheld ($F= 1.11, p > .05$). The results of the independent samples t-test indicated non-statistically significant differences between the experimental and control pre-test scores (t

(98) = -.20, $p > .05$, $C. I = [-1.55, 1.27]$). Table 3 shows the ANOVA tests of between-subjects effects with their difference as the dependent variable.

Table 3. ANOVA table of tests of between-subjects effects with their difference as the dependent variable

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Sig.
Group	12232.02	1	12232.02	353.98	.000
Error	3386.49	98	34.56		
Total	15618.51	99			

Table 3 shows the tests of between-subjects effects between the experimental and control groups. A one-way ANOVA indicated that the effect of the think-pair-share learning was significant for student scores, $F(1, 98) = 353.98$, $p < .05$. The group statistics indicated that the experimental group ($M = 74.61$, $SD = 5.73$) achieved better than the control group ($M = 52.28$, $SD = 3.71$). Table 4 indicates the paired-sample t-test for the pre-test and post-test scores

Table 4. Paired samples t-test for the pre-test and post-test scores

	95% C.I.				t	df	Sig. (1-tailed)	
	Mean	Std Deviation	Std. Error Mean	Lower				Upper
Pre-test- Post-test	-10.93	12.56	1.27	-13.42	-8.44	-8.70	99	.000

Table 4 shows the paired-sample t-test for the pre-test and post-test scores. The results indicated that the students' post-test scores were statistically higher than their pre-test scores ($t(99) = -8.70$, $p < .05$), this follows from the difference between the post-test and pre-test means of -10.93. Table 5 shows the independent samples t-test for the post-test scores.

Table 5. Independent samples t-test for the post-test scores

		Levene's test for equality of variances		t-test for equality of means					95% C.I.	
		F	Sig.	t	df	Sig. (2 tailed)	Mean difference	Std. difference	Lower	Upper
Post-test	Equal variances assumed	6.47	.01	-23.44	98	.00	-22.33	.95	-24.22	-20.44
	Equal variances not assumed			-22.68	74.80	.00	-22.33	.99	-24.29	-20.40

Table 5 shows the independent samples t-test for the post-test scores. Levene's test for equality of variances shows that the equal variance assumption is violated ($t(98) = -23.44$, $p < .05$). However, the independent samples t-test is robust to departure from normality and violation of the equality of variances assumption, hence equal variances is not assumed. The results of the independent samples t-test along this row, indicated statistically significant differences between the experimental and control post-test scores ($t = -22.68$, $p < .05$, $C. I = [-24.29, -20.40]$). Fig. 2 shows the estimated marginal means of the difference between the post-test and pre-test scores.

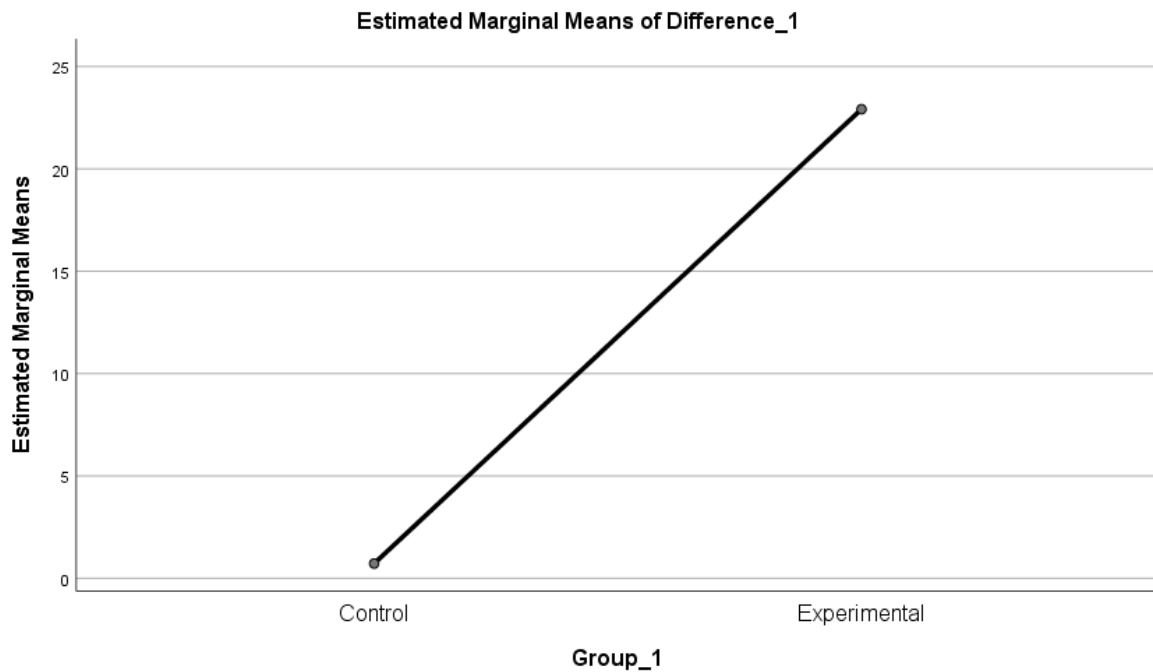


Fig. 2. Estimated marginal means of the difference between the post-test and pre-test scores

Fig. 2 shows the estimated marginal means of the difference between the post-test and pre-test scores. The figure indicated that the estimated marginal mean for the experimental group ($M = 24.61$), was higher than the mean of the control group ($M = 1.22$).

5 Discussion

The improvement in the experimental group's post-test scores over the control group's post-test scores points to the effectiveness of the think-pair-share learning model. Its versatility provided a systematic framework for the teacher to plan for his instruction [2]. The students retained more knowledge during the active engagement with the learning process, thus demonstrating extremely effective learning and teaching method [41]. "Think-share-method provided a structured process for team members to work and accomplish a common goal, stress positive interdependence, individual accountability, and group accountability. The accountability rules made each member individually and collectively responsible for the group's work" [42]. "Students who are taught using the think-pair-share learning have longer information retention, better performance in examinations, stronger critical thinking, and problem-solving skills, more positive attitudes toward mathematics and greater motivation to learn it, better interpersonal and communication skills, and, higher self-esteem" [37]. Teachers who use such effective instructional models translate into high mathematics achievement among their students [1]. These teachers' mathematics knowledge and beliefs are dependent on their instructional choices [26,27,28,29,30,31].

"The think-pair-share learning results in increased participation, improved retention of information, and higher levels of student confidence" [35]. The benefits of cooperative learning activities tend to foster active learning. Information teachers give to their students must develop into communities that discuss, debate, and summarise ideas. Most people claim that an effective and constructive way to learn and grasp the content is to teach others [36]. When students work in pairs to solve mathematical problems, it represents the most effective form of interaction [37]. During such a situation, one student listens while the other explains or discusses or explains his/her viewpoint. Both develop valuable problem-solving skills by formulating their ideas, discussing them, and receiving immediate feedback from the other [37]. During the session, both students are engaged.

When students work in pairs, they focus and concentrate as a group. It allows them to review their viewpoint before presenting it to the whole class, thereby, reducing many mistakes and errors [37]. [43] contend that students who work in small groups tend to learn more content and retain it longer than when it is taught using

other forms of instruction. Students who work using the think-pair-share method appear more contented working in their groups by placing them in groups and giving them tasks in effective ways to capitalise on their social needs. Collaboration and cooperation among students are integral components of the think-pair-share learning approach. By working as a team, [41] claim that such a relationship can create a positive interdependence and individual accountability among students as each member consciously contributes to the team's progress. Cooperation can also foster students' growth, develop social and learning skills and help them construct their knowledge through engaging in the exchange of ideas.

The use of an active classroom or constructive learning technique provided the students with a great opportunity to engage with the content since they explored ideas among themselves before arriving at conclusions [3]. They built consensus through dialogue and open debate when working in their respective groups. As they engaged with themselves, they nurtured confidence and expressed themselves competently. This learning method enabled the lecturer to elicit responses from the students based on their thinking and creativity, with the lecturer largely facilitating the learning process [3]. These strategies include but are not limited to, making mind maps and allowing the students to make presentations.

6 Implications to Teaching and Learning

“The results indicate that cooperative learning experiences promote higher achievement and greater retention than individual learning experiences for all students” [36]. “Cooperative learning, in addition to impacting academic achievements, also positively influences the attitudes of students. The effects of cooperative learning on attitudes are evidenced by increases in self-esteem, social acceptance, and lecturer ratings of students” [44]. Cooperation is working together to accomplish shared goals. Within cooperative activities, individuals seek outcomes that are beneficial to themselves and beneficial to all other group members in mathematics education.

A carefully structured think-pair-share learning during mathematics lessons involves students working in teams to accomplish a common goal, under conditions that involve both positive interdependence and individual and group accountability. To be successful, members must have confidence in each other, promote each other's learning, and hold others accountable to do their share of the work. From the findings of this study, the think-pair-share learning appears to demonstrate positive effects on the learning of mathematics. Although the think-pair-share learning may require more teacher preparation of lesson materials and monitoring of activities, the rewards and benefits teachers and students derive from this method are significant. Mathematics teachers should encourage positive interdependence by assigning their students very meaningful roles.

7 Conclusion

Think-share-pair learning. provides many advantages to teachers and students. These advantages have considerable educational benefits, including intrinsic motivation, positive attitudes, improved self-esteem, social support, group cohesion, and participation [45,46,47]. It represents a significant shift away from the typical lecture-centred learning. In cooperative classrooms, the lecturing process may not disappear entirely, but it lives alongside other methods based on students' discussion and active work with the mathematics content. Teachers who use cooperative learning think of themselves less as expert transmitters of knowledge to students and more as expert designers of intellectual experiences for students [44,48].

Competing Interests

Authors have declared that no competing interests exist.

References

- [1] Rasmussen C, Marrongelle K. Pedagogical content tools: Integrating student reasoning and mathematics in instruction. *Journal for Research in Mathematics Education*. 2006;37(5):388-420.

- [2] Saritas M. Instructional Design in Distance Education (IDDE): Understanding the Strategies, Applications, and Implications. In C. Crawford et al. (Eds.), Proceedings of Society for Information Technology and Teacher Education International Conference. Chesapeake, VA. 2004;681-688.
- [3] Beaton AE, O'Dwyer LM. Separating school, classroom, and student variances and their relationship to socioeconomic status. In DF Robitaille & AE Beaton (Eds.), Secondary analysis of the TIMSS data. Boston, MA: Kluwer Academic Publishers. 2002;211-231.
- [4] Kellaghan T, Madaus GF. Teachers' sources and uses of assessment information. In DF Robitaille & AE Beaton (Eds.), Secondary analysis of the TIMSS data. Boston, MA: Kluwer Academic Publishers; 2002.
- [5] Kifer EW. Students' attitudes and perceptions. In DF Robitaille & AE Beaton (Eds.), Secondary analysis of the TIMSS data. Boston: Kluwer Academic Publishers; 2012.
- [6] Graetz B. Socio-economic status in education research and policy in John Ainley et al., Socio-economic Status and School Education DEET/ACER Canberra; 1995.
- [7] Oral I, McGivney EJ. Equity and academic achievement in the Turkish education system: Research report and analysis]. Istanbul: Education Reform Initiative; 2014.
- [8] Considine G, Zappala G. The influence of social economic disadvantage on school students' academic performance in Australia. Journal Sociology. 2002;38:127-148.
- [9] Hanushek EA. Assessing the effects of school resources on student performance: An update. Educational Evaluation and Policy Analysis.1997;19(2):141–164.
- [10] Adedeji SO, Owoeye JS. Teacher quality and resource situation as determinants of students' academic achievement in Ogun state secondary schools. Journal of Educational Management. 2002;4:36-45.
- [11] National Research Council. How People Learn: Brain, Mind, Experience, and School: Expanded Edition. Washington, DC: National Academies Press; 2000.
- [12] Deveci O, Karademir CA. Investigation of the 5th Grade Students' Engagements in Mathematics Course towards Student Opinions. European Journal of Educational Research. 2019;8:337–348.
- [13] Finn JD, Zimmer KS. Student Engagement: What Is It? Why Does It Matter? In Handbook of Research on Student Engagement; Springer: Boston, MA, USA. 2012;97–131.
- [14] Finn JD, Voelkl KE. School Characteristics Related to Student Engagement. Journal of Negro Education. 1993;62:249.
- [15] Carini RM, Kuh GD, Klein SP. Student Engagement and Student Learning: Testing the Linkages. Research in Higher Education. 2006;47:1–32.
- [16] Delfino, AP. Student engagement and academic performance of students of the Partido State University. Asian Journal of University Education. 2019;15:42–55.
- [17] Heng, K. The Relationships between Student Engagement and the Academic Achievement of First-Year University Students in Cambodia. Asia Pacific Educational Research. 2013;23:179–189.
- [18] Park SY. Student engagement and classroom variables in improving mathematics achievement. Asia Pacific Educational Review. 2005;6:87–97.
- [19] Asif M, Thomas G, Awan MU, Din AM. Enhancing student engagement through heterogeneous pedagogical approaches: Action research in a university level course in Saudi Arabia. International Journal of Educational Management. 2020;35:1–28.

- [20] Wong NY, Lam CC, Kong QP. The Relationship between Student Engagement and Learning Outcome in Mathematics. *Curriculum in Teaching*. 2003;18:81–95.
- [21] Aguanta Jr ER, Tan DA. Effects of dyad cooperative learning strategy on students' academic performance and attitude towards mathematics. *International Journal of English Education*. 2018;7:303–313.
- [22] Gasevic D, Jovanovic J, Pardo A, Dawson S. Detecting Learning Strategies with Analytics: Links with Self-reported Measures and Academic Performance. *Journal of Learning Analytics*. 2017;4:113–128.
- [23] Yip MC. Learning strategies and self-efficacy as predictors of academic performance: A preliminary study. *Quality in Higher Education*. 2012;18:23–34.
- [24] Brophy JE. Teaching social studies for understanding and higher-order applications. *Elementary School Journal*. 1990;90:351-417.
- [25] Brown CA. A study of the socialization to the teaching of a beginning secondary mathematics teacher. Unpublished doctoral dissertation. The University of Georgia; 1990.
- [26] National Council of Teachers of Mathematics. Curriculum and evaluation standards for school mathematics. Reston, VA: National Council on Teachers of Mathematics; 2010.
- [27] Thompson AG. Teachers' beliefs and conceptions: A synthesis of the research. In *Handbook of Research in Mathematics Teaching and Learning*, D.A. Grouws, ed. New York: Macmillan. 1992;127-146.
- [28] Wilson M. Investigation of structured problem-solving items. p. 137-203 in *Assessing Higher Order Thinking in Mathematics*, G. Kulm, ed. Washington, DC: American Association for the Advancement of Science; 1990a.
- [29] Wilson M. Measuring a van Hiele geometry sequence: A reanalysis. *Journal for Research in Mathematics Education*. 1990b;21:230-237.
- [30] Darling-Hammond L. School reform at the crossroads: Confronting the central issues of teaching. *Educational Policy*. 1997;11(2):151-166.
- [31] Bransford JD, Brown AL, Cocking RR. How people learn: Brain, mind, experience, and school: Expanded edition. Washington, D.C.: National Academy Press; 2000.
- [32] Ball DL. With an eye on the mathematical horizon: Dilemmas of teaching elementary school mathematics. *Elementary School Journal*. 1993;9:373-397.
- [33] Grossman PL, Wilson SM, Shulman LS. Teachers of substance: Subject matter for teaching. In *Knowledge base for the beginning teacher*, M.C. Reynolds, ed. New York: Pergamon Press. 1989; 23-36.
- [34] Rosebery AS, Warren B, Conant FR. Appropriating scientific discourse: Findings from language minority classrooms. *The Journal of the Learning Sciences*. 1992;2(1):61-94.
- [35] Healey M, Roberts J (eds). *Engaging Students in Active Learning: Case studies in geography, environment, and related disciplines*. Cheltenham: Geography Discipline Network and School of Environment, University of Gloucestershire; 2004.
- [36] Cohen EC, Brody M, Sapon-Shevin. *Teaching Cooperative Learning: The Challenge for Teacher Education*. Albany: State University of New York Press; 2004.

- [37] Baines EP, Blatchford A, Chowne. "Improving the effectiveness of collaborative group-work in primary schools: effects on Science attainment." ESRC Teaching and Learning Research Programme special issue of the British Educational Research Journal. 2007;33:663-680.
- [38] Weimer M. Learner-Centred Teaching: Five Key Changes to Practice. San Francisco, CA: Jossey-Bass; 2002.
- [39] Webb NM, Farivar SH, Mastergeorge AM. Productive helping in cooperative groups. Theory into Practice. 2002;41:13-20.
- [40] Cooperstein SE, Kocevar-Weidinger E. Beyond active learning: A constructivist approach to learning. Reference Services Review. 2004;32(2):141-148.
- [41] Felder RM, Brent R. Understanding Student Differences. Journal of Engineering Education. 2001;94: 57-72.
- [42] Lowyck J, Poeyssae J. Design of collaborative learning environments. Computer in Human Behavior. 2001;17(5-6):507-516.
- [43] Lea, Stephenson S, Troy J. Higher Education Students' Attitudes to Student Centred Learning: Beyond "Educational Bulimia". Studies in Higher Education. 2003;28:321-334.
- [44] Hinde RJ, Kovac J. Student active learning methods in physical chemistry. Journal of Chemical Education. 2001;78(1):93-99.
- [45] Fernandez-Río J, Cecchini JA, Méndez-Giménez A, Méndez-Alonso D, Prieto JA. Design and validation of a questionnaire to assess cooperative learning in educational contexts. Annual Review of Psychology; 2017.
- [46] Han SL, Son HS. Effects on cooperative learning on the improvement of interpersonal competence among students in classroom environments. International Online Journal of Education and Teaching. 2020;7(1):17-28.
- [47] Liu TF, Lipowski M. Sports gamification: Evaluation of its impact on learning motivation and performance in higher education. International Journal of Environmental Research and Public Health. 2021;18:1267.
- [48] Perrenet JC, Bouhuijs PAJ, Smits JGMM. The suitability of problem-based learning for engineering education: Theory and practice. Teaching in Higher Education. 2000;5(3):345-358.

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