

Learning Engagement in Mathematics: A Test of an Active Learning Model

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Abstract

This experimental study explored the effect of the 4WShs active learning model on learning engagement in mathematics classes. The research design used for conducting this study was true experimental research design (pre-test post-test equivalent group design). A sample comprising 190 students selected from two public sector schools was divided into experimental and control groups using a matched random sampling technique. The newly developed active learning model was used as treatment for an experimental group while the same contents of mathematics were taught to the control group using a traditional method. After practice of three months, learning engagement of both groups was measured using a classroom observation checklist. The analyzed data revealed a significant superiority of students belonging to the experimental group over their counterparts in learning engagement. Hence, the newly developed active learning model proved to be effective for developing learning engagement among students.

Key Words

Learning Engagement,
Active Learning,
Secondary School
Students, Mathematics
Class, Teaching
Mathematics

Introduction

Mathematics develops logical thinking ability among learners which is key for development in modern era. Okereke (2006) claimed that mathematics is the science of objects that are applicable in every field of life. Learners have to understand mathematics as it fosters their interests and capabilities in logical thinking and problem solving. In real sense, it is a complex subject as compared to others. The majority of students are suffering mathematical anxiety in Pakistan and many intelligent students become reluctant to learn mathematics, and consequently fail in the examination (GoP, 2009). The causes of this failure are faulty traditional teacher-centered instructional strategies. These instructional strategies are no more practical but are theoretical and prone to memorization in nature (Teo & Wong, 2000). In teacher-centered scenarios, learners may not learn mathematics as an interesting and innovative subject (Amirali & Halai, 2010). Ma (1999) analyzed 26 studies and found a negative correlation between students' mathematical-anxiety and achievement across the world. To overcome these problems, it is needed to adopt such instructional strategies that present mathematics as an interested and innovative subject. Moreover, it should be connected to the real life of learners (Waring & Evans, 2015). That is why, Grouws and Cebulla (2000) recommended the active and dynamic instructional-strategies for teaching mathematics. This may only be possible by implementing learner-centered instructional-approach like inquiry method, group work and active-learning strategies. Eggen and Kauchak, (2001) concluded on the basis of many mathematics related studies that an active and social approach for teaching mathematics decreases mathematics anxiety.

The majority of the teachers in Pakistan use traditional methods while teaching mathematics that develop mathematics avoidance in secondary school students. The secondary stage is a base of higher education. At the higher level, they need to apply mathematics in different subjects. Therefore, students may be continuously engaged in mathematical learning in active learning scenarios. Learning engagement assures students' involvement in a learning process and results in improved mathematical achievement (Dalrymple, Kemp, & Smith, 2014). Learning engagement increases the achievement level of students by fostering positive behaviors for learning. Hu and

Kuh (2001) have claimed that the degree of students' performance in mathematics is directly proportional to their positive engagement in learning activities. Coates (2007) is of the view that learning engagement develops different aspects of student learning experience i.e. active-learning, doing difficult academic-activities and enriching their educational experiences by formative-communication with teacher. Similarly, Trowler (2010) explained that students' learning-engagement is an interaction among time, efforts, and other related resources to maximize learning outcomes and enhance their overall performance. Learning-engagement is a multidimensional construct that may focus on continuous learning of students. Fredricks, Blumenfeld and Paris (2004) have mentioned four aspects of learning engagement: emotional, behavioral, and cognitive. In behavioral engagement students comply with attendance and involvement without negative behavior. Emotionally engaged students show their interest, enjoyment and sense of belonging as affective reactions. Similarly, students spend more time in learning and accept challenges happily in cognitive-engagement. Students' engagement in learning process is beneficial for the students, teachers, school and the whole education system as well. The engaged students not only complete the assigned task efficiently but also perform it with their core of heart. Davies et al. (2007) found that the learning engagement develops sense of ownership for their learning by increasing motivation, self-efficacy and self-esteem and strengthened relationships with peers and teachers.

Continuous engagement in learning is an active phenomenon. In this process, students may be attentive in the class, committed to their task, and well verse with what they are being asked to do. Kuh et al. (2007) clarified that learning engagement is an active involvement of students in learning within or outside the class that leads them to the achievement of desirable learning outcomes. To attain positive learning engagement of students, there is need of such student-centered teaching approaches where students may be active participant. Weimer (2002) stated that in a student-centered teaching approach, students are engaged in continuous discovering that results in gaining deep and profound knowledge. Collins and O'Brien (2003) claimed that everything like content, activities, materials, and speed of students' learning are affected by student-centered approaches. Rapid developments in technology with different needs, goals, and learning preferences have changed the nature of students' learning. Furthermore, teacher-student relationships may also be shifted towards peer-based collaborative learning where teachers are continuously engaged in constructing new learning ideas for students (Dunleavy & Milton, 2009). Engaging the disengaged student is the biggest challenge for today educators. As it is noted by Williams (2003) that 25% students are not engaged in learning activities. While, Cothran and Ennis (2000) are of the view that 66% students as disengaged in learning activities (cited in Harris, 2008). To re-engage them in learning process, it requires the constructivist instructional strategies with safe learning environments. Such knowledge-building learning environment may be possible only in active learning situation where learners naturally share their understanding collaboratively to strengthen overall learning of each individual (Fletcher, 2005). Moreover, Dalrymple, Kemp and Smith (2014) are of the view that interactive and stimulating teaching approach develops a real and purposive learning. In interactive-learning process, teachers permit learners diverse learning-styles by encouraging their active-involvement to rectify individual weaknesses of students (Curtin, 2005). Therefore, it is required to understand student-centered strategies with respect to the student rights and pay critical attention towards the impact of engagement on students' learning (MacFarlane, 2015).

In a learner-centered approach, learning is cognitive construction of knowledge which is an active and dynamic process. Due to these characteristics, learner-centered approaches are considered more suitable and provide all the activities that motivate students to participate and think about the contents presented in the classroom (Al-Shammari, 2012). Mocinic (2012) identified several active learning strategies including pair-work, students' discussion, brainstorming, class discussion, games involving competitions and puzzles, debates for students' engagement in thinking to solve problems, group-work involving working in team and role plays which integrate real-world situations. The basic elements of active-learning are students' activity with deep learning (Evans 2015) and continuous engagement. While in traditional approach, students just receive information from teacher passively without understanding, and it decreases the thinking power of learners (Chance, 2005). In this approach, students have to complete learning activities by themselves because they are held responsible for their learning. Active-learning situation places students at the focal point of entire education system where they practice in different ways: students participate in the class activities by interacting via discussion, reading, presenting, and sharing of written work; they are engaged in higher order thinking like comprehension, application, analysis, synthesis, and evaluation (Feden & Vogel, 2003). But placing the students in active learning situation needs training for students for working in groups and performing different roles (Huitt et al. 2015).

Thinking activities like analysis, synthesis and assessment are recommended by Bonwell and Eison (1991) for students to engage them in learning process. But it can only be possible when the learning environment is prone to active learning. Students have to complete many learning tasks in active-learning situation. Many researches have conducted studies to examine the efficacy of active learning strategies. The meta-analysis of 225 studies have reflected that active-learning strategies are highly affective for the students' learning in the subjects of science,

technology, engineering and mathematics (Freeman et al., 2014). Moreover, a project by MAA National Studies of College Calculus indicated that a combination of good teaching practices with active-learning approach develops students' confidence in learning Calculus (Bressoud, 2015, 2016).

In the view of the previous discussion, it can be inferred that active learning strategies engage students in purposeful learning and help in achieving desired educational goals. Considering the direct linkage between active learning strategies and students' engagement in learning process, a study was conducted to explore the effect of 4WsHs active learning model for teaching mathematics on students' learning engagement. This model was developed specifically for teaching mathematics (Shah, 2016). This model has four phases: What and How includes activation for leaning new concept and presentation of new concept, Where and How is the application of new learned concept, Why and How is the practice of new concept and Where on and How is the assessment of students' learning and feedback for further learning. Every phase has specific active learning techniques. The objective of the study was to explore the effect of active-learning approach in newly developed active learning model for teaching mathematics on the learning engagement of students. To achieve this objective, the hypothesis to be tested was learning engagement scores of the students taught by traditional lecture method versus 4WsHs model in the mathematics classroom have no significant difference.

Research Methodology

The study was experimental, and pretest-posttest equivalent group design was used to examine the effect of newly developed active-learning model for teaching mathematics (4WsHs) on the learning engagement of students. In this design, comparison groups are equated before treatment in order to control the external variables and assure the internal validity up to a maximum level (Koul, 2007). For this study, a sample of 190 students was drawn from the students of 9th grade of two public school; GHS Khaki Mansehra (N=94) and GHS Berkund Mansehra (N=96). Students were placed into control and experimental groups by using matched random sampling technique on the basis of pre-test scores of the students. The pre-test and post-test comprised an achievement test prepared by researchers. This test was validated through experts' opinions, and its reliability was found to be 0.85. The mathematical equivalence of control and experimental group presented in the following table.

Table 1. Mean Academic Achievement Scores' Comparison of Different Groups on Pre-Test

| No. | Groups | No. of students | Mean scores | S.D | D | p |
|-----|---------|-----------------|-------------|-------|-------|-------|
| 1 | E-Group | 95 | 27.72 | 11.4. | 0.009 | 0.000 |
| 2 | C-Group | 95 | 27.68 | 11.3. | | |

E-Group = Experimental Group; C-Group = Control Group

For examining the learning engagement effect of treatment based on newly developed active learning model, an observation checklist followed by a learning engagement rubric was used. This rubric contained 10 factors of learning engagement i.e. performance orientation, rigorous thinking, meaningfulness of work, clarity of work, individual attention, students' confidence, verbal participation, consistent focus, positive body language, and mathematical abilities. The rubric was prepared in the light of 5D+ Teacher Evaluation Rubric developed by Center for Educational Leadership (2012). Both

observational checklist and learning engagement rubric were validated using experts' opinions. Furthermore, both instruments were pilot tested on 40 students of GHSS Sherpur Mansehra. The reliability of learning engagement rubric was found to be 0.81.

Procedure of Experiment

Before treatment, the students of both groups were observed for their learning engagement in the mathematics classroom. Students' learning-engagement was observed with the help of a fellow teacher. Each factor was rated at five-points rating scale i.e. very low, low, average, high and very high. Eight students of each group were observed daily. During learning engagement observation, 5 minutes were given to each target student per lesson and approximately 8 target students were observed. Thus, 6 sessions were allocated for observing learning engagement of the students of experimental and control groups. These observations were repeated simultaneously to assure that each student was properly observed (Achen & Lumpkin, 2015). The contents of intervention (three units of 9th class Mathematics textbook) were divided into 30 lesson-plans in accordance with four phase cycle based on 4WsHs model. As compared to the intervention group same contents were taught to the control-group in traditional teaching situation. Teachers having the same teaching experience and qualification were deputed to teach both the experimental and control groups in both schools. These teachers were provided with one-week training for teaching mathematics through active learning and implementing the 4WsHs model in the classroom.

They were also provided with lesson plans and a guide for active learning strategies. The experiment was conducted in parallel sessions in both schools. When the treatment was over, learning engagement of every student was measured again through observational checklist learning engagement. After scoring the observational checklist, the engagement scores in different aspects of learning engagement were determined.

Data Analysis

To find out the effect of teaching through 4Ws4Hs active-learning model for teaching mathematics on learning-engagement of students, the collected data was analyzed using t-test as statistical tool. The obtained results were presented in tables given in the following:

Table 2. Comparison of Different Groups in Learning Engagement on Pre-Test

| S No. | Aspect of Learning | Comparison Groups | N | M | SD | t | p |
|-------|---------------------------|-------------------|----|---------|---------|--------|------|
| 1 | Performance Orientation | E-Group | 95 | 1.6737 | .60919 | .566 | .572 |
| 2 | Rigorous Thinking | C-Group | 95 | 1.6211 | .67128 | 2.111 | .036 |
| | | E-Group | 95 | 1.4526 | .06128 | | |
| 3 | Meaningfulness of Work | C-Group | 95 | 1.2842 | .05111 | .604 | .547 |
| | | E-Group | 95 | 1.3158 | .51080 | | |
| 4 | Clarity of Work | C-Group | 95 | 1.2737 | .44821 | -.774 | .440 |
| | | E-Group | 95 | 1.3684 | .58442 | | |
| 5 | Individual Attention | C-Group | 95 | 1.4316 | .53896 | .503 | .615 |
| | | E-Group | 95 | 1.4526 | .59731 | | |
| 6 | Student Confidence | C-Group | 95 | 1.4105 | .55534 | -.243 | .808 |
| | | E-Group | 95 | 1.3789 | .58671 | | |
| 7 | Verbal Participation | C-Group | 95 | 1.4000 | .60845 | -.435 | .664 |
| | | E-Group | 95 | 1.2737 | .47135 | | |
| 8 | Consistent Focus | C-Group | 95 | 1.3053 | .52741 | -.827 | .409 |
| | | E-Group | 95 | 1.2737 | .51451 | | |
| 9 | Positive Body Language | C-Group | 95 | 1.3368 | .53813 | -.708 | .480 |
| | | E-Group | 95 | 1.2947 | .50262 | | |
| 10 | Mathematical Ability | C-Group | 95 | 1.3474 | .52122 | -1.859 | .065 |
| | | E-Group | 95 | 1.3474 | .57922 | | |
| 11 | Total Learning Engagement | C-Group | 95 | 1.5158 | .66626 | -.385 | .701 |
| | | E-Group | 95 | 13.7579 | 3.24108 | | |
| | | C-Group | 95 | 13.9368 | 3.16836 | | |

*Significant at 0.05 level

Table 2 shows the comparison of experimental and control groups in different aspects of learning engagement. The students of both groups were at the same learning-engagement level. The students of both groups had no significant difference (p>0.05) in different aspects of learning engagement.

Table 3. Comparison between Different Groups in Learning Engagement on Post-Test

| S No. | Aspect of Learning | Comparison Groups | N | M | SD | t | p |
|-------|-------------------------|-------------------|----|--------|--------|--------|------|
| 1 | Performance Orientation | E-Group | 95 | 2.9263 | .85355 | 7.151* | .000 |

| | | | | | | | |
|----|---------------------------|----------|----|---------|--------|--------|------|
| | | C-Group | 95 | 2.0737 | .78878 | | |
| 2 | Rigorous Thinking | E-Group | 95 | 2.8842 | 1.0705 | 6.340* | .000 |
| | | C-Group | 95 | 2.0421 | .72810 | | |
| 3 | Meaningfulness of Work | E-Group | 95 | 2.8105 | .84166 | 5.811* | .000 |
| | | C-Group | 95 | 2.1053 | .83122 | | |
| 4 | Clarity of Work | E-Group | 95 | 2.7263 | 1.0663 | 4.471* | .000 |
| | | C-Group | 95 | 2.0842 | .90698 | | |
| 5 | Individual Attention | E-Group | 95 | 2.6000 | .90389 | 3.713* | .000 |
| | | C-Group | 95 | 2.1474 | .77141 | | |
| 6 | Student Confidence | E-Group | 95 | 2.7368 | .85316 | 6.357* | .000 |
| | | C- Group | 95 | 1.9895 | .76485 | | |
| 7 | Verbal Participation | E-Group | 95 | 2.6632 | .94092 | 4.551* | .000 |
| | | C-Group | 95 | 2.0842 | .80772 | | |
| 8 | Consistent Focus | E-Group | 95 | 2.7263 | .91608 | 5.871* | .000 |
| | | C- Group | 95 | 2.0211 | .72902 | | |
| 9 | Positive Body Language | E-Group | 95 | 2.6000 | .91559 | 4.376* | .000 |
| | | C-Group | 95 | 2.0632 | .76923 | | |
| 10 | Mathematical Ability | E-Group | 95 | 2.6842 | .97045 | 4.341* | .000 |
| | | C-Group | 95 | 2.0947 | .90004 | | |
| 11 | Total Learning Engagement | E-Group | 95 | 27.3579 | 4.4600 | 11.16* | .000 |
| | | C-Group | 95 | 20.7053 | 3.7242 | | |

*Significant at 0.05 level

Table 3 indicates that after treatment, both experimental and control groups were not at same learning engagement level in the case of performance orientation ($t=7.151$, $p=0.000 < 0.05$), for and rigorous thinking ($t=6.340$, $p=0.000 < 0.05$), meaningfulness of work ($t=5.811$, $p=0.000 < 0.05$), clarity of work ($t=4.471$, $p=0.000 < 0.05$), and individual attention ($t=3.713$, $p=0.000 < 0.05$). Similarly, both groups had significant difference in the other aspects of learning engagement such as students confidence ($t=6.357$, $p=0.000 < 0.05$), verbal participation ($t=4.551$, $p=0.000 < 0.05$), consistent focus ($t=5.871$, $p=0.000 < 0.05$), positive body language ($t=4.376$, $p=0.000 < 0.05$), mathematical ability ($t=4.341$, $p=0.000 < 0.05$), and total learning engagement ($t=11.159$, $p=0.000 < 0.05$). Values of the mean scores indicate that students of experimental group were significantly at better learning engagement level after treatment as compared to their counterparts.

Discussion and Conclusion

In this study, the analyzed data revealed that the treatment-group was significantly more engaged in the learning process as compared to their counterparts on post-test ($t=11.159$, $p<0.05$) for learning-engagement in mathematics class. Thus, the hypothesis that “learning engagement scores of the students taught by traditional lecture method versus 4WsHs model in the mathematics classroom have no significant difference” was rejected in favor of treatment-group. Same results were found by Stahl, Simpson, and Hayes (1992) and Wlodkowski and Ginsberg (1995) in their research studies. Further, Adams and Burns (1999) also found that learning takes place positively when learners are continuously engaged in learning activities.

In learning through 4WsHs active learning model, students feel their own responsibilities for learning in an active-learning mode. Thus, it is concluded that the activities embedded in 4WsHs active learning model for teaching mathematics enhance positive learning engagement among learners because all the four phases of this model support learning engagement of the learners. In the first phase previous knowledge of students is explored as recommended by Dewey (1902) and Vygotsky (1978), and it is the best way to engage students in purposeful learning. Similarly, in the first phase of the model, teacher also presents new contents to the students that directly involve them in the learning process as suggested by Ebert et al. (1997). In the second phase, students apply the

learned contents through different group activities for mastering the concept. Malik and Janjua, (2011) asserted that students working in active learning groups can master material better than working on their own. In the third phase, students practice the learned contents collaboratively. According to Biggs and Tang (2011), conceptual changes take place when students are engaged in collaborative learning activities. The last phase of the model is for assessment of students' learning which is supported by Johnson and Johnson (2009). They suggested that students may engage in promoting interaction if there is a strong group structure, feedback, positive interdependence and individual accountability. Thus, the 4Ws4Hs active learning model for teaching mathematics is very effective in engaging students in learning process.

Recommendations

Further studies may be conducted for the validation of 4Ws4Hs active learning model for teaching mathematics in different settings. It may be beneficial for teachers to apply active learning approaches in their mathematics classes for enhanced learning engagement of the learners.

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