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Relationship between Epistemological Beliefs and Students' Academic Achievement in Mathematics

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Abstract

Epistemological beliefs (EB) play a vital role in students' performance. The paper was designed to examine the relationship between students' EB about the Mathematics curriculum andtheir academic achievement (marks) at the secondary level. Eight hundred and ten participants (girl students) were selected through cluster random sampling technique from public-sector secondary schools of Lahore District. The Mathematics inventory prepared by Grouws **(**1994) was adapted to identify the secondary school students' EB regarding the Mathematics curriculum that was comprised of seven sub-scales. Students' academic achievement was gained from their Mathematics score obtained in grade IX. In data analysis, the Pearson Product-Moment Correlation was applied to identify the association between girl students' EB and their academic achievement. The result showed that students' EB regarding the Mathematics curriculum positively correlate with Mathematics academic achievement at the secondary level.

Keywords: Epistimological Belifs, Girls Students, Mathematics Curriculum, Secondary Level.

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Introduction

Students' Epistemological Beliefs (EB) influence their learning outcomes (Schommer, 1990). The researchers concluded that EB has a multifaceted model that included: the structure of knowledge which has run from easy to complex; certainty of knowledge which vary from sure to unsure learning; source of knowledge that has ranged from authoritative to reasoning; innate ability to learning which is static to changeable; the speed of learning ranges from fast toward slow (Buehl et al., 2002; De Corte et al., 2002; Ravindran et al., 2005; Hofer & Pintrich, 2002; Muis, 2004; Schraw et al., 2002; Wood & Kardash, 2002). Lombardi et al. (2016) researched that epistemological beliefs have been identified with students' content awareness. Students' beliefs about the idea of information and learning have been explored with the possibility that they are a piece of the basic component of metacognition (Schommer 1990; Hashmi, Khalid, & Shoaib, 2019). Specialists have featured that EB may impact on students' intellectual procedures of reasoning, creation of learning, their decision of learning approaches, and their scholarly accomplishments (Cano, 2005; Chan, 2004; Hofer & Pintrich, 2002; Otting et al., 2010; Phan, 2008; Sadi & Dağyar, 2015; Schommer, 1990, 1993). As indicated by Hofer and Pintrich, (2002), students' epistemological beliefs are the beliefs about knowledge and knowing. Schommer (1993) observed students' EB as solid indicators of their intellectual exhibitions and full of feeling reactions. Moreover, their epistemological beliefs influence towards learning, and the instructional methods tried to make a connection with the learning situation (Magolda, 2004).

Constructivism has been related to epistemological beliefs since the pioneering work of Piaget (1950) and Perry (1970). Epistemological beliefs were concluded by educational psychologists as beliefs, such as the idea of learning; certianity, source; acquiring; and information structure (Duell & Schommer-Aikins, 2001; Hofer & Pintrich, 2002). In Mathematics instruction, epistemological beliefs are regularly translated as a person's understanding and thoughts that shape the manners in which the individual conceptualizes and takes part in arithmetic behavior (Schoenfeld, 1985; Star & Hoffmann, 2005).

Girl students had weaker critical beliefs in brisk learning, certain information, expert, and in fixed capacity (Enman & Lupart, 2000; Schommer, 1993; Sinatra, 2001; Wood & Kardash, 2002). On the contrary, Hofer and Pintrich (2002) asserted that girl students had a solid belief in the source of information. School students considered information as frequently unpredictable, inconsistent, and ambiguous but they progressively refined beliefs about the structure, development, and change of learning, with more grounded beliefs (Wood & Kardash, 2002). Onen (2011) assumed that girl students had mature beliefs in learning and information than boy students. Moreover, girl

students' attitudes show that they study for achievement scores, whereas boy students see their achievement as an outcome of their skills (Deryakulu, 2004). Literature shows that there are fewer studies that specifically examined the girl students' epistemological beliefs, so the present study was designed to measure the association between girl students' EB and their academic achievements. Consequently, this study may help to fill the gap in the existing literature.

Literature Review

In this section, the researchers reviews the studies that have explored relationships between hypothesized variable i.e. epistemological beliefs. The constructivist conception of teaching and learning is found to be positively related to three types of classroom instructional practices, whereas the traditional conception about teaching and learning is found to be only significantly and negatively linked to standard contemporary practices A study showed that there are differences between the students epistemological beliefs compared to the epistemological beliefs of their teachers. Students' mathematical epistemological beliefs about time and their congruency scores predicted their mathematical performance (Schommer-Aikins et al., 2015).

Löfström and Pursiainen (2015) concluded in their study that epistemologies are domain-specific therefore students may struggle with the association of mathematical and pedagogical knowledge. They identified six aspects that can challenge association: 1) the students believed that pedagogical knowledge is highly relative; 2) knowledge of methods of inquiry in education was weak; 3) theoretical pedagogical knowledge as unrelated to practice; 4) formalistic beliefs about Mathematics; 5) performance-orientated in solving the mathematical problems; and 6) they relied on authority, rather than proof, as a justification for mathematical knowledge.

Rastegar et al., (2010) investigated the relationship between epistemological beliefs and Mathematics achievement, as for the mediating role of achievement goals, Mathematics self-efficacy, and cognitive engagement. Three self-report questionnaires were used. Achievement goals and Mathematics self-efficacy, the revised form of the Schommer epistemological beliefs questionnaire and the subscale of cognitive engagement. The Mathematics course score was also considered as the Mathematics achievement index. They concluded that achievement goals, Mathematics self-efficacy, and cognitive engagement have a mediating role between dimensions of epistemological beliefs and Mathematics achievement. Beliefs, processes, and difficulties associated with mathematical problem solving of Grade 9 students examined by Alvi et al., (2010). They conducted semi-structured interviews with students about five different word problems. They concluded that struggle with solving mathematical word problems was due to five major reasons. These reasons were making sense of the problem statement, conceptual understanding, contextualization, visualization of the problem, and critical thinking and reasoning.

Schommer-Aikins and Duell (2013) conducted a study to understand how domain-specific and general epistemological beliefs (beliefs about knowledge and learning) influence mathematical problem solving with a domain-general and specific questionnaire. The result of this study indicates the indirect effects of general epistemological beliefs and direct effects of domain-specific epistemological beliefs on mathematical performance. Arslantaş (2015) used epistemological belief scale which consisted of three sub-dimensions: 1) belief of learning depending on effort; 2) belief of learning depending on talent; and 3) belief of the existence of only one truth. The findings showed that there was a statistically significant relationship between only the belief of learning depending on talent, among other sub-dimensions of epistemological beliefs, and academic achievement. Koller (2001) conducted a study to measure secondary school students' mathematics specific epistemological beliefs. The sample was comprised of 2138 participants that were selected from secondary schools of Germany. The researcherdeveloped Student's Mathematics-Related Beliefs Questionnaire (MRBQ) to measure four aspects of mathematics-related beliefs; constructive conception, certain knowledge, simple knowledge, and relevance of mathematics. The researcher also tested the effects of math beliefs on achievement via three mediator variables, interest, learning strategies, and course selection. Results indicated that all four dimensions of mathematical world views are the significant predictors of achievement.

Mosvold and Fauskanger (2013) examine teachers' beliefs about mathematical knowledge for teaching definitions. Researchers conducted focus-group interviews to examine the adaptability of the U.S. developed measures of mathematical knowledgefor teaching. The content analysis technique was applied to examine teachers' beliefs about mathematical knowledge for teaching definitions. Results showed that teachers believe knowledge of mathematical definitions is an important aspect of mathematical knowledge for teaching, but they do not regard it as important to actually know the mathematical definitions themselves. Ertekin and Peker (2010) conducted a study on the relationship between epistemological beliefs and teaching anxiety in mathematics. The sample of the study was comprised of 279 participants that were studying in the primary education mathematics teaching, secondary education mathematics teaching, and class teaching programs. Epistemological belief scale was administrated on the teacher candidates. Results of the Pearson product-moment correlation coefficient showed that there a weak, negative correlation between the anxiety of teaching mathematics and the epistemological beliefs of teacher candidates.

Research Objectives

The objectives of the research were to:

- Examine the girl students' epistemological beliefs about Mathematics.
- Find out the relaitionship girl students' epistemological beliefs and their academic achievement in Mathematics.

Research Questions

Following research questions were developed on the basis of above research objectives:

1. What are the girl students' epistemological beliefs about Mathematics?
2. Is there any relaitionship girl students' epistemological beliefs and their academic achievement in Mathematics?

Research Methodology

This research was a quantitative whereas correlational survey in nature, as the research aimed to analyze the association between the girl students' epistemological beliefs regarding the Mathematics curriculum and their academic achievement at the secondary level. All girl students that were enrolled in grade X (session 2017-19) in the Public sector secondary school of Lahore District comprised as the population of the study. A two-stage cluster random sampling technique was used to draw the sample. At the first stage, randomly 27 girl secondary schools were selected, whereas, in the second stage, 810 girl students from grade X were selected randomly from the selected schools. The Mathematics Conceptions Inventory developed by Grouws **(**1994) was adapted to identify the students' epistemological beliefs regarding the Mathematics curriculum at the secondary level. This inventory consisted of seven domains i.e. the Composition of Mathematical Knowledge (CMK); the Structure of Mathematical knowledge (STMK); Status of Mathematical Knowledge (SMK); Doing Mathematics (DM); Validating Idea in Mathematics (VIM); Learning Mathematics (LM); and Usefulness of Mathematics (UM). Students' academic achievement (scores) comprised of their Mathematics score obtained in grade IX. The inventory was validated by three experts for use in the Pakistani context. The inventory has 53 out of 71 statements after validation. The total reliability of the instrument was $\alpha = 0.871$ which is statistically acceptable.

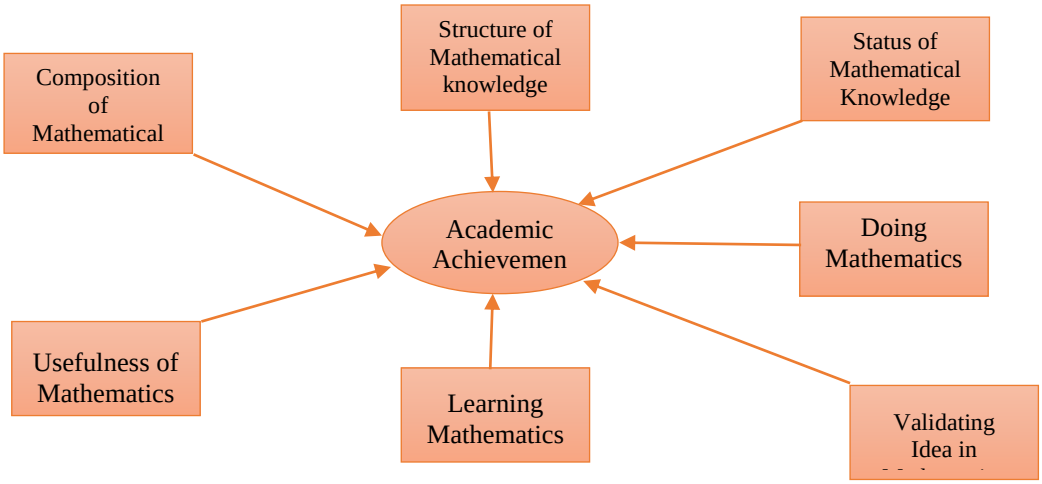

Figure 1. Conceptual Framework

Data Analysis and Interpretation

The data were analyzed through descriptive (i.e. mean) and inferential statistics (i.e. Pearson product correlation).

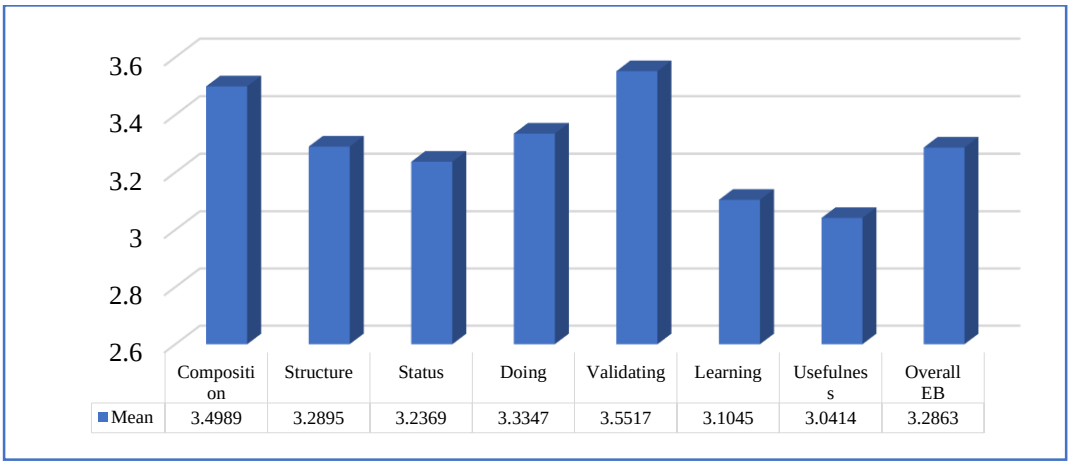

Figure 2: Descriptive Statistics about Girl Students' Epistemological Beliefs

Figure 1 demonstrates the descriptive statistics of the respondents' epistemological beliefs about the Mathematics curriculum at the secondary level. The results indicate that the respondent had more strong beliefs about validating ideas in Mathematics (*M*= 3.5517) as compared to other domains of epistemological beliefs. Conversely, respondents had weak beliefs about the usefulness of Mathematics in their daily life as *M* = 3.0414. Nonetheless, there is a slight difference between respondents' epistemological beliefs about the structure and status of mathematical knowledge i.e.

M = 3.2895 and 3.2369 respectively. In the comparison of the remaining domains, the figure illustrates that respondents had a stronger belief about the composition of Mathematical knowledge (*M* = 3.4989) as compare to belief about doing Mathematics (*M* = 3.3347).

Table 1
Correlation matrix between girl students' epistemological beliefs and their academic achievement

D	CMK	STMK	SMK	DM	VIM	LM	UM	EB	AA
CMK	1								
STMK	0.512*	1							
SMK	0.377*	0.562*	1						
DM	0.464*	0.608*	0.599*	1					
VIM	0.461*	0.569*	0.532*	0.662**	1				
LM	0.369*	0.489*	0.427*	0.510*	0.550*	1			
UM	0.273*	0.312*	0.333*	0.357*	0.349*	0.413*	1		
EB	0.670*	0.787*	0.733*	0.823*	0.817*	0.736*	0.573*	1	
AA	0.003	0.012	0.073*	0.065	0.047	0.050	0.048	0.056	1

Note: * = $p < 0.05$.; D= Domains; CMK= Composition of Mathematical Knowledge; STMK= Structure of Mathematical Knowledge; SMK= Status of Mathematical Knowledge; DM= Doing Mathematics; VIM= Validating idea in Mathematics; LM= Learning Mathematics; UM= Usefulness of Mathematics; EB= Epistemological Beliefs (Overall); AA= Academic Achievement.

To examine the relationship between girl students' epistemological beliefs and their academic achievement at the secondary level, Pearson correlation analysis was conducted (Table 1). The result showed a positive insignificant relationship between girl students' epistemological beliefs and their academic achievement. Correspondingly, the table is evident that there is a weak relationship between girl students' epistemological beliefs and six of its domains (i.e. CMK; STMK; DM; VIM; LM; UM) with their academic achievements as *r* = 0.003; 0.012; 0.065; 0.047; 0.050; 0.048 and 0.056 respectively. On the other hand, the table also illustrates that all of the epistemological beliefs dimensions of the Mathematics curriculum are substantially connected. Similarly, the table shows that there is a positive, weak but significant relationship between girl students' epistemological belief about the status of mathematical knowledge as *r* = 0.073.

Discussion

It is found that, regarding their Epistemological Beliefs, students had more strong beliefs in the domain of Validating Ideas in Mathematics than in the domain of the Usefulness of Mathematics. These findings are aligned with the results of Schommer-Aikins and Easter (2006) and Colby (2007) however, various researchers (i.e. Arslantaş, 2015; Enman & Lupart, 2000; Schommer, 1993; Sinatra, 2001; Wood & Kardash, 2002) found that students had more strong believes in other domains of epistemological beliefs. These

contrary results may be found due to contextual differences and variations in instruments that are used in previous studies. Moreover, results showed that there is a positive but weak relationship between girl students' epistemological beliefs regarding the Mathematics curriculum and their academic achievement. Previous research studies have confirmed that epistemological belief indirectly influences academic performance (Arslantaş, 2015; Cano, 2005; Colby, 2007; Garcia, 2005; March, 2010; Phan, 2006, 2008; Sadi & Dağyar, 2015; Schommer, 1993) while in numerous studies EB was determined at different grade-level that are positively associated with academic achievement, and intelligence (Arslantaş, 2015; Schommer, 1993; Tumkaya, 2012). Moreover,a few researchers have found a strong relationship between EB and academic achievement in different subjects (Sadi & Dağyar, 2015; Schommer-Aikins& Easter, 2006). The divergent findings were due to the use of different rating scales at different levels/ different methods used to measure academic achievement. Whereas, it is also determined that only the status of the mathematics knowledge domain is significantly related to academic achievement. Similar results were found by Star and Hoffmann (2005) & Sadi and Dağyar (2015) and opposite result found by Garcia (2005). The significance of the result might be due to the students' interest.

Conclusion

Epistemological beliefs has been linked to Constructivism. In Mathematics, these beliefs are multifaceted construct that is comprised of different domains such as composition, structure, & status of mathematical knowledge; doing Mathematics; validating ideas in Mathematics; learning Mathematics, and the usefulness of Mathematics. It is concluded from the results that girl students have more strong beliefs about validating ideas in Mathematics as compared to other domains. Moreover, girl students' epistemological belief about the status of mathematical knowledge is significantly correlated with their academic achievement. Similarly, a positive relationship was found between students' academic achievement at the secondary level and their overall epistemological beliefs (including all its domains) regarding Mathematics curriculum.

Recommendations

The study's findings revealed that the status of mathematical knowledge beliefs have only a minor association with the students' academic achievement. Therefore, teachers may seek to recognize students' epistemological beliefs and provide relevant instructions to increase their students' epistemological beliefs about Mathematics curriculum as a new session of secondary classes begins. The students' epistemological beliefs may be communicated to them and their parents through parents-teachers conferences. As a result, parents may be able to strengthen their children's mathematical epistemological beliefs at home. They may speak about the value of mathematics based on their own personal experiences.

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