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THE RELATIONSHIP BETWEEN EPISTEMOLOGICAL AND PEDAGOGICAL BELIEFS OF MATHEMATICS TEACHERS IN OMAN

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ABSTRACT

The primary aim of the present study was to identify the mathematics teachers' pedagogical and epistemological beliefs as well as the relationship that exists between them. To achieve this purpose, Epistemic Belief Inventory and Learning Conceptions Scale were adapted in Omani context. A total of 400 mathematics teachers (56% were male and 44% were female) participated in this study. Results revealed that mathematics teachers hold constructivist teaching beliefs more than conventional teaching beliefs, and this associated with their epistemological beliefs. Furthermore, mathematics teachers hold advanced epistemological beliefs. The study further proposed that researchers should conduct comparable studies with various samples and in various countries. Cross-cultural research will be valuable to find out how culture influences the beliefs and practices of teachers. The findings of the study have significant implications for research on teachers' beliefs, Mathematics instruction and teacher preparation.

Keywords: *Certainty Knowledge, Constructivist Conceptions, Innate Ability, Quick Learning, Source of Knowledge, Structure of Knowledge, Traditional Conceptions*

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INTRODUCTION

Teachers' pedagogical and epistemological beliefs are considered to be significant factors as they could shape their conception of learning and teaching. These beliefs are significant to the perception not only why teachers use different teaching methods, but also how their students learn (Albalushi, 2020). Moreover, such beliefs are believed to have influences on the teaching practices of teachers' in their classrooms (Lee et al., 2013) which are vitally significant to the entire educational process. Consequently, studying and examining the teachers' beliefs could assist their professional development and preparation as well as future classroom practices.

In fact, several studies revealed that the academic achievement of Omani students is relatively poor in mathematics (Ministry of Education, 2010). Student's mathematics achievement in high school in Oman was very weak. This weakness might be due to the fact that the conventional education patterns and learning and teaching strategies are no longer compatible with the information explosion era in which students need to learn new patterns and the teachers must employ effective methods of teaching which enhance the students' performance in mathematics.

Based on an international study of mathematics and science (Ministry of Education, 2011). Oman comes in the 46th level in mathematics among the fifty participated countries. This result is considered as evidence of the low level of Omani students in mathematics. More seriously, Oman comes in the fourth level among the five participated Arab countries (Arab Organization for Education, Culture and Science, 2014). Moreover, the TIMSS report in 2019 revealed that Oman comes in the 35th level among the thirty-nine participated countries in terms of mathematics (Arab Organization for Education, Culture and Science, 2019).This might be attributed to the fact that teaching strategies are no longer compatible with the information explosion era in which students need to learn new patterns and the teachers must employ effective methods of teaching which enhance the students' mathematics achievement. The reasons behind such reluctance might be teachers' beliefs (Ministry of education, 2016). Research provides evidence on the link between teaching practices and student achievement (e.g., Lavy, 2011; Schwerdt & Wuppermann, 2011; Sergio & Margrida Alives, 2015). For instance, Sergio and Margrida Alives (2015) revealed that teacher's beliefs are straightforwardly associated with their practices and affect the students' educational experiences and results. Taking this into account, teachers should have an acknowledgement of their beliefs and how they use these beliefs in their teaching practices. Perkkilä (2006) reported that teachers' teaching practices differ with their beliefs. Furthermore, teaching practices of teachers are thought to be decided by their educational beliefs (i.e., their conceptions of learning and teaching) that have to be antecedent to their epistemological beliefs (i.e., beliefs about learning and knowledge acquisition) (Yilmaz & Sahin, 2011; Chan & Eliott, 2004). Teacher's epistemic beliefs and their pedagogical beliefs affect their adoption of recent strategies and techniques to be employed in classrooms (Fluck & Dowden, 2010; Yilmaz & Sahin, 2011; Kuzborska, 2011; Chan & Elliot, 2004; Lee, Zhonghua, Huan, & Xanthan, 2013). According to Lee, Zhonghua, Huan, and Xanthan (2013), teachers' pedagogical beliefs mediate the relation between epistemological beliefs and teachers' teaching practices. To sum up, pedagogical beliefs and epistemic beliefs might influence the learning strategies of individuals, problem solving, academic achievement and process of forming conceptions (Chan & Elliott, 2004; Cano, 2005; Cheng, Chan, Tang, & Cheng, 2009). Hofer (2001) offered a functioning model in which it is hypothesized that the teachers' epistemological theories would directly affect their educational practices as well as their tasks in the classroom which affect the epistemological theories of students regarding the beliefs about student learning, knowing and knowledge.

With this in mind, investigating mathematics teachers' epistemic beliefs and pedagogical beliefs is vitally significant because such beliefs have a key role in their teaching methods and effective instruction, as well as their pedagogical understanding (Bryan, 2003; Akay & Boz, 2010; van de Grift and Jansen, 2014; Pajares, 1992). Researchers contend that for teaching and learning process to change, educational beliefs of teachers about teaching and mathematics must change (Corkin, Ekmekci, & Papakonstantinou, 2015).

Although many studies have been done to scrutinize the influence of the beliefs of teachers on their classroom practices (Turner et al, 2016; Yoon, Kang, Kim, 2015; Bedel, 2012; Hofer, & Pintrich, 1997), most of these studies are primarily concerned with science teachers or teachers of other subjects. More importantly, the impact of epistemological beliefs and pedagogical beliefs on teaching practices has been studied and investigated by different scholars. However, there exists a heated debate among researchers on how and to what extent such variables influence teaching practices in the classroom.

Moreover, there are a few studies which examined the pedagogical beliefs as a meditative and moderator variable and its influence on the teaching practices and epistemological beliefs. Only the study of Lee *et al* (2013) has been identified by the researcher. More importantly, it seems that all the previously mentioned studies have been conducted in non-Arab world. For instance, Petko's study was conducted in Switzerland while Lim and Chai's (2007) study was carried out in Singapore. The studies of Liu (2010), Cook (2012), Rezvani (2011) and Lee *et al*. (2013) were conducted in Taiwan, Jamaica, Iran and China respectively. However, Terzi, Cetin, and Eser (2012) and Yilmaz and Kaya (2010) were concerned with the Turkish educational context.

This study will fill the gap by investigating the relationship between the epistemological and pedagogical beliefs of mathematics teachers and their influence on the teaching practices in the Omani context. This study might be helpful for learners, teachers, curriculum designers, policy makers and the entire educational process in Oman.

Epistemological Beliefs

Hofer (2004) pointed out that individual epistemology is presently a well-known strand of research which investigates the beliefs of students about the nature of knowledge and knowing. Epistemic studies offer three distinct research about epistemological beliefs among which formative models, a system of beliefs as well as other ideas. Moreover, Schommer (1994) proposed five measurements (a system of beliefs which is made out of many autonomous measurements) for epistemological beliefs among which *Omniscient Authority* (Knowledge is given over by the authority or got from reason), *Innate Ability* (The capacity to learn is gained or innate), *Structure of Knowledge or Simple Knowledge* (Knowledge is sophisticated or simple), Certain Knowledge (Knowledge is conditional or certain) and *Quick Learning* (Learning is gradual or speedy).

Pedagogical Beliefs

Teachers' pedagogical beliefs reflect their conceptions about learning and teaching. Pedagogical beliefs are classified into knowledge transmission (Teacher-centred or Traditional) or construction of knowledge (Student-centred or Constructivist). The constructivism theory assumes two models for learning: constructivism model and traditional model. In constructivism model, learning is not the process of receiving knowledge but rather a student's dynamic process of developing and remaking his/her phenomena conceptions since students understand new knowledge relying upon

their current information. Constructivist instructional method depends on the past conceptions of students about the learned subject and their belief about it. It stresses understanding as opposed to remembering and repeating information. The constructivist model could be summed up in this statement "knowledge is developed in the student's mind. This knowledge model has significant ramifications for teaching. Kiraly (2014) maintained that social information, for example, the images for the components or the days of the week could be taught by direct education. On the other hand, traditional knowledge is grounded on the prevalent sense belief that a real world is present without paying attention of whether we take interests in it or even notice it. Traditional theories have shaped the way classrooms are built, the way the knowledge of students is evaluated, and the way courses are taught. In the traditional model, the teacher is the sole source of the knowledge. Thus, in several classrooms, the chairs are fastened in the floor which enable all students to face the teacher (Kiraly, 2014). Tynjälä (1999) maintained that these differences between traditional theory and constructivist theory of knowledge mirror the difference between the philosophy of science called relativist as well as the philosophy of science called realist.

According to the best knowledge of the research, few or no studies investigated the relationship between pedagogical and epistemological beliefs in the Arab world in general and in Oman in particular. This study will fill the gap by investigating mathematics teachers' pedagogical beliefs as well as epistemic beliefs in the Omani context. The current investigation will upgrade the comprehension of the measurements of academic and epistemological beliefs that would be helpful to the professional growth of teachers as well as the improvement of learning and teaching results.

Furthermore, Chan and Elliott (2004) argued that it has been accounted for that epistemological beliefs are associated with methods and conceptions of instruction. As most of the related studies have been conducted in Western cultures and studies of similar nature conducted in Arab or Omani cultures are scarce, and the degree to attain simpler findings is unknown and needs better understanding. Since personal epistemic and pedagogical beliefs shaped by the cultural values the individuals hold (Rao, Moely, & Sachs, 2000; Purdie & Hattie, 2002; Chan & Elliott, 2004). Furthermore, epistemic and pedagogical beliefs are cognitive in nature and relevant to metacognitive variables (teaching and learning strategies), close correlation might take place between pedagogical beliefs epistemological beliefs, and this correlation should be explored (Chan & Elliott, 2004). Both of personal epistemic and pedagogical beliefs held mathematics teachers are worth investigating in that such variables might their teaching practices they do in the classroom and consequently affect teaching and learning outcomes. Hofer (2008) advocated to conduct cross cultures studies for better understanding the relation among different variables. This study was conducted to investigate mathematics teacher's epistemic beliefs, their pedagogical beliefs, and the correlation between pedagogical and epistemic beliefs. In particular, the current study answered the following study questions: 1) what are the levels of epistemic beliefs among mathematics teachers? 2) What are the levels of pedagogical beliefs among mathematics teachers? 3) Do teacher's epistemic beliefs contribute to their pedagogical beliefs?

METHODOLOGY

This section presents the methodology of the study. It highlights the study design, the population of the study, the sample of the study, the data collection instruments, the data analysis and the procedures of the study.

The Study Design

This study adopted the quantitative approach in which the quantitative data was collected from the participants of the study. This approach is used because it is useful for collecting data from a huge number of participants and this helps achieve the study objectives.

Population and Sampling

The population of the study included all secondary school mathematics teachers in eleven districts in Oman, namely, Muscat, South Batina, North Batina, Dakilya, Buraima, Westa, Musandam, Dofar, Daheera, South Sharkya and North Sharkya. Then, a stratified sample of four hundred mathematics teachers' enrolled in eleven districts of Oman are considered to be the sample of the study; Of whom, 225 were females and 175 were males. The age of the participants ranges between 25 and 55 years old (Mean= 43.45, SD= 3.56).

Data Collection Instrument

Three questionnaires were accumulated to frame one survey. The initial section of the questionnaire posed inquiries which are concerned with the participants' demographic information such as gender, years of teaching experience. The second part included an adapted epistemological beliefs survey. The third part included an adapted teacher pedagogical beliefs survey.

To measure teachers' epistemological beliefs, Epistemic Belief Inventory (EBI) offered by Schraw, Bendixen, and Dunkle (2002) was adapted in the Omani context. The EBI consisted of 32 items utilizing a five-point Likert type scale ranging from 1=strongly agree to 5= strongly disagree. The questionnaire was developed to assess beliefs based on five subscales: Certain Knowledge (C-K), Simple Knowledge (S-K), Quick Learning (Q-L), Omniscient Authority (O-A), and Innate Ability (I-A). The items: 2, 6, 14, 20, 24, 30, and 31 were reverse coded.

Data Analysis

The five original factors were clearly extracted from the EFA analysis accounting for 65% of the variance. Of the 32 items, 30 items were retained to measure the five factors. The CFA results revealed that the five-factor measurement model adequately fits the data. Lower scores refer to more naïve epistemological beliefs while higher scores refer more unconventional epistemological beliefs. AVE is around above 0.5 and all items with eigenvalues bigger than 1. The reliability for the five subscales is found to be between .58 and .71.

The EBI incorporates 32 items utilizing a five-point Likert type scale ranging from 1=strongly agree to 5= strongly disagree. The questionnaire is intended to quantify the beliefs as per five subscales: Innate Ability (I-A), Omniscient Authority (O-A), Quick Learning (Q-L), Simple Knowledge (S-K), and Certain Knowledge (C-K). The items: 2, 6, 14, 20, 24, 30, and 31 are opposite coded. The five original elements were unmistakably extricated from the EFA analysis explaining 65% of the variance. Of the 32 the items, 30 items were held to quantify the five elements. The results of CFA showed that the five-factor measurement model satisfactorily fits the study. Higher scores embody further developed epistemological beliefs while lower scores characterize more guileless epistemological beliefs. The reliability for the five subscales is accounted for between .58 and .71.

To measure teachers' pedagogical beliefs, the Teaching and Learning Conceptions Scale (TLCS) developed by Woolley, Woan-Jue Benjamin, and Anita. Woolley (2004) was adapted to suit the Omani context. TLCS comprises 21 items which assess three various conceptions of learning and teaching of teachers, namely, traditional conception (TC), constructivist conception (CC), and traditional management (TM). Teachers rated the items based on a six-point Likert-type scale with points rating the agreement level from (1) strongly disagree to (6) strongly agree.

The three original factors were clearly extracted from the EFA analysis accounting for 75% of the variance. Of the 21 items, 20 items were used to measure the three factors. The CFA results revealed that the three-factor measurement model appropriately is suitable for the data. AVE is around above 0.5 and all items with eigenvalues bigger than 1. The Teaching and Learning Conceptions scale's internal consistency coefficients are reported by the researchers to be, 78, .73, and .61 for the subscales TC, CC and TM, respectively. In this study, only TC and CC subscales were used. The questionnaires of the study were sent online to the participants of the study and then were collected via email and analyzed quantitatively using SPSS software. The obtained results will be presented in the next section.

RESULTS

Using the scoring systems for CC subscale (Creswell, 2012), the mean score of the teacher's constructivist conception was "high", 4.86, with a standard deviation of 3.11. The standard deviation as well as mean score in the TC subscale scores is 3.00 and 1.69, respectively. The mean score indicates that the teachers' traditional conception is "moderate".

The participants by and large posted a profile of advanced epistemological beliefs with the highest mean in the Certainty of Knowledge subscale (O-A) 3.77 with no missing data registered. Table 1 provides the means in the other sub-scales.

Table 1
Results of Descriptive Statistics (n = 210)

Instrument		Mean Score	Interpretation
CT		4.85 (3.11)	High
TT		3.00 (1.69)	High
	C-K	3.77 (1.40)	Moderate
	S-K	3.76 (1.37)	Moderate
EBI	I-A	3.57 (1.24)	Moderate
	Q-L	3.54 (2.13)	Moderate
	O-A	3.59 (2.15)	Moderate

Note: Standard deviations are enclosed in parenthesis.

Besides, the results of the Pearson Product Moment correlation coefficient between the scores of the instructors' pedagogical belief subscales as well as the epistemological belief inventory scale are presented in Table 2. It could be noticed that most of the subscales of epistemological beliefs are essentially associated with educational beliefs at the 0.01 level of confidence. The Quick Learning subscale was not related significantly to the two constructs of (CC as well as TC). Overall, epistemological beliefs are negatively connected with traditional conception and adversely associated positively with constructivist conception.

Table 2
Correlation Coefficients among the Variables

EB Variable	CC	TC
O-A	.545**	-.574**
I-A	.442**	-.439**
C-K	.377**	-.403**
S-K	.154**	-.190**
Q-L	.011**	0.006**

** Significant at 0.01 level

To further prove the examination, the data was exposed to multiple regression analysis. With all the assumption for the system satisfaction, the standard multiple regression was utilized to examine multiple correlation, R^2. Such measurement accounts for the variance of the dependent variable, that is represented by the direct amalgamation of the independent variables. The adapted R2 is the population quality which could be attributed from the features of the sample. In addition, the standardized regression coefficients, Beta, provide a sign of the commitment of every independent variable in anticipating the dependent variable as well as the independent variable *p*-value accounts for a significance measure of this variable in anticipating the dependent variable.

In light of this system, the R values were 0.599 and R2 0.359. Such findings demonstrated that 35.9% of the variance in the instructors' CC was accounted for the independent variables. The value of F-test for the analysis was found to be at 31.728 and is significant at the 0.01 level of significance.

In terms of the individual Beta values, all posted significant coefficients as found in Table 3. Such results propose that each variable which composes the epistemological beliefs is considered to be important attitude indicators toward the usage of computers. It should be noted, notwithstanding, that the variable, Quick Learning showed an unimportant and insignificant positive association with CC as seen in Table 2.

Table 3
Regression Coefficients of Standard Regression Model (CC) Variable

	Unstandardized coefficient		Standardized coefficient	t-value
	B	Std. Error	*Beta*	
O-A	.264	.049	.389	5.356**
Q-L	.260	.059	.239	4.395**
I-A	.118	.049	.166	2.414**
S-K	.131	.057	.115	2.320**
C-K	.124	.056	.142	2.216**

** - Significant at 0.05 level; * - Significant at 0.01 level

Table 4
Regression Coefficients of Standard Regression Model (TC)

Variables	Unstandardized coefficient B	Std. Error	Standardized coefficient *Beta*	*t*-value
Source of Knowledge	-.399	.063	-.445	6.290**
Quick Learning	-.325	.076	-.227	4.282**
Structure of Knowledge	-.223	.073	-.149	3.066**
Certainty of Knowledge	-.171	.072	-.148	2.371**
Innate Ability	-.107	.063	-.113	1.690**

** - Significant at 0.05 level; * - Significant at 0.01 level

As for the EBI variables and TC, the analysis yielded .626 and .392 for the R and R^2 values, respectively. Thus, Thus, 39.2% of the variance in the instructors' TC was accounted for collectively by the EBI variables. Besides, the statistics of F-test was significant at the .01 level of confidence. The standardized regression coefficients, Beta, all provide important values as noticed in Table 4, proposing that all are important TC indicators. As stated in the discussion above, it posted an insignificant correlation coefficient with attitude; the Quick Learning variable remains a significant indicator when combined with the other variables of EBI and collectively tested. In general, epistemological beliefs are predictors of pedagogical beliefs.

Table 5.
Beta Values (CC) and Correlation Coefficients

Variables	Correlation Zero-order	Partial	Part	Part squared
Source of Knowledge	.545	.303	.255	.065
Innate Ability	.442	.142	.115	.013
Certainty of Knowledge	.377	.131	.105	.011
Structure of Knowledge	.154	.137	.110	.012
Quick Learning	.011	.253	.209	.044

Table 6
Beta Values (TC) and Correlation Coefficients

Variables	Correlation Zero-order	Partial	Part	Part squared
Source of Knowledge	-.574	.350	.292	.085
Innate Ability	-.439	.100	.078	.006
Certainty of Knowledge	-.403	.140	.110	.012
Structure of Knowledge	-.190	.179	.142	.020
Quick Learning	-.006	.247	.199	.040

To figure out which of the variables of EBI was the best indicator of CC, standardized regression coefficients (*Beta*), partial correlation coefficients and part correlation coefficients, were tested. Table 5 demonstrates that Source of Knowledge has the biggest Beta value, part correlation coefficient and partial correlation coefficient, showing that it was the best indicator of CC and has a significant impact in CC prediction. This indicator represented 6.5% of the total CC variance after the control of the other four independent study variables. Similarly, the Source of Knowledge variable gained the best Beta, Beta, partial, part and part squared coefficient as shown in Table 6. This result

proposes that it was the best TC indicator, accounting for 8.5% of the total TC variance after the controlling the impact of the other four EBI factors.

DISCUSSION OF THE RESULTS

The obtained results of the current study showed that the teachers for the most part have unconventional beliefs about the nature of knowing as well as knowledge. For the five measurements (i.e. Quick Learning, Certainty of Knowledge, Structure of Knowledge, Source of Knowledge, and Innate Ability), teachers attained a mean value which was higher than the mid-point of the five-point scale, indicating that teachers would generally believe that Knowledge is not simple, Knowledge derived from reason, Knowledge is tentative, the capability to learn is developed, and learning is ongoing. These results might be due to mathematics curricula, teachers' pedagogical beliefs, education system, educational process, and Omani culture.

The relatively high mean scores of innate ability and quick learning can be attributed to Omani culture in which hard work and effort are regarded as a significant factor of success. The relatively high mean scores of omniscient authority can be also attributed to the societal context of Omani, the interaction between Oman and Western cultures, professional development training, and the globalization. As such, teachers acquire their knowledge from different sources. According to Omani culture and religion, the individuals should search for the truth and knowledge from different sources. In other words, knowledge of experts and the other sources of knowledge should be judged at a societal level according to circumstances. The highest mean scores of the certain knowledge could be attributed to teacher's environment, which pose some issues to the teachers. The highest mean of simple knowledge could be attributed to the professional development which improve teacher's ability to deal with difficult issues. The highest mean for fast learning could be attributed to the existence of fixed rules for learning technique among the instructors.

Regarding constructivist and traditional beliefs, the findings revealed that Omani teachers of mathematics had constructivist convictions about learning and teaching, Epistemological convictions (Quick Learning, Certainty of Knowledge, Structure of Knowledge, Source of Knowledge and Innate Ability) are positively associated with constructivist originations about learning and teaching, but negatively correlated with traditional conceptions Furthermore, epistemological beliefs predict constructivist and traditional conceptions very well. These results indicate that teachers' constructivist conceptions and their epistemological beliefs are linked. This can be attributed to the teacher's epistemological beliefs and teacher-student interpersonal relationships and students' motivation. As mentioned earlier, mathematics teachers hold advanced beliefs about their ability of learning and knowledge acquisitions, which in turn affect their conceptions about teaching and learning. Our findings seem to be in line with the relevant literature (e.g., Cheng, Chan, Tang, & Cheng, 2009; Eren, 2010; Chai & Khine, 2008; Windschitl, 2002).

This study presents several contributions, for example, it highlighted the relationship between epistemological and pedagogical beliefs of mathematics teachers in Oman and how such beliefs affect the teachers' practices in the classroom. The findings of the current study can be valuable to mathematics teachers in the developing countries, like Oman, in that such findings might contribute to understanding the problems at higher levels of education. Besides, the present study would offer the Ministry of Education in Oman with recent data which will assist the Ministry to make appropriate policy decisions and apply the educational strategies with greater certainty. More importantly, the obtained findings of this study have been positively added to the literature by filling

the existing research gap in the Arab world in general and Oman in particular; this study could be also considered as a foundation for the research community to proceed with further research on mathematics, teachers' beliefs, and learning and teaching mathematics effectively.

CONCLUSION

The present study has revealed that mathematics teachers' epistemological beliefs can affect their pedagogical beliefs. Further, our study revealed that mathematics teachers' hold advanced epistemological and pedagogical beliefs. Having said that, it is vital to comprehend the ways in which beliefs can be changed. In the future, more studies could be conducted to investigate the mediation role of pedagogical beliefs on the association between epistemological beliefs and teachers teaching practices. Besides, further research could also be conducted using structure equation model (SEM) to explore the effect of epistemological beliefs, pedagogical beliefs, and their teaching practices on students' learning strategies as well as learning outcomes.

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