Assessment Practices of Mathematics Teachers in Oman

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Abstract: Mathematic teachers' assessment practices can be concluded as essential practices of mathematics teachers toward achieving the aims of teaching mathematics. This research aimed to determine the teachers' assessment practices of mathematical thinking in Oman. A total of 245 mathematics teachers (134 females and 111 males), who teach at public schools in Oman, participated in this research. A scale of assessment practices of mathematical thinking was used to record the responses of the teachers. The results of the research showed that the teachers used several assessment practices to assess students' mathematical thinking. The formative assessment practices were used more than the other assessment practices, and the least used was electronic assessment practices. The findings of this study provide practical implications for mathematic teachers in Oman.

Keywords: Mathematic teachers; Oman; teaching mathematics; assessment practices

1. Introduction

According to the scholars in the field of mathematics education, teachers' assessment practices are the main elements of students' development in their knowledge and skills in mathematics (Hafizi & Kamarudin, 2020; Alkharusi, 2010; Har, 2010; Maoto et al., 2018; Yavuz Mumcu & Aktürk, 2017). The assessment practices offer essential information concerning students' mathematics learning to teachers, educational organizations, and institutes. Moreover, the assessment provides indicators about the effectiveness of teaching practices like classroom management, instructional planning, evaluation practices, and teaching methods. These information help teachers, educational associations, and institutes reform and improve teachers' practices by determining the students' strength and weaknesses at different points of learning. It allows them to decide on the more appropriate practices to improve students' learning (Faragher et al., 2019; Marinho et al., 2017). For example, students face difficulties in specific topics like fractions; hence, they need to improve their understanding of fraction magnitude (Sivasubramaniam & Kamarudin, 2020). Therefore, it is essential to increase students' attention towards the teachers' assessment practices and the information obtained from these practices.

Some mathematics education studies were issued concerning teachers' practices with respect to assessing students' mathematics learning. For instance, Richland and Begolli (2016) examined the teachers' assessment practices aimed to define the students' high-level thinking in mathematics. The results revealed that the assessment practices helped to improve students' mathematical thinking and mathematics learning. Further, Wang and Cai (2018) investigated the tasks used by teachers to assess and improve the students' thinking in mathematics.

The studies showed that teachers used various methods by incorporating qualitative and quantitative tools to assess their students' mathematical learning and thinking inside and out of the classroom. The tools include quizzes, short questions, oral tests, and paper-pen-test. These tools can be used to portray the students' mathematics level by incorporating different question types, such as multiple-choice, matching, open-ended and close-ended questions, mental exercises, and long-answer questions (Alkharusi, 2010; Buabeng et al., 2019). Teachers also applied different qualitative assessment tools such as interviews, journals, simulations, collecting notes, projects, and observations. They analyze the students' responses in learning tasks to gain perspective regarding the students' learning process (Buabeng et al., 2019).

Moreover, teachers' assessment practices are not limited to gathering information about the students' learning and assessing their learning level, and whether they benefit from the analysis to develop other teaching approaches like instruction, evaluation, and classroom environment management. The analysis results can be applied to improve students' learning by defining the weaknesses and strength of students' learning capacities (Sivasubramaniam & Kamarudin, 2020). They can also be used to develop teachers' performance by modifying teaching methods and the tasks level provided to students (Gill et al., 2013). Institutions of education also use the assessment practices' outcome to evaluate different educational system parts, such as teaching practices, assessment systems, and curriculums. The data helped define which aspects need to be improved (Baker, 2010; Richland & Begolli, 2016). Thus, teachers' assessment practices help develop students' learning, teachers teaching, and reform the educational plans in general.

The importance of thinking skills in mathematics within the teachers' assessment practices of mathematics is mentioned by mathematics educators (Hafizi & Kamarudin, 2020). For example, Gibney (2014) stated that assessment tasks need to address teachers' awareness of mathematical thinking to improve students' mathematical thinking. Teachers can improve their students' knowledge from the information of the analysis and answers to the activities. This information provides teachers with an in-depth perspective of their students' mathematical thinking (Turner et al., 2016).

2. Literature Review

Assessment practices in mathematics help to enhance the students' mathematical learning and thinking. They also help to increase the student's success by improving their mathematics problem-solving abilities. They constitute some of the learning styles that help students to organize their learning and thinking in mathematics (Har, 2010). For instance, the findings of Abdullah et al. (2019) revealed that students could successfully solve mathematical problems when they tried to comprehend the problem and draw a plan for solving the problem before they start to solve it. Some of the evaluating tasks, such as free-response tasks, developed the students' thinking. Students can activate their thinking by addressing not restricted and non-routine answers (Hunter & Jones, 2018).

The teachers modified the tasks and questions appropriate for the students to gain information on students' strength and weaknesses (Sivasubramaniam & Kamarudin, 2020). It also helped teachers to give students the suitable feedback concerning students' learning levels (Ling et al., 2012). They could estimate their efficiency in teaching mathematics based on the assessment results. The results of assessment practices allow decision-making concerning students' learning and teachers' teaching. Thus, teachers need to have sufficient assessment knowledge and skills (Unal & Unal, 2019).

Research concerning mathematics education revealed that mathematics teachers' assessment practices contain various assessment practices in and out of the classrooms. The assessment practices of teachers are categorized into different methods, i.e., diagnostic, summative, and formative assessments (Brooks, 2017; Tee et al., 2019). In comparison, others classified assessment practices into alternative and traditional assessments (Baker, 2010; Gill et al., 2013). In addition, some new assessment practices appeared as a conclusion of technological tools application in education, known as the digital or electronic assessment practices. The electronic assessment practice involves both teachers and students in using electronic tools and applications such as computers, iPad, websites, and mobile applications (Newhouse & Tarricone, 2014; Sharp & Hamil, 2018). Teachers use both traditional and formative assessment practices to evaluate and develop students' mathematical thinking because the traditional assessment practices could not introduce enough information about their abilities and skills in mathematical thinking (Hunter & Jones, 2018). However, it is hard to distinguish all types of assessment practices because there are some overlapping areas.

Previous studies have utilized various methods and instruments for data and information collection concerning teachers' assessment practices of. Some researchers used interviews to determine the application of mathematics assessment practices (Marinho et al., 2017). They categorized the assessment practices into quantitative and qualitative practices. Meanwhile, Alkharusi (2010) used questionnaires to evaluate the assessment practices of teachers. The findings indicated that teachers' experiences influence their assessment practices. Wang and Cai (2018) and Abdullah et al. (2019) examined some evaluation tasks addressed by teachers and how they responded to students' answers. Furthermore, Reyes-Cedeno et al. (2019) used a set of tools contained questionnaires and interview to collect data for quantitative and qualitative analyses. Various tools that were used by researchers helped to recognize the assessment practices from different aspects.

In Oman, mathematics teachers depend on assessment documents issued by the Ministry of Education and distributed to all Omani public schools. These documents defined the assessment procedures, reports, and tools that should be addressed by mathematics teachers. The document describes each assessment period and the distribution of degrees to the assessment tools and mathematics content. Besides, the document allows the teachers to harmonize assessment tools and procedures for the level and privacy of students in the school (Ministry of Education, 2018).

Many researchers in mathematics education concentrated on mathematics teachers' assessment practices to gain knowledge regarding the teachers' practices by conducting various research types, including assessing the assessment practices using qualitative and quantitative methodologies. However, most studies were conducted on mathematics teachers' assessment practices in general. Few of them have focused on the teachers' assessment practices of mathematical thinking. For example, Alhunaini et al, (2020) developed an instrument for measuring teachers' assessment practices of mathematical thinking. They tested the instrument by using confirmatory factor analysis. The results showed that the instrument reached the good fit indices. Thus, this research tried to gain a perspective regarding the assessment practices of mathematics teachers in Oman through applying the instrument that was developed by Alhunaini et al, (2020). The objective of this research was to investigate mathematics teachers' assessment practices of mathematical thinking in Oman. The research would introduce information concerning the degree of teachers' usage of each practice in public schools and the mostly applied practice.

3. Methods

3.1 Participants and Procedures

The participants in this research were 245 mathematics teachers (134 females and 111 males) who teach at public schools in Oman. They teach mathematics for grades 5 to 12. The teaching experience of the teachers varied from 1 to 25 years. The data collection commenced upon approval of the Ministry of Education. The researcher briefed the teachers that they were free to participate in the research, and their responses would stay confidential. Then, after the application of the instrument, the data were analyzed to answer the research questions.

3.2 Instrument

The instrument used in the current research was a questionnaire of assessment practices of mathematical thinking. It was developed by Alhunanni et al (2020). The instrument contained 21 items distributed into 5 dimensions as follows; diagnostic assessment (4 items), formative assessment (4 items), summative assessment (4 items), alternative assessment (4 items), and electronic assessment (5 items). The instrument adopted some previous assessment practices to the NCTM (2000) standards and mathematics syllabus content applied in the Omani governmental schools. The instrument was a questionnaire that contained items using the 5-point Likert scale (5 = Always, 4 = Mostly, 3 = Sometimes, 2 = Rarely, and 1 = Never). The items were written in Arab. The reliability was tested using Cronbach's alpha coefficient for all dimensions. Referring to Table 1, all dimensions have Cronbach's alpha of more than 0.7, with an overall Cronbach's alpha of 0.855. Besides, the Cronbach's alpha coefficient for all dimensions in this research is 0.91, indicating that all dimensions have reached the accepted internal consistency.

Table 1: The Cronbach's alpha coefficients for the dimensions

Assessment practices of mathematical thinking dimensions	**α**
Diagnostic Assessment	0.816
Formative Assessment	0.816
Summative Assessment	0.816
Alternative Assessment	0.820
Electronic Assessment	0.830
All items of APMT	0.855

The instrument was tested by confirmatory factor analysis, as shown in Figure 1. The results showed good fit indices for the scale of assessment practices of mathematical thinking. The scale achieved the suitable criteria as CMINDF = 2.594, which achieved the threshold of < 3; CFI = 0.922, which passed the threshold of > 0.90; IFI = 0.922, which reached the threshold of > 0.90; TLI = 0.911, which met the threshold of > 0.90; GFI = 0.922, which achieved the threshold of > 0.90; SRMR = 0.049, which reached the threshold of < 0.80; and RMSEA = 0.055, which met the threshold of < 0.80. Lastly, the values of higher loadings of the five dimensions are statistically significant, indicating a T-value of ≥ 1.964, with P-value ≤ 0.05.

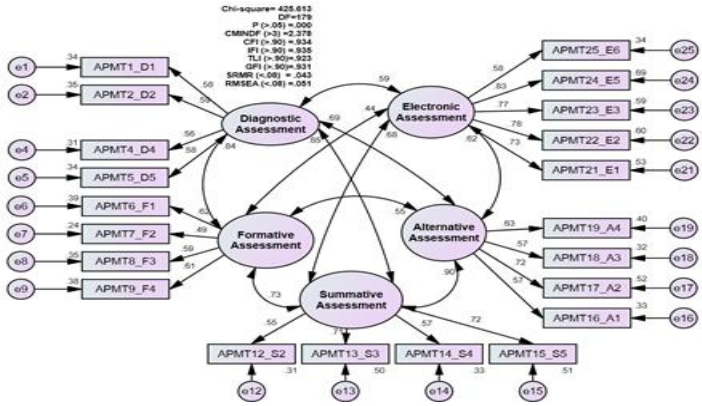

Figure1. Confirmatory factor analysis for assessment practices of mathematical thinking.

4. Data analysis

The normality of items on the scale was tested through skewness and kurtosis. The result showed that all dimensions are located within the normal distribution (< 3 for skewness and < 7 for kurtosis), as mentioned by Kline (2015). The means and standard deviation were calculated to define the level of using each type of assessment practices. Repeated measured was addressed to determine with assessment practices was more used by the teachers.

5. Results and Discussion

The current research aimed to investigate mathematics teachers' assessment practices of mathematical thinking. To determine the effectiveness of teachers' assessment practices, the means and standard deviation were calculated for each type of assessment practices as follows:

Diagnostic assessment

Table 2 presents the mean of items related to teachers' diagnostic assessment practices' mathematical thinking in descending order. The results showed that the overall mean of diagnostic assessment is (4.05), with a standard deviation of 0.85. The mean indicates that teachers mostly used the diagnostic assessment within their teaching practices. They often give mathematical problems to students before starting a topic. They also asked their students to study some tasks, including graphical representation, to discover their abilities in presenting the mathematical representation. However, the least utilized diagnostic practice is diagnostic tests to identify students' skills in mathematical thinking.

Table 2. Means and standard deviation of teachers' diagnostic assessment practices

Item	Mean	SD
Putting up mathematical problems to students before starting mathematics subjects.	4.44	0.99
Ask students to study tasks such as graphic representations to discover their ability to represent of mathematical representations.	4.20	1.18
Measure the level of students' mathematical thinking before starting to teach mathematics.	3.92	1.33
Apply diagnostic tests to identify students' skills in mathematical thinking.	3.66	1.30
Mean	4.05	0.85

Formative assessment

The results showed that teachers mostly apply the formative assessment practices of mathematical thinking, which can be concluded from the overall mean of the formative assessment practices of 4.5 and a standard deviation of 0.7. They employ multiple-choice questions to measure the students' ability in acquiring mathematical skills. Furthermore, they gave students pre-determined assignments and activities to develop their mathematical thinking abilities. They help their students' mathematical thinking by monitoring them using some suggestions to guide them. They also analyze the students' answers to identify their progress in mathematical thinking skills. Table 3 displays the means and standard deviation of teachers' formative assessment practices.

Table 3. Means and standard deviation of teachers' formative assessment practices

Item	Mean	SD
Employ multiple choice questions to measure the level of students' ability of acquiring mathematical skills while my mathematics teaching.	4.71	0.78
Giving students pre-determined assignments and activities to develop their mathematical thinking abilities.	4.58	0.95
Give students suggestions that enable them to monitor their progress in mathematical thinking skills.	4.44	1.02
Analyze students 'answers to identify students' progress in mathematical thinking skills.	4.27	1.15
Mean	4.5	0.70

Summa'tive assessment

The means and standard deviation of items concerning teachers' summative assessment practices is presented in Table 4. The results indicated that the overall mean of teachers' summative assessment practices reached 4, with a standard deviation of 0.96. The result revealed that the teachers applied the summative assessment of mathematical thinking via different assessment tools, such as homework and classroom tasks. They consider the extent of homework and classroom activities organization when evaluating the students' level of mathematical thinking. They inform each student of his or her strength and weaknesses on the measuring instrument used to evaluate performance. They also used their students' presentations to evaluate their level of mathematical thinking. The least summative practice of the teachers is conducting a description of the mathematical thinking skills that each student has at the end of the teaching mathematics course.

Table 4. Means and standard deviation of teachers' summative assessment practices

Item	Mean	SD
Consider the extent of organization of the homework and classroom activities when evaluating the level of mathematical thinking of the student.	4.37	1.10
Inform each student of his or her strength and weaknesses on the measuring instrument used to evaluate performance.	4.04	1.22
Use students' presentations to evaluate the level of mathematical thinking of them.	3.99	1.30
Make a description of the mathematical thinking skills that each student has at the end of teaching mathematics course.	3.6	1.37
Mean	4.00	0.96

Alternative assessment

The results in Table 5 revealed that teachers sometimes use alternative assessment practices when they assess their students' mathematical thinking, with an overall mean of 3.89 and a standard deviation of 1.01. They considered their students' tendency towards mathematics when feedback is provided. They activated the students' portfolios to evaluate their mathematical thinking. However, the least alternative assessment practices of mathematical thinking of the teachers were comparing each student's level with other students' levels in mathematical thinking.

Table5. Means and standard deviation of teachers' alternative assessment practices

Item	Mean	SD
Consider the student's tendency towards mathematics when feedback is provided.	4.33	1.09
Activating the student's portfolio to evaluate students' mathematical thinking.	4.07	1.32
Training students to evaluate strong and weak samples or models of classroom work related to the mathematical thinking of previous students.	3.73	1.41
Comparison of a student's level with the levels of other students in mathematical thinking	3.42	1.45
Mean	3.89	1.01

Electronic assessment

Table 6 shows the means and standard deviation of the electronic assessment practices of mathematical thinking. The overall mean of electronic assessment practices is 3.28, with a standard deviation of 1.07. The results showed that the teachers sometimes use electronic calculators to train students on some mathematical conclusions. They also sometimes apply phone applications for developing students' mathematical thinking skills and activate websites related to mathematical thinking to train students on self-assessment. The least electronic assessment practice of mathematical thinking is designing some electronic tests related to mathematical thinking skills.

Table 6. Means and standard deviation of teachers' electronic assessment practices

Item	Mean	SD
Use electronic calculators in training students on some mathematical conclusions.	3.65	1.32
Employing some phone applications for developing students' mathematical thinking skills.	3.43	1.38

Assign students to perform some tasks using computerized mathematics programs in the implementation of graphs.	3.17	1.41
Activating websites related to mathematical thinking to train students on self-assessment	3.09	1.36
Design of some electronic tests related to mathematical thinking skills.	3.07	1.34
Mean	3.28	1.07

Table 7 shows the order of teachers' usage of mathematical thinking assessment practices depending on the means and standard deviations. Table 7 shows that the formative assessment practices is the first order as highly practiced by the teachers to assess students' mathematical thinking. This is followed by a diagnostic assessment and summative assessment. Table 7 also shows that alternative and electronic assessments are identified as the least practiced assessment types of mathematical thinking.

Table 7. The assessment practices of mathematical thinking

The assessment practices	**Mean**	***SD***
Formative assessment	4.50	.70
Diagnostic assessment	4.05	.85
Summative assessment	4.00	.96
Alternative assessment	3.89	1.01
Electronic assessment	3.28	1.07
Mean		

To make sure from the significant order of the teachers' assessment practices of mathematical thinking that is presented in Table 7, repeated measured analysis. The analysis can be used to determine the significant differences between assessment practices of mathematical thinking. Table 8 includes the results of repeated measured analysis related the teachers' assessment practices of mathematical thinking.

Table 8.Analysis of Variance Summary Table

Source	**Type III Sum of Squares**	**Df**	**MS**	**F**	**P**
Between Subjects Effects	188.30	4	47.07	120.53	0.000
Error	381.21	967	0.391		

Note. *p < 0.05

The results in Table 8 show that the value of F is 120.53, which is statistically significant at $\alpha = 0.05$. Thus, the results indicated a statistically different overall means between the teachers' assessment practices of mathematical thinking. This refers to the differences in the teachers' assessment practices of mathematical thinking between different assessment practices. Scheffe's post-hoc test was used to determine the source of differences, and the results are displayed in Table 9.

Table 9. Scheffe's Post Hoc Test for assessment practices

Constructs	**1**	**2**	**3**	**4**	**5**
1. DA		-0.446*	0.053	0.166*	0.774*
2. FA			0.499*	0.612*	1.220*
3. SA				0.113*	0.721*
4.AA					0.688*
5.EA					

Note. *p < 0.05. Diagnostic assessment= DA; Formative assessment= FA; Summative assessment= SA; Alternative assessment=AA; Electronic assessment=EA

Table 9 shows statistically significant differences between teachers' diagnostic assessment practices and their formative assessment practices. However, no significant difference is noted between the teachers' diagnostic assessment practices and their summative assessment practices. There is also a statistically significant difference between teachers' diagnostic assessment practices and their alternative and electronic assessment practices. Moreover, the results indicated a statistically significant difference between the teachers' formative assessment practices and their summative assessment practices, alternative assessment practices, and electronic assessment practices. The results also indicated a statistically significant difference between the teachers' summative assessment practices and their alternative and electronic assessment practices. The teachers' alternative assessment practices, and their electronic assessment practices also showed a statistically significant difference. Thus, it can be concluded that the teachers' formative assessment practices are the highest assessment practices, followed by a diagnostic and summative assessment and alternative assessment practices. The least practice is electronic assessment practices.

6. Conclusion

In conclusion, the results showed that teachers mostly apply the assessment practices of mathematical thinking. They address different assessment tools such as tests, homework, quizzes, classroom activities, projects, and representations. They applied the diagnostic assessment via different problems and tasks related to mathematical thinking. The teachers used the formative assessment to develop and monitor the students' mathematical thinking by giving the students the required activities and analyzing their responses to these activities. They inform the students about their results in the summative assessment tools. The students' profiles were activated as alternative assessment practices when they evaluate the students' mathematical thinking. Electronic assessment mostly appeared when teachers train their students in calculation skills using electronic calculators. The teachers implemented different assessment types and tools because they followed the assessment documents, as instructed by the Ministry of Education. Those documents ask teachers to apply different tools such as quizzes, oral tests, projects, and activate the students' profile to evaluate their mathematics learning (Ministry of Education, 2018). Teachers apply various types and tools of assessment to meet the variety of students thinking levels and tendencies towards mathematics. These results are consistent with the results of previous studies. For example, Brooks (2017) stated that teachers apply assessment tools because they need to recognize more of their students' learning. Hunter and Jones (2018) referred that teachers should not depend only on the traditional assessment practices but also use alternative assessment practices to gain an in-depth perspective about the students' mathematical thinking.

The results revealed that formative assessment practices appeared as the highest assessment practice of mathematical thinking, followed by diagnostic and summative assessments. The results also indicated that electronic and alternative assessment practices are the least assessment practices of mathematical thinking. The formative assessment practice is the most utilized because it is used as a predictor for summative assessment (Tee et al., 2019). The results of the assessment helped to determine the strength and weaknesses of students' learning. This helps them to provide students with timely feedback. The finding is consistent with Ling et al. (2012), who stated that teachers provided their students with timely feedback about their achievement level.

Furthermore, applying alternative assessment practices in mathematical thinking is less than the traditional assessment practices because it is easier to implement. Unal and Unal (2019) reported that teachers tend to use traditional assessment practices more than alternative and electronic assessment practices because traditional assessment practices are easily utilized than the alternative assessment. Moreover, the teachers' assessment practices were influenced by other variables that were not included in this study, such as assessment beliefs, classroom assessment environment, and the teachers' self-efficacy in assessment (Alkharusi, 2010; Marinho et al., 2017). Newhouse and Tarricone (2014) stated that electronic assessment required both teachers and students to be familiar with the electronic tools and application, which is not usually available.

Mathematics teachers in Oman need to increase their assessment practices of mathematical thinking. They need to develop their abilities to use modern technology of learning, such as social media, mobile, and online meeting applications, to be up-to-date with the current scenario. The COVID-19 pandemic proves that the process of teaching and assessing needs to be reformed to meet the requirements of online classes and the practice of social distancing.

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