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Using Teaching Practices Inventory to Evaluate Mathematics Faculty Teaching Practices in Higher Education

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Teaching Practice Inventory (TPI) was developed and used by Carl Wieman and hence named as Carl Wieman, evaluation model (Wieman & Gilbert, 2014) to assess the effectiveness of teaching practices of courses by faculty instructors. In TPI high scoring courses means that teaching practices may support students' learning. It is also a response validated survey that allows individual faculty members to describe their teaching practices. This descriptive study aims to investigate faculty members' teaching practices in undergraduate mathematics courses at King Saud University using the TPI. This TPI inventory was distributed to undergraduate teaching members who teach 15 courses. We received 78 responses: 40 from the mathematics department at the First Common year, and 38 from the Mathematics Department at the College of Science. The results indicate that faculty are adept at incorporating collaboration and in-class activities into their teaching; however, they are less skilled in other categories, including evaluation methods, diagnoses and training, and guiding teaching assistants. The results reveal that female instructors are statistically significantly ($\alpha \leq 0.05$) more skilled at collaboration. Based on these results, the researchers recommend designing professional development programs to help faculty members at King Saud University improve their teaching practices.

Keywords: teaching practices, university instructors, Carl Wieman, evaluation model, teaching

INTRODUCTION

Mathematics is the language of modern science; all sciences depend in one way or another on mathematics. Therefore, mathematics is at the forefront of educational skills: it contributes to students' critical thinking, helps them identify and solve problems, and

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gives them the skills to disseminate their knowledge into daily life (Cheng et al., 2004; Clayson, 2009; Ericsson, 2006; Sadler et al., 2013).

For these reasons, teachers' pedagogical methods are crucial in mathematics classes in order to ensure students' adequate learning (Al-Qaisi, 2005; Knight & Wood, 2005). Such teaching becomes especially important during the transition between high school and higher education and during students' first year of college. At this stage in their education, students may face new challenges in primary mathematics courses (Diezmann et al., 2004), which may affect their overall grades and even affect their ability to complete their degrees later on. Teaching practices can have a critical effect on students' ability to succeed; university instructors have a huge impact on students' learning and interact with them daily during most of their learning process (Ambrose et al., 2010). Therefore, faculty teaching practices must be analyzed to help students succeed at these difficult courses (Shaaban & Afifi, 2007).

Prior studies have focused on the traits of effective instructors who stimulate students' interest and motivation. For example, teachers should be able to integrate student-centered learning into the classroom and engage students in the knowledge construction process (Al-Zahrani, 2014; Assas, 2011; Derting & Ebert-May, 2010). A teacher's role is therefore not only to transfer knowledge, but to create opportunities for students to acquire learning and thinking skills on their own and then to employ these skills in solving problems both in class and throughout their lives. This helps students to deepen their understanding, correct their misconceptions, develop a sense of achievement, and develop creative and critical thinking skills, all important objectives of the educational process (Abd-El-Khalick, & Lederman, 2000). In addition, such methods can help students form positive attitudes towards learning and develop problem-solving, time management, and dialogue skills (Boghossian, 2012; Onen et al., 2011).

Despite the growing understanding of what could enable teacher to help students improve their achievements and skills, there is still a need to improve teachers and university instructors' teaching methods (Shaaban & Afifi, 2007). Numerous studies have found that the performance of mathematics teachers at schools and universities is low, which hinders the achievement of desired goals and educational outcomes (Al-Zahrani, 2014; Alahmadi, 2014; Assas, 2011; Hassan, 2006; Lami & Adai, 2013;). These studies indicate that teachers and faculty members must develop effective teaching skills according to international standards, including the ability to organize and manage pedagogical processes (Berk, 2005). Regarding gender differences in teaching skills, social theories (Adenzato, Cavallo, & Enrici, 2009, Schulte-Ruther, Markowitsch, Shah, Fink & Piefke, 2008) suggest that males are more effective in many practices. Other studies such as Murphy, Eduljee, Parkman & Croteau, 2019) indicated that male are more skills in some activities such as " actively participating in organized classroom group activities." And that females are more skilled in other activities such as "volunteering to answer professor's questions."

In reviewing the literature, however, we found a scarcity of studies that address the performance assessments of university lecturers and faculty members (Gibbs & Simpson, 2005). However, Wieman and Gilbert (2014) note that one of the most important obstacles in higher education is the difficulty of determining a comprehensive way to evaluate the teaching performance of faculty members. This affects universities' ability to define quality standards that can be used to improve university teaching practices. To solve this problem, Wieman and Gilbert developed a tool to assess the teaching practices of faculty members in science, technology, engineering, and mathematics (STEM). According to Wieman (2015), this tool can capture both general and specific changes over time within a department. Over time, it has attracted the interest of many educators and institutional staff and has been used in a number of universities to assess more than 200 STEM programs around the world (Undergraduate STEM Education Initiative, 2011; Smith et al., 2013; Horaa et al., 2013).

Kardia and Wright (2004) stated that "Teaching requires skill, insight, intelligence, and diligence, and faculty struggle and succeed in a variety of ways to meet the challenges of the classroom." Male and female faculty members exhibit teaching practices in different ways. Teachers' perception about their teaching practices is considered as a crucial aspect their professional development. Moreover, knowing this issue is critical to assisting faculty in their efforts to improve their teaching. One of the goals of this study was to compare teaching practices of male and female instructors to determine whether gender differences vary by the types or the nature of the skills.

More specifically, knowing how they allocate their time in the classroom in terms of lecturing and active classroom practices may allow us to design professional development program that is suitable for each of them.

In this study, we have used the inventory which was created by Wieman and Gilbert to characterize the teaching practices made by instructor teaching mathematics courses. As the developers of in inventory indicated, it can help math courses instructors implement fruitful reflection on their teaching. Therefore, this study attempted to apply Wieman's evaluation model to the teaching practices of undergraduate mathematics faculty. Given the general decline in mathematics teachers' performance, both in general (Horaa et al., 2013) and specifically among university lecturers (Wilson & Mack, 2014), we hope that this model will allow us to investigate the size of the problem, identify some of the reasons for this decline, and suggest ways to overcome it. In short, the aim of this study was to investigate faculty members' teaching practices in undergraduate mathematics courses at King Saud University using the TPI. To this end, this study seeks to answer the following questions:

(1) How can using Wieman's model help us better understand the teaching practices of primary mathematics faculty members at KSU?
(2) Are there statistically significant differences ($\alpha \leq 0.05$) in the performance of faculty members of different genders?

How are KSU mathematics courses taught in comparison to those at other international universities?

METHOD

In this study, data was taken from a large cross-sectional study aimed at mapping changes in the teaching and learning of mathematics at King Saud University (KSU) in Saudi Arabia. Descriptive and analytical methods were applied to achieve the research objectives described above. The tool, which is the main source of the data, consists of

72-item inventory with scoring rubric. The inventory is fully described in Wieman and Gilbert (2014) study. Other data used for answering the third question in this study was taken from Wieman and Gilberts (2014) scoring rubric after obtaining a permission letter from the main author. According to this rubric, if the ETP scores were capturing all practices important for learning, these courses would have the highest ETP scores. Therefore, this may indicate there are tremendous contributions by the inventory to the effective teaching practices.

The TPI is divided into eight categories (Table 1): course information, supporting materials provided to students, in-class activities, assignments, feedback and testing, training and guidance, collaboration, and other (i.e. diagnostics, pre/post testing, new methods, etc.). Each category contains both open and multiple-choice questions in order to evaluate instructors' performance

Sample

The inventory was distributed to all undergraduate teaching faculty who teach 15 courses at first common year and the Mathematics Department at the College of Science. We received 78 responses, 40 from first common year and 38 from mathematics department

Procedure

The Teaching Practices Inventory Tool (Wieman & Gilbert, 2014) was used for the purpose of this study, in order to gather data from faculty members teaching mathematics courses at King Saud University (KSU).

We have obtained informed consent/ethical approval from Carl Wieman to use and translate the tool. We also obtained a permission from the administration at king Saud University to apply this study.

A copy of the study tool was translated into Arabic language by a group of specialists and to ensure that both English and Arabic versions were identical, the translated version was translated back into English by a translator who did not read or look at the original copy. The original and the back-translated versions of the instruments were compared and evaluated in terms of form (language) and meaning by three experts in mathematics education.

Then the tool was used in both English and Arabic versions as some of the faculty members have good English background. This procedure is to ensure that all faculty members understand all items, and hence respond to all of these items.

The survey was distributed to faculty members during the second semester of the academic year 2017/2018.

Scoring rubric

The Teaching Practices Inventory is an inventory that was developed for use in math and science courses. It includes lists and scores to determine the extent to which research-based teaching practices are being used. The raw data result come from the inventory provide us with huge amount of information about the teaching practices followed by instructors teaching each of courses in the faculty of mathematics department and the first common year at King Saud university. To ease the difficulty of determining the extent and type of use of research-based practices form the raw results, a scoring rubric that extracts from the inventory data for each course was developed. The scoring rubric is clearly described by Wieman and Gilbert in their study that was conducted in (2014), where they have indicated that they "provide abbreviated descriptions of all of the inventory items that receive points in the scoring rubric along with references to the supporting research ".

The developers of this rubric indicated that:"The rubric assigns points to each practice for which there is research showing that the practice improves learning". The ETP score provides an efficient way to sort through the mass of data provided by the full inventory to identify areas of interest, but it would be a mistake to look at only the ETP score for a course. The breakdown by category and the full inventory response provides a much richer characterization of the teaching

The article (The Teaching Practices Inventory) provides a detailed account of how the inventory was developed and has been tested so far. Carl Wieman is a Nobel Prize winner in physics who in recent years has been working on a variety of STEM projects. This article illustrates the high caliber of his work, completed with a variety of colleagues".

Data Analysis

We then analyzed our findings to identify the teaching practices of faculty members at King Saud University using frequency and percentages, arithmetical mean and standard deviations, and t-tests to compare the performance of male and female instructors. We also compared our findings with data provided by Carl Wieman and Gilbert regarding the performance of mathematics faculty members at the University of British Columbia in order to have a standard upon which to base our results (Gibbs & Simpson, 2005; McNeilage, 2013; Kuh, 2008). We compared our findings with the University of British Columbia because it is a global center for teaching, learning and research, and consistently ranked among the top 20 public universities in the world as well as we get the Carl Wieman's permission to use the data of the university faculties. We categorized the scores in groups by five (max = 67) and then calculated the frequencies and percentages of the course in each category for both KSU and UBC (Table 5). We determined the frequency distributions of the rubric raw scores, which fall in each category (5points) to show the number of courses which received various scores. Then, we calculated the frequencies and percentages of the course in each category for both KSU and UBC (See Table 4).

FINDINGS

Performance of KSU Mathematics Faculty

To understand the nature of KSU mathematics instructors' teaching practices, we first analyzed all faculty members' responses to the TPI inventory (Table 1). It should be noted that the highest possible mean score for the inventory is 8.375 (67/8). It is clear that instructors scored the highest in collaboration (mean score = 5.37, percent of mean = 89.5%) and in-class activities (mean score = 8.63, percent of mean = 57.5%), while they scored the lowest in the 'other' category (mean score = 2.37, percent of mean =

23.7%) and feedback and tests (mean score = 3.73, percent of mean = 28.7%). The total TPI score resulted from applying the inventory at KSU is 3.7 out of 8.375.

Table 1
TPI Scores of All Survey Respondents (n = 78)

Category	Max score	Mean score	Std. Dev.	Weighted Perc.
Course information	6	2.49	1.696	41.5
Supporting material	7	2.79	1.352	39.9
In-class activities	15	8.63	2.783	57.5
Class assignments	6	2.13	1.178	35.5
Feedback and tests	13	3.73	1.170	28.7
Other (i.e. evaluation methods, diagnoses)	10	2.37	2.487	23.7
Training teaching assistants	4	1.89	1.189	47.3
Collaboration	6	5.37	0.561	89.5
Total	67	3.70	0.8242	5.5

We next examined TPI scores by course (Table 2). This allows us to identify the strengths and weaknesses of particular courses and determine if any fall below departmental norms. The most effectively taught courses are 1 (Math 101; introductory mathematics), which had a mean score of 4.50 across all categories out of 8.375; 4 (Math 140; pre-calculus), with a mean score of 4.00; and 2, with a mean score of 3.88. The least effectively taught courses, meanwhile, are 8 (Math11, integral calculus (mean score = 3.06) and 14 (Math-254 (numerical methods) (mean score = 2.88).

Table 2
Overall TPI Scores by Course

Course #	Course information	Supporting material	In-class activities	Class assignments	Feedback and tests	Other	Training teaching assistants	Collaboration	Total mean	ETP score
1	4	3	11	2	4	3	3	6	4.50	36
2	1	3	10	3	4	2	3	5	3.88	31
3	1	2	9	2	3	2	3	6	3.13	28
4	4	4	9	4	4	1	1	5	4.00	32
5	1	4	7	2	3	2	1	5	3.13	25
6	5	4	4	0	2	1	3	5	3.06	24
7	4	3	8	3	5	3	1	5	3.63	32
8	1	3	10	3	3	2	1	5	3.50	28
9	1	3	6	3	3	2	2	6	3.00	26
10	1	2	6	2	3	2	3	5	3.75	24
11	1	3	10	3	4	1	3	5	3.63	30
12	1	3	8	2	5	1	0	5	3.13	25
13	4	4	10	3	1	1	1	5	3.63	29
14	4	2	6	0	4	1	1	5	2.88	23
15	3	2	5	2	4	1	0	5	2.75	22
Max	6	7	15	6	13	10	4	6	8.38	67

Gender differences in TPI scores

To determine whether there were any differences in male and female instructors' scores, we broke out the TPI scores by gender (Table 3). We found a significant difference in only one category: collaboration.

Table 3
Difference between Female (n =36) and Male (n = 42) Instructors' TPI Scores

Category	Sex	Mean	SD	t	p
Course information	Male	2.60	1.781	.605	.547
	Female	2.36	1.606		
Supporting material	Male	2.69	1.259	–.734	.465
	Female	2.92	1.461		
In-class activities	Male	8.60	3.155	–.112	.911
	Female	8.67	2.318		
Class assignments	Male	2.07	1.058	–.483	.630
	Female	2.21	1.321		
Feedback and tests	Male	3.64	1.144	–.715	.477
	Female	3.83	1.207		
Other	Male	2.10	1.165	–1.062	.292
	Female	2.69	3.438		
Training teaching assistants	Male	2.10	1.078	1.708	.092
	Female	1.63	1.289		
Collaboration	Male	5.19	.552	–3.273	.002
	Female	5.58	.500		

Comparison of KSU with international mathematics departments

To determine how King Saud University (KSU) mathematics courses compare to those at other international universities, we compared our data to that from the University of British Columbia (UBC). We first categorized the scores in groups by five (max = 67). This means that we determined the frequency distributions of the rubric raw scores, which fall in each category (5points) to show the number of courses which received various scores. Then, we calculated the frequencies and percentages of the course in each category for both KSU and UBC (See Table 4).

From Table 4 it is clear that KSU math courses scored between 23 and 36 (out of a maximum value of 67), while courses taught by UBC scored between 10 and 48 (Figure 1). However, despite the fact that KSU has a smaller range, it has a lower average ETP score (27.67) than does UBC (32.61).

Table 4
Frequencies and Percentages of the Groups of ETP Scores for Both KSU (n = 15) and UBC (n = 28) Math Courses

Course	Frequency		%	
score	KSU	UBC	KSU	UBC
[0,5]	0	0	0	0
(5,10]	0	1	0	3.2
(10,15]	0	0	0	0
(15,20]	0	2	0	6.5
(20,25]	6	2	40.0	6.5
(25,30]	5	7	33.0	22.6
(30,35]	3	8	20.0	25.8
(35,40]	1	6	6.7	19.9
(40,45]	0	2	0	6.5
(45,50)	0	3	0	9.7

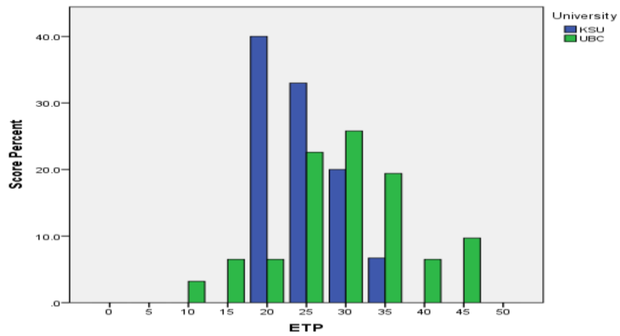

Figure1
Histograms of the ETP Scores for the Courses in the Two Universities

To better understand how KSU mathematics courses compare to those at UBC, we divided ETP scores into three levels: low = 0–22, medium = 23–44, and high = 45–67). It seems that all KSU courses have scores centered on the medium range, while the scored of UBC courses are distributed across the three levels (about 13% in the low level, 50% in the medium, and 37% at the high level) (see figure 1).

DISCUSSION

Wieman and Gilbert (2014) confirmed that the TPI can identify "the extent to which effective teaching practices are used by the different faculty within a department, as well as the differences between departments." They added that "high-scoring courses incorporate many different, mutually beneficial practices across all categories that support and encourage student learning, while low-scoring courses have very few."

Based on that, our results indicate that KSU mathematics instructors scored high in two categories, which are; "collaboration" and "in-class activities", but they scored low in other categories such as evaluation methods, 'other,' and training teaching assistants. This may be because instructors are still strongly attracted to traditional evaluation methods, which depend totally on traditional tests, which are mainly based on regular question (Froyd, 2008; Anderson et al., 2001). In addition, lower scores in the mentorship of TAs may be due to the fact that teaching assistants often do not attend lectures or help instructors in their work; as soon as they receive a TA position, they also receive a scholarship from the Ministry of Higher Education as part of the King Scholarship Program, meaning that there is no incentive for them to work closely with the instructors (Ministry of Higher Education, 2010; Ghafour, 2011; Molavi, 2015), because as soon as they are assigned the TA position, they start the process of getting a scholarship to have their master and Ph.D. programs outside the country. Regarding gender differences in teaching skills, social theories related to genders (Adenzato, Cavallo & Enrici, 2009; Schulte-Ruther, Markowitsch, Shah, Fink & Piefke, 2008) suggest that males are more effective in many practices, however, our study results showed that female instructors are significantly more skilled at collaboration than male instructors. This could be interpreted that female teaching at universities are currently starting their work in teaching, and hence they are struggling to prove themselves among a male dominated society. Murphy, Eduljee, Parkman and Croteau, (2019) study indicated that male are more skills in some activities such as " actively participating in organized classroom group activities." And that females are more skilled in other activities such as "volunteering to answer professor's questions.". this result might support the findings of this study.

Wieman and Gilbert (2014) stress that the highest-scoring courses will score at least 50 out of a possible score of 67 and that the lowest-scoring courses will receive scores of 10–11. While, the ETP scores of KSU courses range between 22 and 36, UBC scores range from 10 and 48. Neither university is reaching the highest level of teaching practice. This implies that future research is needed to provide in-depth information on areas of weakness and to design professional development programs to help faculty improve their teaching practices (Derting & Ebert-May, 2010; Lami & Adai, 2013; Sawada, 2002; Roediger, 2010).

Limitations in teaching may affect students' active learning in the classroom (Black & William, 1998; Freeman et al., 2014; Singer et al., 2012). The inventory and its scoring rubric provide us with a range of opportunities to better teaching by implementing common practices that are known to improve students' learning (PULSE Vision and Change Rubrics, (Bianco et al, 2013). Comparing the TPI results of two universities allowed us insight into mathematical teaching practices. We hope that our results will inform administrators and faculty members and inspire reform, as well as help KSU faculty identify areas for improvement and develop concrete steps to bettering their teaching skills.

CONCLUSION

This study proved that faculty are skilled at incorporating collaboration and in-class activities into their teaching; and less skilled in other categories, such as evaluation methods, diagnoses and training, and guiding teaching assistants. The results showed that female instructors are more skilled than males in collaboration. Therefore, the researchers recommend the design of professional development programs that would improve faculty members' teaching practices. It was suggested that other similar studies should be carried out on teaching practices of instructors in other colleges at king Saud University or other universities.

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