Assessing Preservice Teachers’ Knowledge of Area

Wun Thiam Yew <tywun@usm.my>
Lim Hooi Lian <hllim@usm.my>
Chew Cheng Meng <cmchew@usm.my>
School of Educational Studies, Universiti Sains Malaysia

Abstract
This paper attempts to assess preservice teachers’ knowledge of area. In this study, the researchers employed survey research design to assess preservice teachers’ knowledge of area. A questionnaire was employed to collect the data. Convenient sampling technique was employed to select the participants of the study. Respondents of the study consisted of 46 preservice teachers (majored or minored in mathematics) who are attending Bachelor of Science with Education program at a public university in Peninsula Malaysia. This paper presents the analysis of the responses of the preservice teachers related to a particular mathematical task, namely notion of area. The finding suggests that 78.26% of the preservice teachers in this study have successfully selected all the shapes that have an area. They had the correct notion of area that 2-dimensional shapes (closed plane shapes) and 3-dimensional shapes have an area. Different categories of incorrect notion of area were identified. Implications of the findings were also discussed.

Keywords: preservice teachers, knowledge of area, survey research design, convenient sampling technique

Introduction
One cannot teach what one does not know. Teachers must have in-depth knowledge of the subject they are going to teach. Fennema and Franke (1992) advocated that "No one questions the idea that what a teacher know is one of the most important influences on what is done in classroom and ultimately on what students learn" (p. 147). Furthermore, “Teachers who do not themselves know a subject well are not likely to help students learn this content.” (Ball, Thames, & Phelps, 2008, p. 404). This applies also to preservice teachers. This paper attempts to assess preservice teachers’ knowledge of a specific mathematical topic, namely perimeter and area, in particular, on the notion of area.

1. Notion of Area
Numerous definitions of area were provided by the researchers or mathematics educators. Table 1 shows some of these definitions. Martin and Struchens (2000) noted that “The concept of area is often difficult for students to understand, perhaps due to their initial experiences in which it is tied to a formula (such as area = length × width) rather than more conceptual activities such as counting the number of square units it would take to cover a surface” (p. 223). Cavanagh (2008) found that 53% of the 43 Year 7 students from two government high schools in Sydney in his study defined area as ‘space inside the shape’ while 19% referred it as ‘length by width’. However, Tierney, Boyd, and Davis (1990) revealed that many prospective primary school teachers from a teachers college in their study thought that area is ‘length by width’. When the prospective teachers were asked what they would teach a ten year old child about area, “80% of
them drew a rectangle and wrote “l × w” or “l by w” near it. Some of these students (prospective teachers) placed arrows around a rectangle in a way which denoted perimeter rather than area” (pp. 307-308). The remaining 20% of prospective teachers defined area as the space inside a figure. Furthermore, Casa, Spinelli, and Gavin (2006) noticed that many adults thought that area is ‘length by width’. “They understand area as a formula rather than as a concept - the amount of space covered by the inside boundaries of a two-dimensional figure” (Casa et al., 2006, p. 168).

Table 1

<table>
<thead>
<tr>
<th>Researchers or mathematics educators</th>
<th>Definition of area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball, 1988, p. 170.</td>
<td>The area is the number of unit squares it takes to cover the figure or region.</td>
</tr>
<tr>
<td>Bennett &amp; Nelson, 2001, p. 653.</td>
<td>The number of units it takes to cover a surface (or region) is called its area.</td>
</tr>
<tr>
<td>Billstein, Liberskind, &amp; Lott, 2006, p. 750.</td>
<td>Area of a region is the number of nonoverlapping square units that covers the region.</td>
</tr>
<tr>
<td>Cathcart, Pothier, Vance, &amp; Bezuk, 2006, p. 330.</td>
<td>Area is the amount of surface enclosed by a curve in the plane.</td>
</tr>
<tr>
<td>Haylock, 2001, p. 268.</td>
<td>Area is a measure of the amount of two-dimensional space inside a boundary.</td>
</tr>
<tr>
<td>Long &amp; DeTemple, 2003, p. 771.</td>
<td>The number of units required to cover a region in the plane is the area of the region.</td>
</tr>
<tr>
<td>Rickard, 1996, p. 306.</td>
<td>Area is represented as the number of square units needed to cover a shape.</td>
</tr>
</tbody>
</table>

Baturo and Nason (1996) suggested that area can be viewed from two different perspectives, namely static and dynamic perspectives. From the static perspective, area can be viewed as the amount of surface enclosed within a boundary. If a preservice teacher selected one or more open shapes and explained that the shape(s) had an area of zero, then it indicated that the preservice teacher is having a dynamic perspective of area. Baturo and Nason (1996) found that none of the 13 preservice primary school teachers in their study selected open shapes (including the lines) as having an area. It can be inferred that they did not have a dynamic perspective of the notion of area. Furthermore, all of them indicated that these shapes (i.e., open shapes) needed to be closed showing that they had a static perspective of the notion of area. Baturo and Nason (1996) also
found that three of the preservice teachers in their study appeared to associate the notion of area with the measurement of area (i.e., area does not exist until it is measured).

Wun (2010) revealed that half of the eight preservice secondary school mathematics teachers in his study had the correct notion of area that 2-dimensional shapes and 3-dimensional shapes have an area. Finding of Wun and Lim (2011) suggested that 36% of the preservice special education teachers in their study had the correct notion of area that 2-dimensional shapes (closed plane shapes) and 3-dimensional shapes have an area. Review of research literature had also shown that some students and preservice teachers encountered difficulty in differentiating between the attributes of perimeter, area, and volume (Baturo & Nason, 1996; Beaumont, Curtis, & Smart, 1986; Ramakrishnan, 1998; Reinke, 1997; Wun, 2010; Wun & Lim, 2011).

2. Conceptual Framework of the Study
Nik Azis (1996) suggested that there are five basic types of knowledge, namely conceptual knowledge, procedural knowledge, linguistic knowledge, strategic knowledge, and ethical knowledge. In the present study, the researchers have adapted Nik Azis’s (1996) categorization of knowledge to assess preservice teachers’ knowledge of area.

3. Methodology
In this study, the researchers employed survey research design to assess preservice teachers' knowledge of area. Convenient sampling technique was employed to select the participants of the study. Respondents of the study consisted of 46 preservice teachers (majored or minored in mathematics) who are attending Bachelor of Science with Education program at a public university in Peninsula Malaysia.

This paper reports only the responses of the participants on Task 1.2 (see Appendix A). This task was adapted from previous study (Baturo & Nason, 1996, p. 245). In Task 1.2, the respondents were asked to select the shapes (12 shapes) that have an area. The objective of this task was to determine the participants’ conceptual knowledge about the notion of area. Six 2-dimensional shapes (A, C, D, H, I, K) were used to ascertain whether the respondents understood area from a static perspective. Based on this perspective, “area can be considered as the amount of surface enclosed within a boundary” (Baturo & Nason, 1996, p. 245). Two open shapes (B, G) were included to investigate further the participants’ understanding of the notion of area from a static perspective.

Two 1-dimensional shapes (E, L) were included to ascertain whether the respondents understood area from a dynamic perspective. If the participants selected one or both of these shapes and explained that the shape(s) had an area of zero, then this response indicated that the respondents are having a dynamic perspective of area (Baturo & Nason, 1996). Finally, two 3-dimensional shapes (F, J) were included because review of research literature had shown that some students and preservice teachers encountered difficulty in differentiating between the attributes of perimeter, area and volume (Baturo & Nason, 1996; Beaumont, Curtis, & Smart, 1986; Ramakrishnan, 1998; Reinke, 1997; Wun, 2010; Wun & Lim, 2011).
Task 1.2 was also used to determine the participants’ linguistic knowledge of area based on the language of mathematics (such as mathematical terms and symbols) that the subjects used to justify the selection of shapes that have an area. There are some good behaviors that the respondents needed to follow when dealing with area. Knowledge and justification of knowledge is an important aspect in any discipline. Thus, this task was also used to determine the participants’ ethical knowledge of area by ascertaining whether the respondents justify the selection of shapes that have an area.

A questionnaire was employed to collect the data. The questionnaire was administered to all the preservice teachers (majored or minored in mathematics) who are attending Bachelor of Science with Education program at a public university in Peninsula Malaysia.

4. Findings of the Study
In this section, findings of preservice teachers' knowledge of area was presented in terms of its components as stipulated in the previous section.

4.1. Conceptual Knowledge
The finding suggests that 78.26% of the preservice teachers in this study have successfully selected all the shapes that have an area. They had the correct notion of area that 2-dimensional shapes (closed plane shapes) and 3-dimensional shapes have an area. The distribution and percentage of respondents’ selection of shapes that have an area and their notion of area is shown in Table 2.

Table 2
Distribution and Percentage of Respondents’ Selection of Shapes That Has an Area and Their Notion of Area

<table>
<thead>
<tr>
<th>Selection of shapes that have an area</th>
<th>Notion of area</th>
<th>Number of respondents</th>
<th>Percentage of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, C, D, F, H, I, J, K</td>
<td>2-dimensional shapes and 3-dimensional shapes</td>
<td>36</td>
<td>78.26</td>
</tr>
<tr>
<td>A, C, F, H, J</td>
<td>Limited to regular 2-dimensional shapes (such as triangle, circle, and trapezium) and 3-dimensional shapes</td>
<td>8</td>
<td>17.39</td>
</tr>
<tr>
<td>A, C, D, F, H, J</td>
<td>Limited to regular 2-dimensional shapes (such as triangle, circle, and trapezium) and 3-dimensional shapes</td>
<td>1</td>
<td>2.17</td>
</tr>
<tr>
<td>A, C, F, J</td>
<td>Limited to triangle, circle, and 3-dimensional shapes</td>
<td>1</td>
<td>2.17</td>
</tr>
</tbody>
</table>

Nevertheless, 19.56% of the preservice teachers had the incorrect notion of area that only regular 2-dimensional shapes (such as triangle, circle, and trapezium) and 3-dimensional shapes have an
area. One of the preservice teachers (i.e., 2.17%) had the incorrect notion of area that only triangle, circle, and 3-dimensional shapes have an area.

The finding suggests that all the preservice teachers in this study did not select the two 1-dimensional shapes (E, L) that do not have an area. It can be inferred that all of them did not have a dynamic perspective of area or this knowledge was not accessible to them during the survey. It revealed that all the preservice teachers in this study have a static perspective of area.

4.2. Linguistic Knowledge
When asked to justify their selection of shapes that have an area, the finding suggests that 84.78% of the preservice teachers in this study used appropriate mathematical terms to justify their selection of shapes that have an area. Specifically, 60.87% of the preservice teachers employed appropriate mathematical term ‘closed shape’ to justify their selection of shapes that have an area. 13.04% of the preservice teachers used appropriate mathematical term ‘calculate’ (i.e., can be calculated) to justify their selection of shapes that have an area. It indicated that they appeared to associate the notion of area with the measurement of area (i.e., area does not exist until it is measured).

4.35% of the preservice teachers employed appropriate mathematical terms ‘enclosed shape’ and ‘bounded shape’ to justify their selection of shapes that have an area respectively. 2.17% of the preservice teachers used appropriate mathematical term ‘measure’ (i.e., can be measured) to justify their selection of shapes that have an area respectively. It indicated that they appeared to associate the notion of area with the measurement of area (i.e., area does not exist until it is measured). The distribution and percentage of respondents’ justification for the selection of shapes that have an area is depicted in Table 3.

The finding suggests that 10.87% of the preservice teachers in this study used inappropriate words to justify their selection of shapes that have an area. Specifically, 2.17% of the preservice teachers used inappropriate words ‘line joins together’, ‘lines meet’, ‘complete shape’, ‘complete diagram’, and ‘fixed structure’ to justify their selection of shapes that have an area respectively. Table 3 demonstrated that only 4.35% of the preservice teachers in this study did not provide any justification for their selection of shapes that have an area.

4.3. Ethical Knowledge
Knowledge and justification of knowledge is an important aspect in any discipline. The finding suggests that 95.65% of the preservice teachers in this study had taken the effort to justify the selection of shapes that have an area. Nevertheless, as reported in the previous section, 84.78% of the preservice teachers in this study provided appropriate justification for their selection of shapes that have an area while 10.87% of the preservice teachers provided inappropriate justification for their selection of shapes that have an area. The remaining 4.35% of the preservice teachers did not provide any justification for their selection of shapes that have an area.
Table 3

*Distribution and Percentage of Respondents’ Justification for the Selection of Shapes That Has an Area*

<table>
<thead>
<tr>
<th>Justification for the selection of shapes that have an area</th>
<th>Number of respondents</th>
<th>Percentage of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed shape</td>
<td>28</td>
<td>60.87</td>
</tr>
<tr>
<td>Can be calculated</td>
<td>6</td>
<td>13.04</td>
</tr>
<tr>
<td>Enclosed shape</td>
<td>2</td>
<td>4.35</td>
</tr>
<tr>
<td>Bounded shape</td>
<td>2</td>
<td>4.35</td>
</tr>
<tr>
<td>Can be measured</td>
<td>1</td>
<td>2.17</td>
</tr>
<tr>
<td>Inappropriate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line joins together</td>
<td>1</td>
<td>2.17</td>
</tr>
<tr>
<td>Lines meet</td>
<td>1</td>
<td>2.17</td>
</tr>
<tr>
<td>Complete shape</td>
<td>1</td>
<td>2.17</td>
</tr>
<tr>
<td>Complete diagram</td>
<td>1</td>
<td>2.17</td>
</tr>
<tr>
<td>Fixed structure</td>
<td>1</td>
<td>2.17</td>
</tr>
<tr>
<td>No justification</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did not provide any justification</td>
<td>2</td>
<td>4.35</td>
</tr>
</tbody>
</table>

**Conclusion**

In conclusion, 78.26% of the preservice teachers in this study had the correct notion of area that 2-dimensional shapes and 3-dimensional shapes have an area. This finding is in contrast with the finding of Wun’ (2010) study which found that half of the eight preservice secondary school mathematics teachers in his study had the correct notion of area that 2-dimensional shapes and 3-dimensional shapes have an area. This finding is also in contrast with the finding of Wun and Lim’ (2011) study which suggested that 36% of the preservice special education teachers in their study had the correct notion of area that 2-dimensional shapes (closed plane shapes) and 3-dimensional shapes have an area. 84.78% of the preservice teachers in this study used appropriate mathematical terms to justify their selection of shapes that have an area. 95.65% of the preservice teachers in this study had taken the effort to justify the selection of shapes that have an area.

The implication of this finding is that mathematics educators as well as mathematics teacher educators need to organize teaching and learning activities that provide opportunity for their
students and preservice teachers to investigate examples and nonexamples of shapes that have and do not have an area. They included open shapes, 1-dimensional shapes, 2-dimensional shapes, and 3-dimensional shapes because previous studies had shown that some students and preservice teachers encountered difficulty in differentiating between the attributes of perimeter, area, and volume (Baturo & Nason, 1996; Beaumont, Curtis, & Smart, 1986; Ramakrishnan, 1998; Reinke, 1997; Wun, 2010; Wun & Lim, 2011).

References


Appendix A

Task 1.2: Notion of area (luas)

Tick the shapes that have an area (luas).

A  B  C

D  E  F

G  H  I

J  K  L

(a) Why did you select this shape/these shapes?

(b) Why didn't you select this shape/these shapes?