MODELLING COMPETENCIES IN STATISTICS AMONG PRIMARY PUPILS

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Abstract

In the 21st century, the kind of skill needed by pupils is different from what they needed 20 years ago. The outcome of the 21st century focuses on the skills, knowledge and expertise pupils must master to succeed in college, work and life. In order to do this, pupils should be taught to master critical thinking skills. The effective way is by including modelling in their syllabus. In mathematics learning, mathematical modelling deals with modelling and application in mathematics teaching, characterizing pupils’ modelling competency and application of modelling activities toward building up the competencies. Quantitative approach was used in this study. In this study, thirty-five fifth grade pupils from a school in Petaling Jaya were chosen as the participants. These pupils were selected using simple random sampling procedure. Open ended task based on a real world problem involving complex data was given to the pupils. The open ended task consists of measures of central tendency questions. Pupils’ answers were categorised using Six Levels for Assessing Mathematical Modelling Competency. All the levels have different explanation in order to help the researcher classify the answers. Inferential statistics was used to analyse the competency level of the sample. The findings showed that most of the pupils manage to transfer the real model into a proper mathematical problem but they could not work with the data. Those who managed to answer the questions correctly were able to relate the mathematical problem to the given situation. The same real world problem can be used in future for measuring dispersion among higher grade pupils.

Keyword: Mathematical Modelling, Competency, Measures of Central Tendency

INTRODUCTION

Over the past few decades, the prevalence of statistics in the media and workplace has increased drastically. In many countries, mathematics curricula for primary and secondary schools have been reformed to include statistics (North & Scheiber, 2011). The 18th ICMI Study shows that the new curricula published in the past years in many countries such as Brazil, Costa Rica, South Africa, Spain, the United Arab Emirates and the United States of America include statistics from the first year of primary school level which is for 6-year-old. Furthermore, the past two decades have seen the development of a reform movement in statistics education, emphasizing features such as statistical thinking, active learning, conceptual understanding, genuine data, technology use, collaborative learning, and communication skills (Moore, 1997). According to Gal (2002), statistical literacy is the ability to interpret, evaluate critically and to communicate statistical information. The interpretation is similar to the mathematical modelling characteristic whereby students are inquired or investigated, through mathematics.
Several definitions of mathematical modelling competency have been given by different researchers. Blum, Galbraith, Henn and Niss (2007) defined it as "the ability to identify relevant questions, variables, relations or assumptions in a given real world situation, to translate these into mathematics and to interpret and validate the solution of the resulting mathematical problem in relation to the given situations, as well as the ability to analyse or compare given models by investigating the assumptions being made, checking properties and scope of a given model. According to Blum and Kaiser (1997), modelling competencies are divided into several sub-competencies, namely competencies to understand the real problem and to set up a model based on reality, competencies to set up a mathematical model from the real model, competencies to solve mathematical questions within the mathematical model, competencies to interpret mathematical results in real situations and competencies to validate the solution. Ludwig and Xu (2010) divided mathematical modelling competencies into six different levels to code student understanding. Many research studies have been done on mathematical modelling internationally but very few have been done in Malaysia. There is only one article written by Leong (2013) about Mathematical Modelling in the Malaysian Secondary Curriculum. The author discussed the importance of introducing mathematical modelling in the mathematical curriculum at secondary level in Malaysia; he also explained how Singapore and the USA had implemented mathematical modelling in their curriculum. Early last year, the UTM Centre for Industrial and Applied Mathematics (UTM-CIAM) organised the Malaysia Mathematical Modelling Camp 2015 with co-organisers from the Oxford Centre for Industrial and Applied Mathematics (OCIAM) & Department of Mathematical Sciences, Faculty of Science, UTM. The camp was aimed at bringing together graduate students nationwide to work on industrial mathematics problems under the guidance of experienced mentors.

The purpose of this study is to determine fifth grade pupils (10-11 year-old) mathematical modelling competency.

METHODOLOGY

In this study, six different levels of mathematical modelling competency introduced by Ludwig and Xu (2010) will be used to measure fifth grade pupils' mathematical modelling competency. The levels are given in Figure 1.

| Level 0: The student has not understood the situation and is not able to sketch or write anything concrete about the problem. |
| Level 1: The student only understands the given real situation, but is not able to structure and simplify the situation or cannot find connections to any mathematical ideas. |
| Level 2: After investigating the given real situation, the student finds a real model through structuring and simplifying, but does not know how to transfer this into a mathematical problem (the students creates a kind of word problem about the real situation). |
| Level 3: The student is able to find not only a real model, but also translates it into a proper mathematical problem, but cannot work with it clearly in the mathematical world. |
| Level 4: The student is able to pick up a mathematical problem from the real situation, work with this mathematical problem in the mathematical world, and have... |
mathematical results.
- Level 5: The student is able to experience the mathematical modelling process and validate the solution of the mathematical problem in relation to the given situation.

Figure 1: Six levels for assessing mathematical modelling competency.

In this study simple random sampling method was used to eliminate biasness. Pupils from a school in Petaling Jaya were the participants. There are four grade five classes with a population of 129 pupils. Only 30 pupils (14 girls, 16 boys) were chosen as the sample. The pupils were chosen randomly from all the five classes. All the pupils chosen have already learned measures of central tendency at school. This study was conducted in the classroom. All 30 of them were given the same task but they solved it individually. The information related to the task was translated into Malay language and certain information was modified because the sample was from a Malay medium school. Even though the majority of the pupils speak good English, they are unfamiliar with the mathematical terms in English. The task is given in Figure 2.

BACKGROUND INFORMATION

The first Sukma Games was held in 1986 in Kuala Lumpur. Sukma Games is a sporting event in Malaysia, held once every two years. This event is often viewed as a high end national level competition and is usually referred to as “Malaysian Olympics”. The participants of the event are picked from a competitive pool of possible strong elite athletes from each respective state. The participating contingent are mainly states and federal territories within Malaysia. The participating contingents are Brunei, Federal Territory, Johor, Kedah, Kelantan, Kuala Lumpur, Labuan, Mabacca, Malaysia Armed forces, Majlis Sukan Universiti-Universiti Malaysia (MASUM/ MSU), Majlis Sukan Sekolah-Sekolah Malaysia (MSSM/ MSS), Negeri Sembilan, Pahang, Perak, Perlis, Penang, Putrajaya, Royal Malaysian Police, Sabah, Sarawak, Selangor and Terengganu. The sports that are contested at the Sukma Games are diving, swimming, archery, athletics, badminton, bowling, boxing, cycling, football, golf, gymnastics, hockey, karate, lawn bowls, petanque, sepak takraw, shooting, pencak silat, squash, sailing, taekwando, tennis, volleyball, wushu and weightlifting. The highest number of events are from athletics which accumulates to 45 events (men and women). One of the events is known as shot put. Shot put is a track and field event involving throwing a heavy spherical object as far as possible. This year the Majlis Sukan Sekolah-sekolah Malaysia (MSSM/MSS) wants to choose the most suitable candidate for shot put to compete in Sukma Games 2016.

TASK

Table 2 shows the distance of the shot for six attempts by four athletes. Select the most suitable athlete to compete in the Men’s shot put at Sukma Games 2016 which will be held in Sarawak. You need to explain the method used to select the best shot put athlete.

Figure 2: Mathematical modelling competency task

Table 2: Men’s shot put results recorded at MSSM 58th Championship. (adapted from MSSM track and field championship in 2016)
<table>
<thead>
<tr>
<th>Attempts/Contestants</th>
<th>Wong Yu Kiong</th>
<th>Muhd Abd Razak</th>
<th>Roni b</th>
<th>Aspa Kullah b</th>
<th>Syazwan b</th>
<th>Ifwat b Mahadzir</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; attempt</td>
<td>X</td>
<td>13.33</td>
<td>12.37</td>
<td>12.56</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt; attempt</td>
<td>X</td>
<td>13.38</td>
<td>12.56</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt; attempt</td>
<td>13.46</td>
<td>13.06</td>
<td>13.61</td>
<td>12.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt; attempt</td>
<td>X</td>
<td>13.07</td>
<td>11.73</td>
<td>11.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt; attempt</td>
<td>14.51</td>
<td>13.76</td>
<td>11.49</td>
<td>11.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6&lt;sup&gt;th&lt;/sup&gt; attempt</td>
<td>13.97</td>
<td>13.79</td>
<td>11.99</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

X: Failed attempt

After the task was given to the pupils, the teacher read through the text together with the pupils. They were asked to answer the question on the space provided. All their working has to be shown on the paper as well. They were given 45 minutes to complete the task. Pupils' artefacts (written answers) were collected after that. Based on these artefacts, pupils' working was categorised using six levels of assessing mathematical modelling competency introduced by Ludwing and Xu (2010).

**RESULTS**

In this study, pupils who obtained level 2 numbered 4 pupils, level 3 are 7, level 4 are 6 and level 5 are 13. There is a significant difference where the biggest contributor to the differences are pupils who obtained level 2 and level 5. The standard residual for pupils who obtained level 2 is -3.5 whereas the standard residual for pupils who obtained level 5 is 5.5. The biggest residual value of level 5 indicates that most of the pupils obtained the highest level for competency, and the smallest residual value of level 2 indicates that the least number of the pupils obtained the lowest level for competency. The chi-square test also shows there is significant difference in the value of level 5 and value of level 2 ($\chi^2 = 6.000$, df = 3). The chi-square test results have been detailed in Table 1.

**Table 1**: Distribution of the level (N=30)

<table>
<thead>
<tr>
<th>Level</th>
<th>Observed N</th>
<th>Expected N</th>
<th>Residual</th>
</tr>
</thead>
<tbody>
<tr>
<td>level 2</td>
<td>4</td>
<td>7.5</td>
<td>-3.5</td>
</tr>
<tr>
<td>level 3</td>
<td>7</td>
<td>7.5</td>
<td>-.5</td>
</tr>
<tr>
<td>level 4</td>
<td>6</td>
<td>7.5</td>
<td>-1.5</td>
</tr>
<tr>
<td>level 5</td>
<td>13</td>
<td>7.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Test Statistics**

<table>
<thead>
<tr>
<th>Level</th>
<th>Chi-Square $6.000^a$</th>
<th>Df</th>
<th>3</th>
</tr>
</thead>
</table>

82
Asymp. Sig. .112

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 7.5.

DISCUSSION

This study is to determine fifth grade pupils' mathematical modelling competencies. The results show that thirteen pupils from the sample are able to solve the task given correctly. Six pupils from the sample managed to work on the task mathematically. Seven pupils managed to translate the given task into a mathematical problem but were unable to work on it. Four pupils manage to simplify the task but could not transfer it into a mathematical problem. Students with competency level five managed to make generalisation by justifying the method used to solve the task. Overall, many students could do the task given because they have been drilled with higher order thinking skills questions since they were in Year 1. The new Malaysian curriculum includes problem solving task in every topic so that pupils will be able to analyse each and every question critically (Bahagian Perkembangan Kurikulum, 2010). Four pupils in this sample obtained the 2nd level for competency. After checking with their mathematics teacher, all the pupils were hindered by their earlier experiences of mathematics. This has caused blockage during the entire modelling process. This can be the reason the pupils find it difficult to transfer the task given into a mathematical problem. The finding is similar with that from research done by Schap, Vos, and Goedhart (2011). This study is very useful especially in Malaysia because there has not been any research published to test the mathematical modelling competency among primary school pupils. It is also very important to stimulate modelling competencies through self-initiative because it is insufficient to deal with the modelling examples during classroom lessons (Maaß, 2004).

CONCLUSION

In relation to the modelling task, it was found that the pupils used numerical representation to solve the task given. The method they used to complete the task was not similar. This could be an indication that different teachers have different approaches to teach their pupils. Since random sampling procedure was used, the pupils selected to represent the sample came from different classrooms. This means the mathematics teachers were not the same. This was a descriptive research. The limitation in this research design was in coding the pupil's solution according to the levels because the findings need to be interpreted statistically. Since the sample size was small, this limitation managed to be overcome. Teachers play an important role in conducting the task. Teachers act as mentors, in other words "listening to students, modelling teaching and general classroom management, analysing and discussing their own practise, observing students, negotiating with students and supporting students while they teach" (Rice, 2006). Finally, the education curriculum in Malaysia need to be reformed to include mathematical modelling in the mathematics syllabus.
REFERENCES


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