

NUMERACY AND THE READINESS OF LEARNING STEM SUBJECTS TOWARDS IR 4.0

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ABSTRACT

Purpose – This study with a quantitative approach was done to identify the level of numeracy among male and female students who had undergone a two-year pre-university learning programme in the field of Numbers.

Methodology – The study was carried out in two phases of data collection. The first phase of data collection was done during the first week of teaching and learning (TnL) sessions when those students were in their first semester. Meanwhile, the second phase of data collection was done during the 18th week of their fourth semester in which they had gone through the two years of their learning programme at this pre-university level. Students (N=178) who were involved were given a numeracy test which consisted of 36 items concerning the field of Numbers for both phases of data collection. The students were required to answer within 50 minutes in the provided spaces. All the answer scripts were marked manually. Percentages of the score means were categorized into five numeracy levels. This starts with the basic numeracy level, which is the lowest numeracy level, followed by the low numeracy level, moderate numeracy level, good numeracy level, and high numeracy level.

Findings – Research findings show one-level decline in numeracy level, maintained numeracy level, and increased numeracy level up till four levels. This research also shows that all male students were in the basic numeracy level during the first data collection while during the second data collection, they were dispersed into all numeracy levels. It was also found that all the female students were in the low numeracy level during the first data collection while during the second data collection, they were also dispersed into all numeracy levels.

Significance – It is hoped that this study can provide the whole picture concerning the readiness of learning STEM subjects towards IR 4.0 for two-year pre-university students as well as providing inputs for educators so that necessary actions can be taken.

Keywords: Numeracy, STEM, Pre-university Students, Numbers, Gender

1.0 INTRODUCTION

Mathematics is one of the disciplines in STEM (Science, Technology, Engineering and Mathematics) while mathematics literacy refers to the ability to identify, understand and be involved with mathematics in everyday life (OECD, 2003). Mathematics literacy is also known as numeracy.

The Malaysia Ministry of Education had defined numeracy as the ability to perform basic mathematical operations, understanding simple mathematical ideas and applying mathematical knowledge and skills in daily life (Kementerian Pelajaran Malaysia, 2010). Students at the pre-university level are secondary school leavers who are entering adulthood. Appropriate with this particular phase of age, numeracy is defined as an individual's ability to

apply mathematical knowledge and skills to solve quantitative problems in the real world (Asiahwati Awi, 2015).

Problem Statement

The world is now encountering the effects of the fourth industrial revolution (IR 4.0). This IR 4.0 which promotes computerization in manufacturing was first developed in Germany in 2013 and it is spreading rapidly today throughout the world. Shwab (2016) stated that IR 4.0 is beyond the enhancement of the previous industrial revolution, in which the advancement of new technologies blurs the lines between the physical, digital and biological worlds. The new technologies evolve at an exponential pace and there is no historical precedent that marked the beginning of the evolution, hence being called as the disruptive technologies. These advancements are led by the emergence of artificial intelligence, robotics, the internet of things, autonomous vehicles, biotechnology and nanotechnology, 3-D printing, material science, quantum computing and energy storage (Diwan, 2017).

The IR 4.0 affects not only the world of business, governance and the people, but it gives an impact towards the field of education as well, thus the name Education 4.0 came to existence. The movement of Education 4.0 in the Malaysian education system started when former Higher Education Minister, Datuk Seri Idris Jusoh highlighted the theme of “Higher Education 4.0: Knowledge, Industry and Humanity” in 2018. He believed that the integration of IR 4.0 in the Malaysian higher education system would help the learning institutions to stay relevant and competitive (Halili, 2019). It is the responsibility of educators to diversify their teaching and learning approaches to produce a quality generation (Malaysia Ministry of Education, 2015). The educators need to make the field of education relevant in line with this wind of change primarily through the STEM subjects.

The United States Department of Labor had estimated that in the future, 65% of elementary school students in the world will work on jobs that have never existed today. It is predicted that the global digitalization in the IR 4.0 era will eliminate around 1 to 1.5 billion jobs throughout 2015-2025 as the human positions will be replaced by automatic machines (Naim, 2017). Mathematics literacy (numeracy) is considered as one of the four main literacies in STEM, but it is without a doubt that the manual part of this literacy will become irrelevant soon. Technologies will soon take charge of every statistical analysis to describe and analyse data and to predict future trends. Therefore, the human interpretation of these data will become a much more important part of the future curriculum. Applying the theoretical knowledge to numbers and using human reasoning to infer logic and trends from these data will become a fundamental new aspect of this literacy (Chea & Huan, 2019).

Pre-university students are secondary school leavers who had gone through the Ministry of Education’s Mathematics Curriculum and some of them are continuing their studies at the matriculation level. These matriculation students will go through the pre-university Mathematics curriculum, which is prepared by the Matriculation Division in the Ministry of Education. Thus, the students are considered to have learned mathematics since the early age of pre-schoolers right until the adult age at the matriculation level. Therefore, the effectiveness of the Mathematics curriculum on the students and the usefulness of their learned mathematical knowledge in their daily life need to be researched. Since numeracy is a connector between the mathematics which has been learned and the various context of application in daily life (Department of Education and Early Childhood Development, 2009), this situation may also bring an impact to the numeracy of a student. Finally, it will provide the whole picture concerning the readiness of learning STEM subjects towards IR 4.0 for pre-university students.

Research Objective

The purpose of this study is to identify the level of numeracy among male and female students who had undergone a two-year pre-university learning programme in the field of Numbers. From this study, the difference in numeracy levels will show the readiness of learning STEM subjects towards IR 4.0 for pre-university students.

Research Question

The objective of this study should be able to answer these research questions:

- a) What is the level of numeracy among two-year pre-university students in the field of Numbers?
- b) What is the level of numeracy among two-year pre-university students according to gender?

Significance of Study

In terms of mathematics education, this study should be able to provide insights concerning the level of numeracy among students who have been for at least 13 years learning mathematics with the curriculum set by the Ministry of Education. This will give directions for certain parties to train educators in the field of mathematics education on effective approaches and pedagogical strategies in conveying the knowledge of mathematics. Pedagogical strategies which are in line with technological advancement of IR 4.0 should be given a considerable amount of attention since mathematics literacy or numeracy is highly important in the real modern world.

Moreover, knowledge and understanding on the field of numeracy in Malaysia is still not extensive. Therefore, this study can be considered as an empirical reference for academicians. Since the field of adult numeracy is still new, studies on it are still limited (Ginsburg, Manly & Schmitt, 2006). Studies on early adult numeracy is also scarce in Malaysia. For that reason, this study was done in order to provide a platform for the discussion on numeracy at a higher level and hopefully this will give a positive impact on the development of numeracy in Malaysia.

Research Scope and Limitation

This study was done on pre-university students who continued their studies at the matriculation level. The field of research involving mathematical knowledge and numeracy skills is vast. Therefore, the research scope focused only on the ability of using mathematical knowledge and skills in solving real-life quantitative problems. The variables of knowledge and skills were chosen considering that those are the most valuable assets for the generation of today and the generation of the future (Gurria, 2012). Furthermore, the two variables were highlighted in the curriculum of Mathematics in Malaysia (Kementerian Pelajaran Malaysia, 2010). This study focused only on the field of Numbers with the topics of Whole Numbers, Fractions, Decimals and Percentages.

2.0 LITERATURE REVIEW

The study of Trends in International Mathematics and Science Study (TIMSS) 2015 had also shown that the average score for Malaysian Form 2 (Grade 8) students in Mathematics declined significantly when compared to the results of TIMSS 1999, 2003 and 2007. The average score for achievement in Mathematics for Malaysian students in 1999 was 519, while for 2003 it was 508 (declined 11 points from the score of 1999). For 2007, the average score for achievement in Mathematics for Malaysian students was 474 (declined 34 points from the score of 2003 and declined 45 points from the score of 1999). For 2011, the average score for achievement in Mathematics for Malaysian students plummeted to 440 (declined 34 points from the score of

2007, declined 69 points from the score of 2003, and declined 79 points from the score of 1999). Nevertheless, TIMSS 2015 had shown that the score for achievement in Mathematics for Malaysian students jumped to 465 (increased 25 points from the score of 2011). When looking at the Mathematics achievement among Malaysian students according to gender, the female students' achievement was always higher than the male students (Mullis, Martin, Foy & Hooper, 2016).

Earlier, the survey done by the Department for Education and Skills (DfES) on 8041 residents of England aged between 16-65 years old had produced a national profile of literacy skill and numeracy for adult individuals. The findings showed a lower achievement in numeracy when compared with the achievement in literacy. Only 10% had shown a higher achievement in numeracy compared to literacy while 53% of the achievement in numeracy was below the standard. Only one in four (25%) of the respondents achieved Level 2 or higher in the numeracy assessment. Nearly half (47%) of the respondents were categorized into Entry Level 3 and below in the numeracy assessment which included one out of five (21%) in Entry Level 1 and below. This means that 15 million adult individuals in England were in Entry Level 3 and below for numeracy skill while 6.8 million were categorized to be in Entry Level 2 and below in the year of 2002/2003 (William, Clemen, Oleinikova, & Tarvin, 2003).

Meanwhile, a study by Asiahwati Awi (2015) has shown that the numeracy level in the field of Numbers for secondary school leavers who were continuing their studies in Lower Sixth Form was highest at numeracy level 1 (37%) and this was followed by numeracy level 5 (23%), numeracy level 4 (16.6%), numeracy level 3 (12.2%) and numeracy level 2 (10.8%). Overall, three out of five (60%) secondary school leavers who were involved in the study were found to be in numeracy level 3 and below or with the category of basic numeracy up till the category of moderate numeracy.

In the meantime, results based on gender showed that the number of male students was higher than the female students only in numeracy level 5 and vice versa for the other levels of numeracy. This showed that many male students were in numeracy level 5 when compared to the other levels of numeracy. The difference in numeracy levels between the male students and female students was significant in the field of Numbers and it was concluded that the male students had a better level of numeracy than the female students with a significant difference (Asiahwati Awi, 2015).

According to the report 'The Skills for Life', one out of four females were categorized into Entry Level 2 or lower, a significantly higher rate than the males (17%). In addition, among those who reached Level 2 and above, only one out of five (19%) females managed to achieve that level compared to one out of three (32%) males. This profile had shown a large difference in the achievement of numeracy assessment according to gender in which males showed a greater achievement than the females. Males had shown a higher numeracy level even though control on the difference in education and work as well as the same level of numeracy between males and females had been done in the study (William et al., 2003).

3.0 METHODOLOGY

This part explains the research design, population and sampling, research instrument, types of data analysis, data collection, validity test and reliability test.

Research Design

This study used a quantitative approach research design. Data was obtained from students who had undergone a two-year pre-university learning programme at a matriculation college. The quantitative data was collected through a numeracy test to identify the level of students' knowledge and numeracy skills in solving quantitative problems in the field of Numbers. The students were given 50 minutes to answer a numeracy test which consisted of 36 items. The

test was done at two different times which were the earliest phase of TnL and the last phase of TnL. Respondents' answers were checked manually in order to get the total scores. Scores in the form of quantitative data were then analysed using a computer software. The data was analysed descriptively and after the data was processed, the outcome from the analysis was evaluated.

Population and Sampling

This study involved all pre-university students who continued their studies in a two-year programme at Penang Matriculation College. As many as 226 students of 2015/2017 intake group had participated in this study. Data collection was done twice in which the first phase of data collection was done immediately when they started their learning session in the first week of TnL during the first semester while the second phase of data collection was done when the students were in the 18th week of their fourth semester. All of the students learned the subjects of Mathematics coded as DM015, DM025, DM035 dan DM045 during each of the semesters for the two years of their learning programme.

Research Instruments

The aim of this study is to identify the level of numeracy among pre-university students using a numeracy test. The instrument of this study consisted of two parts. Part A contains items concerning the students' current demographic information. Part B contains items of the numeracy test. For Part B, the set of test paper contains 36 items with 25 close-ended questions (objective questions) and 11 open-ended questions (subjective questions). All the items used in this study were to test the students' numeracy concerning the students' ability to apply mathematical knowledge and skills in the field of Numbers when they need to solve quantitative problems in the real daily life. Topics in the field of Numbers which were chosen were the topics of Whole Numbers, Fractions, Decimals and Percentages. Each topic contributed nine items in five levels of difficulty. All the items used in this study were taken from the available numeracy items which had already been administered on Lower Sixth Form students and pre-university students (Asiahwati Awi, 2015).

Types of Data Analysis

Data was obtained from all two-year programme students. Hence, this study had taken the whole population of students. Descriptive analysis was performed using Microsoft Excel and Statistical Package for the Social Sciences (SPSS) softwares. This study took into account the numeracy level of students in answering the research questions.

The categorization of numeracy levels and the description for each numeracy level were based on the study by Asiahwati Awi (2015). This study observed the status of numeracy levels for both data collections by taking the difference in numeracy levels into consideration. Difference '1' shows the occurrence of one increment in numeracy level, while difference '2', '3' and '4' each shows the increment of two, three and four in numeracy level. At the same time, difference '0' shows no increment in numeracy level and difference '-1' shows a decrease in the numeracy level. Table 1 shows the distribution of score percentages based on the level and categorization of numeracy.

Table 1

The Score Distribution by Level and Categorization of Numeracy

Score (%)	Numeracy Level	Numeracy Category
0 - 45	1	Basic
46 - 55	2	Low
56 - 65	3	Moderate

66 - 75	4	Good
76 - 100	5	High

Data Collection

The respondents were asked to sit for a numeracy test which consisted of 25 close-ended questions and 11 open-ended questions which totaled up becoming 36 items altogether. The respondents were required to answer in the given question paper, and they needed to show their calculation steps for the open-ended questions in the space provided. 50 minutes were allocated for them to answer those questions. Following that, checking of the answers was done manually. Marks were given based on difficulty level of the items in which 1 mark was given for items with difficulty level 1, 2 marks were given for items with difficulty level 2 and so forth until 5 marks were given to items with difficulty level 5. Marks for each item were keyed-in into a computer software by taking the total marks in percentages according to respondents.

Data collection was done in two phases. The first phase was done in the first week of TnL during semester 1, while the second phase was done on the 18th week of their fourth semester. Questions given to the respondents and collecting procedure were the same.

Validity Test and Reliability Test

The numeracy test was taken from a study done by Asiahwati Awi (2015) on secondary school leavers using Lower Sixth Form students as samples. Five panel members with expertise on post-secondary Mathematics education had evaluated all the item for the numeracy test.

Kuder Richardson KR20 analysis was done on the 25 close-ended items by giving the score '1' for correctly answered items and '0' for the wrongly answered items. The value of KR20 was .908 which showed a very high reliability for the instrument as the value was greater than .9 (Babbie, 1992). Thus, all the items were used in the real study since there was no elimination of items.

4.0 RESEARCH FINDINGS

Discussion on the research findings was done to answer the research questions in order to fulfill the objective of this study.

Respondent Distribution Analysis

The distribution of students involved in the study was based on gender. Initially, this study involved 226 students in which the analysis showed that 53 students (23.5%) were males and 173 students (76.5%) were females. The number of students who were involved for the second data collection was less than first data since there were some students who did not finish their two-year programme. In addition, some students were involved in other activities during the second data collection. Therefore, this study analyzed only respondents who were involved in both data collections considered as Data 1 and Data 2. Data 1 is the first data collection which was collected at the beginning of their learning session and Data 2 is the second data collection which was collected at the end of their learning session. Both of the data collections involved 178 students in which 36 students (20.2%) were males and 142 students (79.8%) were females.

Analysis of Students' Numeracy Level

Analysis for the first data collection (data 1) showed that all of the students were in the numeracy levels 1 (basic) and 2 (low). 20.2% (36) which was all the male students were in numeracy level 1 while 79.8% (142) which was all the female students were in numeracy level 2. In the second data collection (data 2), the students were scattered into all levels of numeracy. The overall numeracy level and gender-based numeracy level for data 1 and data 2 are shown in Table 2.

Table 2
Numeracy Level of Data 1 and Data 2

	Gender	Numeracy Level					Total
		1	2	3	4	5	
Data 1	Male	36	0	-	-	-	36
	Female	0	142	-	-	-	142
	Total	36	142	-	-	-	178
Data 2	Male	20	10	3	2	1	36
	Female	75	41	18	7	1	142
	Total	95	51	21	9	2	178

For data 2, 53.4% (95, M=20, F=75), 28.7% (51, M=10, F=41), 11.8% (21, M=3, F=18), 5% (9, M=2, F=7) and 1.1% (2, M=1, F=1) of students each was found to be in numeracy level 1, 2, 3, 4 and 5 in general and according to gender.

Analysis of Difference in Students' Numeracy Level

Analysis on the status of the students' numeracy level was done by taking into account the difference between students' numeracy levels at the beginning of their learning and at the end of their learning. In the collection of data 1, all of the male students were found to be in the category of numeracy level 1 (basic). Findings from the collection of data 2 shows that for the male students (N=36), 55.6% (20) showed no difference in numeracy level while 27.8% (10), 8.3% (3), 5.6% (2) and 2.8% (1) each showed difference '1', '2', '3' and '4'. In total, 44.4% (16) of the male students had shown an increase in their numeracy level.

In the collection of data 1, all of the female students were found to be in the category of numeracy level 2 (low). Findings from the collection of data 2 shows that for the female students (N=142), 28.9% (41) showed no difference in numeracy level while 12.7% (18), 4.9% (7) and .7% (1) each showed difference '1', '2' and '3'. The analysis also showed that there was difference '-1' in which 52.8% (75) of the female students had lower numeracy level compared to the collection of data 1. In total, 18.3% (26) of the female students had shown an increase in their numeracy level. Table 3 shows the difference in students' numeracy for level 1 of data 1. Meanwhile, Table 4 shows the difference in students' numeracy for level 2 of data 1. Both tables show the difference in students' numeracy level after the second collection taken.

Table 3
Difference in Students' Numeracy for Level 1 of Data 1

Numeracy Level Difference between Data 1 and Data 2	Male	Female	Numeracy Level	Total
-1.00				0
0.00	20	0	1	20
1.00	10	0	2	10
2.00	3	0	3	3
3.00	2	0	4	2
4.00	1	0	5	1
	36	0		36

Table 4

Difference in Students' Numeracy for Level 2 of Data 1

Numeracy Level Difference between Data 1 and Data 2	Male	Female	Numeracy Level	Total
-1.00	0	75	1	75
0.00	0	41	2	41
1.00	0	18	3	18
2.00	0	7	4	7
3.00	0	1	5	1
4.00	0			0
	0	142		142

5.0 DISCUSSION AND CONCLUSION

The discussion in this section is based on the findings which eventually answers the research questions and finally achieving the objective of this study. The conclusion will include the implication, suggestions and summary of this study.

Status of Numeracy Level

At the initial stage of starting their pre-university education, the students had the basic or low level of numeracy. This study found that all of the male students were in the basic numeracy level. At this basic numeracy level, an individual should at least have concrete factual knowledge and simple ideas in a subject/field. The individual should be able to do very routine activities in real daily life, and able to apply very simple skills with some assistance. At this level, the individual's skills and knowledge are not enough to perform tasks to achieve a certain goal.

This study also found that all of the female students were in the low numeracy level. At this low numeracy level, an individual should have factual knowledge and simple ideas which are combined with the subject/field. The individual should be able to do routine activities in the context of personal and/or real daily life, and also able to apply routine skills in performing normal and routine tasks. At this level, the skills and knowledge are limited, and this requires some self-development in effort to increase performance.

It is interesting though to look at the findings based on the students' numeracy test results at the end of their two-year pre-university education. Even though initially all the male students were in the basic numeracy level, 44.4% managed to improve at least by one numeracy level. However, 55.6% of the male students did not show any increase in numeracy level. Among the female students, only 18.3% managed to improve at least by one numeracy level. 28.9% of the female students did not show any improvement while 52.8% of them showed a one-level decline in numeracy. Although only 24% of the students managed to show an increase in numeracy level, some of them had achieved high numeracy level.

This study shows a better increase in numeracy level among male students when compared to the female students. This result parallels with the study by Asiahwati Awi (2015) on pre-university students who were studying in Lower Sixth Form in which male students had shown better numeracy level compared to the female students.

Even though this study has shown a decline in numeracy level, it is not so surprising since a decline in a particular skill is nothing new and it happens throughout the world. A study by LeFevre, Douglas and Wylie (2017) had shown that the efficiency of numeracy skills had declined substantially among university students in the last 25 years. This is due to the fact that students have incomplete knowledge of fundamental skills related to numbers,

procedural knowledge of calculation, and related mathematical reasoning skills, and the situation seems unlikely to change (LeFevre, Douglas, & Wylie, 2017).

Implication and Challenges

Findings of this study show that initially students were in numeracy level 1 which is the basic level or numeracy level 2 which is in the category of low numeracy. After a period of two years of learning, the status of the students' numeracy level started with a one-level decrease up till a four-level increase. This should be given some attention and certain actions should be taken. Educators need to realise that many students do not have adequate mathematical knowledge and skills to benefit from class instruction unless additional support is provided. Furthermore, the present tertiary-level students are aged between 18 to 23 years old and they belong to the Generation-Z (Gen Z) who are so revolutionized by technology. The learning preference of the Gen Z students are different from the previous generations as they are more hands-on and directly involved in the learning process (Husin, 2018). Teachers should think about ways to utilize or integrate the technology into the learning process in the classroom. Purnomo (2017) described several approaches in teaching for the era of digitalization in IR 4.0 which are student-centred and involve contextual learning, community integrated learning, collaborative learning and technology-based learning (in Afrianto, 2018). In addition, educators need to ensure that students understand basic mathematical concepts as they prepare themselves to enter the university. The students should actually master knowledge and basic skills before entering the universities. Clearly, students who begin their university-level studies with weak or incomplete knowledge and skill in Numbers are more vulnerable to poor performance for more advanced topics.

Suggestion of the Study

This study covered only samples of matriculation students in the two-year programme who were studying at the pre-university level with a unique learning system. Since the operational procedure for the two-year programme has changed after the academic session for the students in this study, it is recommended to do a similar study with a new batch of samples. This is appropriate since the two-year programme students are now required to join the one-year programme students during their second year of learning. Future research may also involve variables other than knowledge and skill, as well as fields other than Numbers.

Conclusion

In this modern era, students are very close to gadgets or smart devices at least since they were in primary schools. Thus, students should be exposed to a type of curriculum with contents which will prepare them to strive towards IR 4.0. Consequently, the higher education system needs to change to suit the needs of the younger generation. Moreover, the institutions of higher education need to be flexible and ready to anticipate the future for Education 4.0 as many jobs are not catered in the past/conventional education system. The current education system needs to adapt in line with the latest technology and the new generation of students to produce graduates with the right skills for the future. Education 4.0 is a revolution in education, and it is a challenge faced by all countries around the world.

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