MAPPING THE LEVEL OF SCIENTIFIC REASONING SKILLS TO INSTRUCTIONAL METHODOLOGIES AMONG SCEINCES, MATHEMATICS AND ENGINEERING UNDERGRADUATES

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Abstract

Scientific reasoning (SR) is an important area in education practice and research. The ability to think in a scientific manner to approach problems in a logical and coherent way is a desirable outcome of schooling. This thinking skill is important for the cognitive development of young persons and, in addition, it also provides them with skills that may be able to be transferred to other learning and social contexts specifically for future labour market. The aim of this research are: (1) to establish the level of SR among SME undergraduates; (b) to identify the types of instructional methods in teaching SME at universities; and (c) to map instructional methods employed to the level of SR skills among the undergraduates. This study used the quantitative survey data-gathering method. A total of 975 students were participated in this study. There were two instruments used in this study namely, the Lawson Scientific Reasoning Skills and the Lecturers' Teaching Style Survey. The descriptive statistics such as mean and standard deviation, and the inferential statistics such as the t-test and Pearson correlation were used to analyze the data. The findings of the study showed that 63.2% of the students achieved Level 1 (concrete operational) of SR skill, 30.7% achieved Level 2 (transitional operational) and only 6.2% of them achieved Level 3 (formal operational). The overall mean level of the SR skills was 3.23 indicating that the Malaysian IHL students had concrete operational level of SR skills. Furthermore, in general, the Expert and Delegator were dominant lecturers' teaching styles according to students' perception where 819(84.0%) and 853(87.5%) of the students, respectively, were in the highest score level. However, the Personal Model teaching style was the lowest with 282 (28.8%) students' perception were in the highest score level. In addition, there was no correlation between students' perception towards lecturers' teaching style and the level of SR skills. Comparison between universities also revealed that there was no correlation between the SR skills and the lecturers' teaching style among the universities that were investigated. Only Universiti Sains Malaysia(USM) and Universiti Putra Malaysia(UPM) showed that there were negatively week relationship between the two variables where the dominant lecturers' teaching style for USM was Facilitator with r = -.320 and the dominant lecturers' teaching style for UPM were Formal Authority and Delegator with r=-.387 and r=-.321, respectively. These findings indicated that the Malaysian IHL students' level of SR skills was still in the concrete operational level, thus further action should be attempted if improvements are to be forthcoming. The findings further suggested that there were no specific lectures' teaching styles that have relationship with the SR skills level. Thus, this study opens an endless source of other researchers to investigate more to better inform our knowledge in this area of SR skills.

Keywords: Scientific Reasoning Skill, Instructional Methodology.

1   INTRODUCTION

Scientific reasoning (SR), broadly defined, includes the thinking skills involved in inquiry, experimentation, evidence evaluation, inference and argumentation that are done in the service of conceptual change or scientific understanding [1]. SR, by definition, involves both conceptual understanding and inquiry skills.

There is evidence that as is the case of intellectual skills in general, the development of the component skills of scientific reasoning "cannot be counted on to routinely develop" [2]. That is, young children have many requisite skills needed to engage in scientific thinking, but there are also ways in which even adults do not show full proficiency in investigative and inference tasks. It is absolutely essential that basic research on understanding student's SR be used engineer better instructional interventions [1]. Thus, besides investigating the students' SR skills, the key question that directs future research in this area is to determine which types of instruction are best in enhancing the SR skills.

This most valuable attribute should be possessed by Malaysian Science, Mathematics and Engeineering (SME) undergraduates. Much effort by the Malaysian government has been planned and being executed to increase the softskills of the graduates of the Institutes of Higher Learning (IHL) which include their SR skills. However, there hasn't been much widely tested and accepted research evidence work in Malaysian education that clearly documents on the level of SR skills among SME undergraduates in Malaysian Public Universities. Therefore there is an urgent call for this type of study to be carried out particularly in the onset of the new policy of the Ministry of Higher Education on the concerted implementation of Outcome Based Education and softskills development throughout all the Institutes of Higher Learning in Malaysia.

2. OBJECTIVES OF THE STUDY

The objectives of this research were: (a) to determine the level of SR among SME undergraduates; (b) to compare the level of SR skills between the early and final year of SME undergraduates; (c) to compare the level of SR skills between Malaysian Public Institutes of Higher Learning among SME undergraduates; (d) to identify the lecturers' teaching style based on students' perception; and (e) to map instructional methods employed to the level of SR skills among the SME undergraduates.

3. METHODOLOGY

This study used the quantitative survey data-gathering method. There were six universities according to zone involved in this study using the stratification random sampling technique: Universiti Sains Malaysia (north zone), Universiti Putra Malaysia and Universiti Pendidikan Sultan Idris (centre zone), Universiti Teknologi Malaysia (south zone), Universiti Malaysia Pahang (east zone) and Universiti Malaysia Sabah (East Malaysia zone). For each university, the faculties that involved were faculties which have degree students in science, mathematics and engineering program. A total of 975 students were participated in this study which comprised of 462 early year students (1st and 2nd year) and 523 final year students (3rd and 4th year). There were two instruments used in this study namely, the Lawson Scientific Reasoning Skills Test (LSRS) and the Lecturers' Teaching Style Survey (LTSS). The LSRS test was adapted from the instrument of Classroom Test of Scientific Reasoning [3] to measure students' scientific reasoning skills. The LTSS was adapted from Teaching Styles Inventory [4] to measure students' perception on lecturers' teaching styles. The computed alpha reliability coefficients for both instruments were 0.77 and 0.88 respectively. The descriptive statistics and the inferential statistics such as mean, t-test and Pearson correlation were used to analyze the data.

4. RESULTS

4.1 The level of scientific reasoning skills

Table 1 showed the overall level of SR skills among Malaysian Public IHL students. The findings of the study showed that 63.2% of the students achieved Level 1 (concrete operational) of SR skill, 30.7% achieved Level 2 (transitional operational) and only 6.2% of them achieved Level 3 (formal operational). The overall mean level of the SR skills was 3.23 indicating that the Malaysian IHL students had concrete operational level of SR skills. All universities showed that all students achieved level 3 of SR skills accept UMP. UMS and USM achieved highest SR skills of level 3 with percentages of 11.8 and 11.7 respectively. The highest mean of SR skills was achieved by UMS students (mean=5.50), followed by USM students (mean=4.64), UTM students (mean=4.37), UPSI students (mean=3.69), UMP students and finally the lowest is UPM (mean=2.19) students.

Table 1: The Overall Level of SR Skills among Malaysian Public IHL students

University	N	Level of SR Skills (%)			Mean of SR Skills
		1	2	3	
UPSI	293	206 (70.3%)	81 (27.6%)	6 (2.0%)	3.69
UTM	151	87 (57.6%)	55 (36.4%)	9 (6.0%)	4.37
UMP	70	60 (85.7%)	10 (14.3%)	0	3.10
USM	103	57 (55.3%)	34 (33.0%)	12 (11.7%)	4.64
UMS	220	85 (38.6%)	109 (49.5)	26 (11.8%)	5.50
UPM	138	121 (87.7%)	10 (7.2%)	7 (5.1%)	2.19
TOTAL	975	616 (63.2%(	299 (30.7%)	60 (6.2%)	3.23

The level of SR skills between the early and final year students was provided in Table 2. The final year students (mean = 4.36) had higher level of scientific reasoning skills as compared to the early year students (mean = 3.65). The early year students still had an early stage of operational concrete level of scientific reasoning skills and on the other hand, the final year students had an end stage of operational concrete level. All universities showed an increasing pattern of level 2 and 3 of scientific reasoning skills and decreasing pattern of level 1 among final year undergraduates as compared to the early year undergraduates. Mean overall SR skills for the early year students was 3.65 (SD=2.28) while mean overall SR skills for the final year students was 4.36 (SD= 2.60). An independent t-test analysis showed that the difference in the mean were significant, $t(973)=-4.420$, $p<.05$ (Table 3). The results indicated that there was a significant difference in the mean overall SR skills between the early and final year students where the final year students had better SR skills as compared to the early year students.

Table 2: Level of SR Skills between Early and Final Year Students

SR Skills Level	Year		Differences (%)	Overall Total
	Early	Final		
1	294 (69.2%)	322 (58.5%)	-10.7	616 (63.2%)
2	115 (27.1%)	184 (33.5%)	6.4	299 (30.7%)
3	16 (3.8%)	44 (8.0%)	4.2	60 (6.2%)
Total	425 (100%)	550 (100%)		975 (100%)

Table 3: Comparison of Mean Overall of SR Skills between Early and Final Year Students

Tahun	N	Min	Sisihan Piawai	F	t	df	Sig. (2-tailed)
Awal	425	3.65	2.28	6.414	-4.420	973	.000
Akhir	550	4.36	2.60				

4.2   Dominant lecturers' teaching style

Table 4 presented the overall students' perception on lecturers' teaching styles. In general, the Expert and Delegator were dominant lecturers' teaching styles according to students' perception. However, the Personal Model teaching style was the lowest with 282 (28.9%) students' perception were in the highest score level.

From Table 5, there was no difference between the early and final year students' perception on lecturers' teaching style except increasing of higher level for the formal authority and facilitator teaching styles with percentages of 6.5 and 6.6 respectively. More than 80% of the early and final year students assume that their lecturers' teaching styles were Expert and Delegator, hence both were the dominant lecturers' teaching styles according to students' perception. Findings also showed that both early and final year students perceived the personal model as lecturers' teaching style at medium level.

Table 4: Overall students' Perception on Lecturers' Teaching Styles

Lecturers' teaching Styles	No. of students	Level (%)		
		Low	Medium	High
Expert	975	4 (0.4%)	152 (15.6%)	819 (84.0%)
Formal authority	975	21 (2.2%)	537 (55.1%)	417 (42.8%)
Personal Model	975	56 (5.7%)	637 (65.3%)	282 (28.9%)
Facilitator	975	33 (3.4%)	456 (46.8%)	486 (49.8%)
Delegator	975	2 (0.2%)	120 (12.3%)	853 (87.5%)

Table 5 : Perception on Lecturers' Teaching Styles between Early and Final Year Students

Lecturers' Teaching Styles	Year/ No. of students	Level(%)		
		Low	Medium	TinggHigh
Expert	Awal, N=425	3 (0.7%)	66 (15.5%)	356 (83.8%)
	Akhir, N=550	1 (0.2%)	86 (15.6%)	463 (84.2%)
Formal Autority	Awal, N=425	9 (2.1%)	250 (58.8%)	166 (39.1%)
	Akhir, N=550	12 (2.2%)	287 (52.2%)	251 (45.6%)
Personal Model	Awal, N=425	20 (4.7%)	279 (65.6%)	126 (29.6%)
	Akhir, N=550	36 (6.5%)	358 (65.1%)	156 (28.4)
Facilitator	Awal, N=425	13 (3.1%)	216 (50.8%)	196 (46.1%)
	Akhir, N=550	20 (3.6%)	240 (43.6%)	290 (52.7%)
Delegator	Awal, N=425	1 (0.2%)	55 (12.9%)	369 (86.8%)
	Akhir, N=550	1 (0.2%)	65 (11.8%)	484(88.0%)

4.3   Mapping the level of SR skills into instructional methodologies

Table 6 illustrated the correlation between students' perception towards lecturers' teaching style and the level of SR skills. The results indicated that overall, there was no correlation between students' perception towards lecturers' teaching style and the level of SR skills. For the early year students, it was also found that there was no correlation between both variables.

However, there was negatively weak correlation between the final year students' perception on three lecturers' teaching styles, namely $r_{personel\ model}=-0.30$, $r_{facilitator}=-0.34$ dan $r_{delegator}=-0.34$. See Table 7. Comparison between universities (Table 8) also revealed that there was no correlation between the SR skills and the lecturers' teaching style among the universities that were investigated. Only Universiti Sains Malaysia(USM) and Universiti Putra Malaysia(UPM) showed that there were negatively week relationship between the two variables where the dominant lecturers' teaching style for USM was Facilitator with $r = -.320$ and the dominant lecturers' teaching style for UPM were Formal Authority and Delegator with $r=-.387$ and $r=-.321$, respectively.

Table 6: Correlation between Lecturers' Teaching styles and SR Skills

	SR Skills	Perception on Lecturers' Teaching Styles				
		Expert	Formal Autority	Personal Model	Facilitator	Delegator
Mean	3.23	3.82	3.74	3.84	3.76	3.62
Pearson correlation		-.171**	-.151**	-.195**	-.222**	-.236**
Sig.(2-tailed)		.000	.000	.000	.000	.000

Pearson Correlation, *signifcant at 0.05 level, **significant at 0.01 level (2-tailed)

Table 7: Comparison between Early and Final Year Students on Correlation between Lecturers' Teaching Styles and SR Skills

Year		SR Skills	Perception on Lecturers' Teaching Styles				
			Expert	Formal Autority	Personal Model	Facilitator	Delegator
Early	Mean	3.65					
N=425	Pearson Coefficient		-.056	-.042	-.020	-.067	-.127**
Final	Mean	4.36					
N=550	Pearson Coefficient		-.251**	-.228**	-.302**	-.335**	-.335*

Pearson Correlation, *signifcant at 0.05 level, **significant at 0.01 level (2-tailed)

Table 8: Comparison between Universities on Correlation between Lecturers' Teaching Styles and SR Skills

Universiti	No. of students	SR Skills	Correlation beween lecturers' Teaching Styles and SR Skills				
			Expert	Formal Autority	Personal Model	Facilitator	Delegator
UPSI	293	3.69	-.112	-.080	-.060	-.062	-.150*
UMP	151	4.37	.109	.085	.019	.028	-.007
UMP	70	3.10	-.022	.041	-.003	.149	.049
USM	103	4.64	-.171	-.005	-.178	-.320**	-.125
UMS	220	5.50	-.108	-.145*	-.196**	-.177**	-.164*
UPM	138	2.19	-.301**	-.387**	-.287**	-.298**	-.321**

5. DISCUSSION

Findings of the study showed that most students had concrete operational level of SR skills where the overall mean was 3.23. These results confirmed other earlier studies ([5], [6]) that Malaysian student level of SR skills was still in the concrete operational level. However, [7] and [8] studies showed that 25% new undergraduates achieved the formal operational level, 50% were in transition to formal operational level and others were still in the concrete level. [9] stated that there was a correlation between the development of formal thinking and culture differences. Their studies showed that the Chinese were not performed as compared to the American due to the Chinese autocratic culture and hence this situation limited the development of intellectual thinking. According to [6], Malaysian education system is based on Bloom taxonomy had also limited the development of students scientific reasoning skills. In addition, the instructional practices among teachers and lecturers that based on the objectivist approach only produced students full with knowledge but they were not able to develop their thinking process. This is consistent with what had been emphasized by [10], that the objectivist approach is not focused on students' thinking process.

The findings of this study also revealed that the Expert and Delegator were dominant lecturers' teaching styles according to students' perception. These findings concur with other studies namely [11], [12] and [13]. Findings of a study by [11] showed that the dominant lecturers' teaching styles were Expert, Facilitator and Delegator. They also found that science and professional lecturers had higher mean for Expert teaching style. On the other hand, the social science lecturers had higher mean for Facilitator and Personal Model teaching styles. In addition, even though, the sample of a study by [12] was not among SME undergraduates, their findings were consistent with this study. The three teaching styles most prevalent among the English language lecturers were Expert, Personal Model and Delegator styles. Expert and Personal Model teaching styles are teacher-centered in nature. Meanwhile, the most preferred teaching style stated by the students was Facilitator style which is very much student-centered in nature and the Formal authority is the less preferred teaching style.

Findings from a study by [13] indicated that the nursing faculty members were more teacher centered than student centered; their written philosophies supported the teacher-centered approach. However, evidence that faculty used student-centered language, often in a teacher-centered context, indicates that participants in the study may recognize the need for a student-centered environment but may have difficulty with implementation. The Expert, Personal Model and Delegator teaching styles that were perceived by the students in this study were more teacher-centered. Thus, not only the SME area but area such as nursing also revealed the same findings. In addition, the findings of this study showed that there was no correlation between lecturers' teaching style and the level of scientific reasoning skills. Thus, this study cannot map the dominant lecturers' teaching style to the level of SR skills of SME undergraduates in Malaysian Public Institute of Higher Learning.

Nevertheless, this study gave some indications that the Expert and Delegator teaching styles were not contributed to the development of students' scientific reasoning skills. Research has shown that inquiry instruction, using the learning cycle, is an effective constructivist teaching method leading to greater conceptual understanding and scientific reasoning gains over a traditional lecture format (e.g.,[14], [15], [16] and [17]). The strong relationship between a specific teaching style with the SR skills will give some indications to educators about the importance of specific method of teaching that enhancing the reasoning skills. The findings of this study did not show a positive outcome where this study cannot map the dominant lecturers' teaching style to the level of SR skills of SME undergraduates in Malaysian Public Institute of Higher Learning. Nevertheless, this study gave some indications that the Expert and Delegator teaching styles were not contributed to the development of students' scientific reasoning skills.

6. CONCLUSION

As a conclusion, this study can be used as a baseline for SME undergraduates' level of SR skills in Malaysian Public Institute of Higher Learning. Overall, this study also opens an endless source of other researchers to investigate more areas on scientific reasoning skills so that the potential instructional model can be developed to enhance students' level of scientific reasoning skills in the Institute of Higher Learning.

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