INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES
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ISSN: 2222-6990

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To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v8-i5/4243 DOI: 10.6007/IJARBSS/v8-i5/4243

Received: *20 March 2018,* ***Revised:*** *11 April 2018,* ***Accepted:*** *05 May 2018*

Published Online: 08 May 2018

In-Text Citation: (Sabudin, Mansor, Meerah, & Muhammad, 2018)

To Cite this Article: Sabudin, S., Mansor, A. N., Meerah, S. M., & Muhammad, A. (2018). Teacher-Level Factors that Influence Students' Science and Technology Culture: HLM Analysis. *International Journal of Academic Research in Business and Social Sciences*, *8*(5), 961–969.

Vol. 8, No. 5, May 2018, Pg. 961 - 969

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Teacher-Level Factors that Influence Students' Science and Technology Culture: HLM Analysis

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Abstract

It has been observed that there is an issue of declining student enrolment in science and technology at upper secondary level, as well as low performance of Malaysian students. These concerns have been recorded by Trends in Mathematics and Science Studies (TIMSS), and Performance for International Student Achievement (PISA) tests from 2003 to 2009. As a result, the policy of 60:40 target ratio of science to non-science students which has been set by Ministry of Education Malaysia (MOE) may be affected. Accordingly, this scenario has raised concerns and questions related to the quality of science teachers, especially in the aspect of teachers' pedagogical skills. Therefore, this study was conducted to identify the impact of Form Two science teacher's Productive Pedagogy on the Science and Technology Culture among the students. For this purpose, the descriptive study using multi-stage sampling technique involving 40 science teachers and 800 Form Two students at several secondary schools in Seremban, Negeri Sembilan has been carried out. The collected data were analyzed using Hierarchical Linear Modelling (HLM) software to identify the influence of teacher's Productive Pedagogy on the students' Science and Technology Culture. Based on the HLM analysis, it indicates that 40 percent of the differences in the Science and Technology Culture level of practice are contributed by a number of factors at a teacher level. Some of the factors are teacher's gender, age, type of school and dimension of Intellectual Quality (one of the dimensions in Productive Pedagogy). Thus, the results of HLM show that teacher level factors significantly influence the student's outcomes or achievements.

Keywords: Productive Pedagogy, Science and Technology Culture, Teacher's Influence, Student's Outcome, Hierarchical Linear Modelling.

Introduction

The diversity of skills in facing the challenges of 21st century needs to be complemented by every young generation. These skills include creativity and innovation, critical thinking, problem solving skills, lifelong education, communication skills and collaboration (Jacob, 2010). Since teachers are

individuals who interact directly with students in schools, their ability in realizing the desired curriculum is very important. This is because high quality teachers have been acknowledged as one of the major factors influencing the students' learning process (McKinsey & Company, 2007; Darling-Hammond, 2000; Rowe, 2003). In addition, the teaching qualities of the teachers including selection of teaching and learning activities, perceptions towards students' potential, and selection of topics to be taught are believed to influence the effectiveness of teaching and learning process of science subject (Lingard, Hayes & Mills, 2003; Joseph, 2011; Bell, 2011).

Problem Statement

The Trends in Mathematics and Science Studies (TIMSS) and Performance for International Student Achievement (PISA) tests from 2007 to 2015 show the decline in mastering science and mathematics among Malaysian students in the international level. The tests conducted by Organization for Economic Co-operation and Development (OECD) have become one of the concerns among the Malaysians. The performance of Malaysian students is shown in TIMSS and PISA results, which also reflects the decline in mastering science and technology (S&T) knowledge internationally (Ministry of Education Malaysia, 2012a).

Furthermore, the decline is also observed in upper secondary level students' participation in S&T field. Based on the MOE statistics, the participation of students in science field from 2001 to 2011 has never reached the 60:40 target ratio of science to non-science students as targeted by national education policy, even though the percentage of eligible students pursuing S&T is higher than the percentage of S&T students in every year (Ministry of Education Malaysia, 2012b). Indirectly, this situation gives an indication that the number of students who are interested in S&T field is reducing. In fact, these two scenarios have raised concerns regarding the ability to form communities with S&T Culture in the future, as intended by The National Philosophy of Science Education (Curriculum Development Centre, 2003). Moreover, the situation gives impact to the national development process (Halim, 2013).

Literature Review

According to Ministry of Education Malaysia (2012b), teachers tend to practice traditional pedagogy and teaching methods that are too focused on examinations. As a result, the teaching and learning process of science subject at school level is still on the level of knowledge and understanding. Besides, the methods applied by these teachers do not help in creating high-level thinking skill. Consequently, the students become less interested in learning, and this has led to ineffective teaching and learning process. In addition, study done by Osman, Iksan and Halim (2002) found that students' scientific attitudes towards science are low. Therefore, changes in traditional teaching and learning methods of science subject need to be made. These changes involve the aspects of innovation and quality of teaching and learning of science subject. Teachers are often considered as technicians who act in accordance with the suggested curriculum innovation without any self-invention (Halim, 2013). This statement shows that teachers' pedagogical practice is significant in influencing students' academic performance and personal development (Arbaa, Jamil, & Abd. Razak, 2010; McKinsey & Company, 2007; Hayes, Mills, Christie & Lingard, 2006; Rowe, 2003; Darling-Hammond, 2000). The fourth shift in the transformation of the national education system as stated in Malaysia Education Blueprint 2013-

2025 has highlighted about transforming teaching into the profession of choice (Ministry of Education, Malaysia 2012a). As discussed earlier, the current development of science education indicates that the teacher's factor in teaching and learning process of science field is very important. It is also believed to influence the students' interests (Hayes et al., 2006; Othman, 2007). This study was conducted to get an overview regarding the influence of science teachers on the development of students' S&T Culture.

Research Aim and Objectives

This study aims to identify the influence of Productive Pedagogy practice among science teachers on the S&T Culture of Form Two students in secondary schools located at Seremban district. The followings are two main objectives of the study:

a. To identify differences in S&T Culture among Form Two students according to different classes in the study sample.

b. To discover any second-level variables such as teachers that influences the differences in students' S&T Culture according to different classes in the study sample.

Methodology

This descriptive study is conducted using a quantitative approach. The questionnaire is used as the data collection instrument in this study. A total of 40 science teachers and 800 Form Two students in Seremban, Negeri Sembilan were selected through multi-stage sampling technique. The number of respondents has reached the minimum requirements of sampling size in order to carry out Hierarchical Linear Modeling (HLM) analysis as stated by Kreft (1996), Kreft and De Leeuw (1998), Maas and Hox (2005), Hox (2010) and Snidjers and Bosker (2012). This study used two questionnaires, the first questionnaire is related to the Productive Pedagogy practice of the teachers, while the second questionnaire is on the S&T Culture of the students. Pilot study was also conducted involving 30 Form Two students and 30 Form Two science teachers in four secondary schools in Nilai, Negeri Sembilan to test the reliability and validity of the research instrument. The Cronbach's coefficient alpha obtained for the Productive Pedagogy instrument was 0.872, while the Cronbach's coefficient alpha obtained for S&T Culture instrument was 0.783. Therefore, it can be seen that both instruments have recorded value more than 0.7, which can be considered as a good reliability value (DeVellis, 1991).

Data Analysis

The collected data were analyzed using Hierarchical Linear Modelling (HLM) software version 7.0. Before the HLM test was carried out, data collection (specially the first-level data of the students) was ensured to comply with a set of prerequisites. Some of the requirements are the data indicate normal distribution through skewness statistics, no multicollinearity problems in the collected data, data should show linear relationship, and Factor Analysis test was performed to ensure the accuracy and consistency of items in measured constructs (Ibrahim, 2006).

Analysis of Variance Model

Preliminary information regarding the interaction between assumptions in level-1 and level-2 that influences the students' level of S&T culture in different classes in Seremban can be

generated using Analysis of Variance (ANOVA). This analysis gives the overall estimated mean value, and also separates the overall variation value of S&T culture of '*within class*' variation and '*between class*' variation.

Furthermore, this analysis gives information on the observed degrees of freedom in each class. The analysis also provides information on reliability measurement for the average level of S&T Culture for each class in order to estimate the actual mean. Therefore, the hypothesis that all classes have similar mean value of S&T Culture can be tested. Table 1 indicates that from the ANOVA result, there is a significant difference in S&T Culture among Form Two students according to different classes.

Table 1: ANOVA Analysis on S&T Culture among the Students

Fixed effect	**Cooefficient**	**Standard deviation**	**t-ratio**	**p-value**
Intercept, γ_{00}	438.44	3.66	119.63	<0.001
Random Effect	**Variance components**	**df**	**χ2**	**p-value**
Class mean (Between class variation), u_{0j}	461.22	39	275.364	<0.001
Level-1 effect (Within class variation), r_{ij}	1522.01			
Reliability (Intercept)	0.858			
Intra Class Correlation (ICC)	0.233			

Note: The degree of freedom is based on the number of classes involved. For analysis of variance in HLM df = J - 1, where J = number of classes with enough data to be analyzed. In this case, all students and classes are involved in this analysis.

Based on the findings, there is a significant variation in the mean level of students' S&T Culture among the studied teachers' classes as estimated by the calculated value of Intraclass Correlation (ICC) using the formula:

Value of ICC, $\hat{\rho} = \hat{\tau}_{00} / (\hat{\tau}_{00} + \hat{\sigma}^2)$

$$= \frac{461.22}{461.22+1522.01}$$

$= 0.233$

It is indicated that nearly 23 percent of differences are recorded in the students' S&T Culture level among the studied teachers' classes. Based on the ANOVA analysis on the final data, the Chi square statistical test (χ2 = 275.364, df = 39) indicates that there is a significant difference in the students' S&T Culture level between the samples of the studied teachers' classes (p <0.001).

Hence, this initial test results signify possible variables at the teacher class level, which contributes to the differences that exist in the students' S&T Culture level. For that reason, the Means as Outcomes Model has been performed.

Means as Outcomes Model

All factor assessments at the teacher level were tested in this test and the final result is as shown in Table 2 below.

Table 2: Means as Outcomes Model Overall Analysis

Fixed effect	Cooefficient	Standard deviation	t-ratio	p-value
Model for class-level mean Intercept, γ_{00}	476.636581	11.460118	41.591	<0.001
JAN, γ_{01}	-33.952516	9.839897	-3.450	0.002
UMUR, γ_{02}	1.140757	0.367179	3.107	0.004
JSEK, γ_{03}	14.479454	4.028244	3.594	0.001
KI, γ_{04}	-1.836515	0.756809	-2.427	0.021
KSDK, γ_{05}	1.667116	1.372388	1.215	0.233
PBDK, γ_{06}	1.353592	0.687667	1.968	0.058
MMP, γ_{07}	-0.005078	0.445501	-0.011	0.991
Random effect	**Variance component**	**df**	**χ2**	**p-value**
Class mean, u_{0j}	275.57758	32	147.87937	<0.001
Level-1 effect, r_{ij}	1522.01079			

1. *All class-level variables have been "grand mean centered", except JAN prior to analysis.*
2. *The degree of freedom for this model (Means as Outcomes) is based on the number of classes with sufficient data, as well as the number of class-level variables involved in the model. Degree of freedom = J - Q - 1, where J = number of classes with enough data to be analyzed, Q = number of class-level variables involved in the model (40-1-7 = 32). All studied classes are involved in this analysis.*

All of the teachers' backgrounds show significant results, for instance gender (γ_{01} = -33.95, sp = 9.84, p = 0.002), age (γ_{02} = 1.14, sp = 0.37, p = 0.004) and type of school (γ_{03} = 14.48, sp = 4.03, p = 0.001). For teachers' Productive Pedagogy factor, it is found that only Intellectual Quality dimension shows significant result (γ_{04} = -1.84, sp = 0.76, p = 0.021). For the gender of teacher, HLM automatically (default) will provide code 0 to "female" and code 1 to "male" (Garson, 2012). In other words, students in female teacher class are predicted to score 476.64 on S&T Culture when other factors are constant. Meanwhile, since the coefficient value is negative, this means that students in male teacher class are predicted to score 34 points less than the students in female teacher class. For the age of teacher, score of 476.64 on S&T Culture was recorded by students in the classroom whom taught by the same aged teacher with overall mean of teachers' age when other factors are constant.

The test results reveal that the identified teacher-level factors which influence the S&T Culture of the students are gender, age, type of school, and Intellectual Quality dimension of the teachers. The variance value between classes (τ_{00}) is 0.15, which is less than τ_{00} value from null hypothesis test (ANOVA), that is 0.233 and τ_{00} value of teacher background factor test is 0.162. The value of residual variance between classes, $\hat{\tau}_{00}$ = 275.58, is less than the original value of residual variance, $\hat{\tau}_{00}$ = 461.22 as estimated by the random ANOVA test. By comparing the approximate value of τ_{00} between the two models, the ratio index of the reduction in variance can be identified by the following formula:

$$\text{explanation of the variance ratio in } \beta_{0j} = \frac{\hat{\tau}_{00} \text{ (random ANOVA) - } \hat{\tau}_{00} \text{ (PU teacher level)}}{\hat{\tau}_{00} \text{ (random ANOVA)}}$$

$$= \frac{461.22 - 275.58}{461.22}$$

$$= 0.40$$

The actual variance between classes in the students' S&T Culture level which contributed by the teacher-level variable is 40 percent.

The existence of teacher-level factors influencing students' level of S&T Culture are also shown in this analysis. Thus, there is no significant influence between the second-level variable (teacher) on the existing differences of students' S&T Culture in different classes. The constructed null hypothesis is rejected.

Discussion

The exploration in identifying any influence involving teacher-level factors such as the Productive Pedagogy practice on the students' level of S&T Culture was performed through HLM statistical analysis. In the first HLM test, there was a significant difference regarding students' level of S&T Culture. Meanwhile in the second HLM test, teacher-level factors such as gender, age, type of school and Intellectual Quality dimension of teachers are identified as the factors that influence students' level of S&T Culture. There are 40 percent of differences contributed by teacher-level factors on the students' S&T Culture level.

Conclusion

In general, the findings of the study indicate that the factors at teacher-level can affect the students' learning performance. In particular, the S&T Culture level among the students can be influenced by several factors such as their science teacher's gender, age, type of school, and Intellectual Quality dimension in Productive Pedagogy practice. This indirectly shows that teacher-level factors need to be taken into consideration in order to shape and develop students' interests in S&T. Therefore, KPM needs to focus more on developing policies related to science teachers as it can significantly contribute to the cultivation and development of students' interest in this particular field.

Acknowledgement
The authors acknowledged the Ministry of Education Malaysia, Universiti Kebangsaan Malaysia and Universiti Pendidikan Sultan Idris for the full support of this research.

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