Reading Performance of Science, Technology, Engineering and Mathematics (STEM) Students: Comparing STEM-Related and STEM-Unrelated Texts

Jerryk C. Alico
Faculty, Senior High School
Special Assistant, Office of the Vice President for Planning and Development
Mindanao State University
Marawi City

Abstract

This causal-comparative research investigated whether reading comprehension performance differs if students read two different texts one that is related to their chosen field of study while the other is not. It also took interest in determining the influence of demographic and academic profile information on reading comprehension. Thirty students enrolled in the Science, Technology, Engineering and Mathematics (STEM) Strand of the Mindanao State University-Marawi Senior High School took two sets of reading comprehension tests for four times. The first set used texts whose topics are related to STEM while the second set used texts whose topics are taken from other fields of study like social sciences and economics. Findings revealed that in all four sessions of reading comprehension tests, there was a consistent significant difference between the performances of students in STEM-related and STEM-unrelated texts. Specifically, students performed better in test sets that used STEM-related texts. Moreover, there was no difference in the students' performance when they were classified according to their gender and age. Interestingly, the curriculum they undertook in junior high school mattered in their reading comprehension performance on STEM-unrelated texts, which showed that students who were trained in science high schools performed better than other students did. These findings forward significant pedagogical implications for the effective teaching of English as well as other subject areas to Senior High School students with respect to instructional and reading materials used.

Keywords: Reading Performance, Content Familiarity, Reading Interest, Senior High School, STEM

1. Introduction

The role of reading as a skill and as a learning activity cannot be overemphasized, given that it is one of the macroskills in language learning, together with listening, speaking, and writing. Specifically, it is a receptive skill, like listening, which plays a big role in collecting and absorbing information, hence, building learners' knowledge repository. Putting emphasis on reading skill, Anderson (2003) contends that learners would also perform better in other subject areas that necessitate the ability to comprehend reading materials if they enhance their reading ability. Thus, language learners must be trained and honed to

become excellent readers in order that they find reading a useful activity as they undergo the learning process.

In the newly implemented Senior High School in the Philippines, reading is given emphasis in the curriculum, as evidenced by the inclusion of a core subject area *Reading and Writing Skills*. Besides the idea that reading is an important course to take, such inclusion implies that although Senior High School students have spent 10 years in grade school and junior high school, their reading abilities may need enhancement by increasing the difficulty of reading activities and deepening the concepts in their reading materials.

The Senior High School curriculum offers four career tracks: Academic, Sports, Arts and Design, and Technical-Vocational Livelihood (TVL). Two of these have sub-strands—the Academic and TVL tracks. The Academic Track comprises the following strands: Accountancy, Business and Management (ABM), Science, Technology, Engineering and Mathematics (STEM), Humanities and Social Sciences (HUMSS), and General Academic (GA).

With respect to reading research, the Senior High School is an interesting and fertile environment. As students choose a track/strand, they express their personal interest and inclination as well, which may extend to their preferred topics for reading. As reading experts generally claim, students appear to be in an active and interactive process when they read (Grabe & Stoller, 2002). Erten and Razı (2009) respond to that idea by asserting that reading a text must require some background knowledge for readers to succeed in interacting with the text. In this light, it can be hypothesized that students may tend to perform better in reading when the texts they read are taken from their chosen career track or field of study. Haiduc and Liliana (2011) once mentioned that some factors might influence reading comprehension such as text content as well as readers' prior knowledge.

Therefore, it is the aim of this study to test the said hypothesis in the context of Senior High School students, particularly among students enrolled in the Science, Technology, Engineering and Mathematics (STEM) strand of the Academic Track in the Mindanao State University-Marawi Senior High School. This study is hoped to contribute to the improvement of English language teaching as well as other subject areas by using it as basis for enhancing pedagogical practices of teachers with respect to reading materials used. By utilizing texts that facilitate comprehension in teaching Senior High School students, there is a great possibility that learning would be a successful and productive process.

2. Literature Review

2.1. Theoretical Framework

This study takes into consideration the concept of 'schema' as a theoretical foundation. Grabe (1991) described reading comprehension as "a combination of identification and interpretation skills" (p. 125). This implies that for learners to complete the comprehension process, they must be able to form a nexus between the knowledge they get from the text and the knowledge they acquired previously.

The schema theory in particular enshrines the standpoint that background knowledge holds a great part in the reading process. Cognitive scientists formulated such a theory in an attempt to describe how

comprehension occurs. It particularly explains that readers combine their own schema, or the "pre-existing knowledge structures stored in the mind" (Nassaji, 2002, p. 444), with the information in a text to comprehend that text. Because of background knowledge, thus, to a certain extent, readers may find the text they are reading familiar and relatable (Tabatabaei, 2013).

Moreover, there are two commonly known types of schema: *formal* and *content* schemata. Readers are said to have formal schema, or textual schema as what Singhal (1998) calls it, if they are knowledgeable about the conventions of the language of the reading materials as well as the text organization and the exclusive characteristics of the genres of writing (Alderson, 2000; Carrell, 1987, 1988; Carrell & Eisterhold, 1983). In fact, Carrell's (1987) research found that learners find it easier to comprehend a text with familiar rhetorical organization.

If textual schema refers to the knowledge of text structures, content schema, on the other hand, is the knowledge of the text content (Carrell, 1983). According to Alderson (2000), content schema has two types. One is background knowledge, which pertains to the knowledge applicable or irrelevant to the text content. Second is subject matter knowledge that "is directly related to the text content and topic" (Alderson, 2000).

Yule (1996) later on proposed another type of schema called cultural schema. Some authors name it differently, like abstract schema (Nassaji, 2002), story schema (Mandler, 1984), and linguistic schema (Ketchum, 2006). For Ketchum (2006), cultural schema is an extension of content schema in the lens of culture, which is importantly regarded since readers' cultural affinity to the text content may also facilitate their understanding of the text.

Another theoretical foundation of this study is the role of reading interest in reading performance. Alexander and Jetton (2000) purported that there are two main dimensions of interest involved in the reading process: situational and individual. Individual interest includes the predilections of readers to specific topics that are already established even before reading a particular text (Hidi, 1990; Schiefele, 1992). On the other hand, situational interest pertains to interest that situational factors instigate. Examples could be the text given to readers or the nature of the test they will take. Since situational interest tends to be contingent on certain situations only, it does not exist as a long-term disposition (Krapp, Hidi, & Renninger, 1992; Wade, 1992). In the present study, interest is defined contextually as the students' inclination to their chosen field of study in Senior High School, which is technically akin to individual interest. The researcher assumes that since the participants of the study chose STEM as their career track, they may also be interested in topics about science, technology, engineering and mathematics.

2.2. Related Studies

A number of researches have investigated the effects of text familiarity on reading comprehension. One was that of Tabatabaei (2013), which showed that content familiarity significantly affects the performance of intermediate EFL learners with the use of MC cloze test and C-test. Moreover, it revealed that that gender has no significant effect on the performance of students in the two tests. Aghajani, Motahari and Qahraman (2013) also had the same result indicating that the participants' degree of text familiarity affected significantly their test performance.

In addition, Martínez (2014) found that content familiarity significantly affected students' overall comprehension performance and she concluded that the more familiar the text, the better the comprehension. Further, in terms of gender, her results suggested that familiarity with text content could affect the comprehension of both male and female readers.

In the same vein, Al-Shumaimeri (2006) determined and compared the reading performance of high- and low-reading ability students by administering two reading comprehension tests, one with a familiar content and the other with unfamiliar content. Results revealed that in the text with familiar content, both groups of students performed comparably. He purported that the low-ability students' familiarity with the content of the first test may have helped them perform equally with the high-ability students. However, in the unfamiliar text, the high-ability students got significantly higher scores than the low-ability students did, which led Al-Shumaimeri to claim that the low-ability students' unfamiliarity with the content caused their low performance while the high-ability students utilized their superior reading skill to perform better in the test.

So far, the abovementioned researches considered various classifications of research participants such as English proficiency, gender and others. Despite limited ways of classifying readers, they still contributed significant knowledge about the role of text familiarity in reading comprehension. To extend the literature review on the matter, some studies directly related to the nature of the present study are discussed further.

Alderson and Urquhart (1983, 1985a, and 1985b) conducted studies whose participants were students taking English classes in Britain in preparation for university education. The goal was to determine whether a significant difference exists between students' test scores on reading texts in line with their chosen field and on texts with content taken from other fields of study. Their findings showed that in technology, science and engineering students performed better than business and economics students as well as social sciences students did. However, Peretz and Shoham (1990) and Lipson (1984) had contrasting findings. They concluded that, perhaps, a totally unfamiliar text may still be easier to process than a text containing a partly familiar content.

3. Methodology

This study is a causal-comparative research that aims to determine whether a significant difference exists between the reading performances of students in the STEM-related texts and STEM-unrelated texts. Moreover, it also aims to know if there are significant differences in reading performance when readers are classified according to their profile variables, namely, gender, age and junior high school curriculum taken. The last profile variable refers to the school curriculum they underwent in junior high school, which are the following: Restructured Basic Education Curriculum (RBEC), Science Curriculum, and Integrated Curriculum. The Restructured Basic Education Curriculum is the prescribed generic curriculum implemented by mainstream government schools in the Philippines. The Science Curriculum is offered in Science High Schools, some are private-owned while some are government-owned, which put much emphasis on Science-related subjects and skills like pure sciences, research and experimentation. The Integrated Curriculum is common in Marawi City, Philippines where schools include Arabic Language and

Islamic Values Education (ALIVE) in the curriculum to cater to the needs of Muslim students, hence, the name 'integrated'.

One section of students enrolled in the Science, Technology, Engineering and Mathematics (STEM) Strand served as participants of the study. They were the researchers' students in the subject *Reading and Writing Skills* in the second semester of academic year 2016-2017. The following table shows the distribution of students according to profile:

Table 1. Distribution of Students according to Profile

Profile	Frequency	Percent
Age		
16 years old	7	23.3
17 years old	14	46.7
18 years old	9	30.0
Total	30	100.0
Gender		
Male	10	33.3
Female	20	66.7
Total	30	100.0
Curriculum		
RBEC	2	6.67
Integrated	19	63.3
Science	9	30.0
Total	30	100.0

Four sessions of reading comprehension test were conducted in different days within the months of February and March 2017. Each session has two sets of reading comprehension tests. The first set contains reading materials related to Science, Technology, Engineering and Mathematics (STEM), dealing with topics like biodiversity, fossils, water on Earth, and technological devices. These materials, which were taken from ReadWorks.org, were made for Grade 11 students. On the other hand, the second set contains reading topics that are unrelated to STEM like Social Sciences and Economics, which were taken from the reading comprehension tests compilation of Learning Express, LLC titled 501 Reading Comprehension Questions.

The students were given 100 minutes (1 hr and 40 mins) each session to complete the tests. Before each passage, students were asked two questions. One was if they have encountered topics related to the content of the passage and another was how knowledgeable they are about the topic. As expected, all of them were familiar and quite knowledgeable about the topics in the first set of reading comprehension tests. In contrary, they reported less and no familiarity with some of the topics in the second set of tests and they were not so knowledgeable about them. Each set of the tests has 30 comprehension questions with four choices labelled A, B, C and D.

4. Results and Discussion

The main goal of this study is to determine whether STEM students perform better in reading comprehension if they read STEM-related texts and whether differences in reading comprehension performance exist if students are grouped according to their profile information. Using SPSS 14.0, the following are the major findings of the data analysis.

Table 1a. Group Statistics of Respondents' Mean Scores in the Reading Comprehension Tests

Sets	Factor	N	Mean	Std. Deviation	Std. Error Mean
Set A	STEM-related Text	30	24.8667	4.11669	.75160
	STEM-unrelated Text	30	15.0000	5.10578	.93218
Set B	STEM-related Text	30	24.8000	3.20990	.58604
	STEM-unrelated Text	30	13.9000	3.16609	.57805
Set C	STEM-related Text	30	23.5333	3.41127	.62281
	STEM-unrelated Text	30	12.9667	4.10621	.74969
Set D	STEM-related Text	30	24.4333	2.99060	.54601
	STEM-unrelated Text	30	15.9000	4.19647	.76617

Table 1b. Independent Samples Test of the Respondents' Reading Comprehension Performances

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Set A	Equal variances assumed	1.671	.201	8.240	58	.000**	9.86667	1.19744	7.46972	12.26361
	Equal variances not assumed			8.240	55.504	.000**	9.86667	1.19744	7.46743	12.26591
Set B	Equal variances assumed	.075	.785	13.242	58	.000**	10.90000	.82316	9.25227	12.54773
	Equal variances not assumed			13.242	57.989	.000**	10.90000	.82316	9.25227	12.54773
Set C	Equal variances assumed	.352	.555	10.842	58	.000**	10.56667	.97464	8.61571	12.51762
	Equal variances			10.842	56.114	.000**	10.56667	.97464	8.61432	12.51902

	not assumed									
	Equal variances assumed	2.880	.095	9.070	58	.000**	8.53333	.94082	6.65009	10.41658
Set D	Equal variances not assumed			9.070	52.416	.000**	8.53333	.94082	6.64581	10.42086

***Significant at α=0.05*

Tables 1a and 1b present the mean scores of the students in the four sets of reading comprehension test. Data reveal that the students' mean scores in STEM-related texts range from 23 to 24 points while in STEM-unrelated texts, their scores show a large drop to a range of 12 to 15 points. Clearly, the data suggest that the students performed better when they read STEM-related texts. To confirm the significance of these observations, multiple t-Tests were run and Table 1b shows the results. With mean differences of 8 to 10 points across all reading tests, the significance value of 0.00 ($p<0.05$), which is consistent in all sets, certainly mean that there are significant differences between the scores of the students in STEM-related texts and STEM-unrelated texts.

The said result leads to the conclusion that reading comprehension is better facilitated by texts whose contents are in line with students' field of study because these texts can activate students' schema and topic interest that may lead to better understanding. More importantly, this finding is consistent with what other researchers found, particularly that of Alderson and Urquhart's (1983, 1985a, and 1985b). As a pedagogical implication, English teachers as well as those teaching other subject areas must take into consideration the prior knowledge and interest of learners to be able to tailor-fit their instructional materials to the dispositions of learners.

Table 2a. Group Statistics of Male and Female Respondents' Mean Scores in the Reading Comprehension Tests

	Gender	N	Mean	Std. Deviation	Std. Error Mean
STEM-related Texts	Male	10	96.1000	4.48330	1.41774
	Female	20	98.4000	6.54860	1.46431
STEM-unrelated Texts	Male	10	55.1000	5.78216	1.82848
	Female	20	59.1000	9.61851	2.15076

Table 2b. t-Test Results Comparing the Reading Performances of Male and Female Students

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
STEM-related Text	Equal variances assumed	1.321	.260	-.996	28	.328	-2.30000	2.30957	-7.03094	2.43094
	Equal variances not assumed			-1.128	24.979	.270	-2.30000	2.03819	-6.49791	1.89791
STEM-unrelated Text	Equal variances assumed	1.308	.262	-1.204	28	.238	-4.00000	3.32096	-10.80267	2.80267
	Equal variances not assumed			-1.417	26.817	.168	-4.00000	2.82296	-9.79410	1.79410

In Table 2a appears the mean scores of male and female students. It can be gleaned that he two groups have a 2-point difference in the STEM-related texts while a gap of 4 points is found in the STEM-unrelated texts. Although there are point differences between the two groups, the t-Test results in Table 2b do not prove their significance ($p>0.05$). This finding suggests male and female students do not differ in reading comprehension performance in both STEM-related texts and STEM-unrelated texts. Thus, gender does not always account for reading comprehension disparities of readers, particularly the STEM Strand students. This result supports the claim of some researchers, especially Tabatabaei (2013), that gender has no significant effect on the performance of the students in reading familiar and unfamiliar texts.

Table 3a. Mean Scores of Respondents from Different Age Groups

Age Groups		STEM-related texts	STEM-unrelated texts
16 years old	Mean	99.8571	57.8571
	N	7	7
	Std. Deviation	5.30498	6.14894
17 years old	Mean	97.7857	58.4286
	N	14	14
	Std. Deviation	5.95081	9.30438
18 years old	Mean	95.6667	56.6667
	N	9	9
	Std. Deviation	6.44205	9.97497

Table 3b. ANOVA Results Comparing Mean Scores of Respondents from Different Age Groups

		Sum of Squares	df	Mean Square	F	Sig.
STEM-related texts	Between Groups	69.752	2	34.876	.980	.388
	Within Groups	961.214	27	35.601		
	Total	1030.967	29			
STEM-unrelated texts	Between Groups	17.081	2	8.540	.107	.899
	Within Groups	2148.286	27	79.566		
	Total	2165.367	29			

Quite noteworthy in this study is the attempt to know whether students from different age groups have differing reading comprehension performance in both STEM-related and STEM-unrelated texts. It can be noticed that in STEM-related texts, students' mean score decreases in two-point interval as their age increases, with 16-year-olds garnering the highest mean score. On the other hand, such is not true in STEM-unrelated texts wherein 17-year-olds got the highest mean score. Initially, differences in mean scores are evident in the data. However, the ANOVA results in Table 3b do not confirm the significance of these differences ($p>0.05$). Therefore, age does not necessarily factor in while students read texts that are related or not to their field of study.

Table 4a. Mean Scores of Respondents from Different Junior High School Curricula

Curriculum		STEM-related texts	STEM-unrelated texts
RBEC	Mean	95.5000	54.0000
	N	2	2
	Std. Deviation	.70711	2.82843
Integrated	Mean	96.2632	54.5789
	N	19	19
	Std. Deviation	5.69446	7.61078
Science	Mean	101.0000	65.3333
	N	9	9
	Std. Deviation	6.12372	6.87386
Total	Mean	97.6333	57.7667
	N	30	30
	Std. Deviation	5.96243	8.64105

Table 4b. ANOVA Results Comparing Mean Scores of Respondents from Different Junior High School Curricula

	Sum of	df	Mean	F	Sig.

		Squares		Square		
STEM-related texts	Between Groups	146.782	2	73.391	2.241	.126
	Within Groups	884.184	27	32.748		
	Total	1030.967	29			
STEM-unrelated texts	Between Groups	736.735	2	368.368	6.962	.004**
	Within Groups	1428.632	27	52.912		
	Total	2165.367	29			

***Significant at α=0.05*

Last set of results is reflected in Tables 4a and 4b, which compares mean scores of students from different curricular programs in junior high school. According to the data, students from the Science curriculum performed far better than students from other curricula did in both STEM-related and STEM-unrelated texts. On the contrary, students from the RBEC and Integrated curricula have comparable reading comprehension performances in both text types. To decide on the significance of the noted variances, ANOVA was made and it revealed that in STEM-related texts, the mean scores of the three groups of students are not significantly different from one another. This means they performed equally in the test, despite the fact that students from Science curriculum got 5 points more than the two groups.

Moreover, what is unforeseen in the findings is the significant difference among the reading comprehension performances of the three groups in STEM-unrelated texts. Specifically, Science curriculum students scored 11 points higher than the two groups whose scores are almost equal. This result seems to resemble Al-Shumaimeri's (2006) findings, specifically that which compared high- and low-ability students. With due respect to junior high schools implementing the RBEC and integrated curriculum, there persists a common notion that students enrolled in science high schools tend to perform better in academics, especially in Science and Mathematics, due to their intensive and advanced training. Thus, there is a great propensity that Science curriculum students develop considerably high cognitive abilities, which may include reading comprehension. Using Al-Shumaimeri's (2006) classifications, Science curriculum students can be the high-ability readers while those in RBEC and integrated curriculum can be assumed as the relatively low-ability readers. Based on the ANOVA results, it can be construed that, similar with Al-Shumaimeri's claim, the low-ability readers' performance was due to the unfamiliarity of the STEM-unrelated texts while the high-ability readers used their 'superior' reading comprehension skill to score better.

5. Conclusion

Reading, being an active and interactive cognitive process of deriving meaning from texts, is indeed complex and multifaceted. Many factors can influence a reader's ability to comprehend a text, and in this study, a few of them are identified. First and most important is the schemata of readers, which refer to their background knowledge and familiarity of text structures and content of texts. Based on the results, students performed better in reading comprehension tests that used topics related to their chosen field of study, which is Science, Technology, Engineering and Mathematics (STEM). Second is the kind of training they had in their early years of schooling, which pertains to the curriculum adopted by their previous schools. As

shown in the results, students who underwent the Science curriculum got better comprehension scores in STEM-unrelated texts than other students did, suggesting that despite the unfamiliarity of the texts, their considerable competence in reading comprehension compensated for their lack of background knowledge of the texts.

Several implications can be drawn from the findings as well. First, teachers of General English or English for Specific Purposes should take into consideration the chosen field of study and topic interest of their students so that they can tailor-fit their reading materials to the students' preferences. As commonly agreed by educators today, learners' preferences, needs and interest must be addressed during the teaching-learning process. Second, elementary and secondary schools must take stronger and more effective efforts to build the cognitive foundations of young learners under their care so that they will be ready and be able to cope with the cognitive demands of pursuing further education. Teachers, school administrators and even parents must work together to reinforce and strengthen learners' reading ability to ensure holistic approach to educating them. Lastly, interested researchers may conduct a similar study but with a larger sample, more advanced research method and statistical analysis, and more variables to investigate in relation to content familiarity.

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