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TEACHER COMMUNICATION IN BRUNEIAN SECONDARY SCIENCE CLASSES: WAIT-TIME

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Abstract: A study was undertaken to (a) explain the wait-time that reflects the cognitive processes involved in the construction and reconstruction of knowledge in interpreting questions and then providing responses and (b) compare the mean wait-time taken by students with the wait-time intended by teachers, in both theory and practical classes in Bruneian secondary schools. The recorded wait-time was explained using the construction and reconstruction model of human learning proposed by Anderson and Demetrius (1993). Wait-time differences between the theory and practical classes were found to be statistically significant. There was also a significant variation in the wait-time for three different categories of response to the questions – viz. responses by the whole class, an individual student, and the teacher. The mean wait-time data recorded in this study resembles that previously reported elsewhere. However, the wait-time for non-bilingual Bruneian students learning science in a second language includes a component for language translation, which occurs during both the knowledge construction and reconstruction phases. Further research is recommended to (a) evaluate the optimum wait-time under the conditions that prevail in Bruneian science classes and (b) modify the existing information-processing model or to develop new models to explain knowledge construction and reconstruction in classes where non-bilingual students learn science in a second language.

Keywords: wait time, construction and reconstruction of knowledge, information processing model

Abstrak: Kajian ini dilakukan untuk (a) menerangkan masa menunggu yang memantulkan proses kognitif terlibat dalam membina dan membina semula pegetahuan semasa mentafsir soalan dan seterusnya memberi respons, (b) membandingkan min masa menunggu yang diambil oleh pelajar dengan masa menunggu yang diharapkan oleh guru dalam kelas teori dan amali di sekolah menengah Brunei. Masa menunggu tercatat dijelaskan dengan menggunakan model membina dan membina semula pembelajaran manusia yang dicadangkan oleh Anderson dan Demetrius (1993). Perbezaan adalah siginifikan secara statistik antara masa menunggu dalam kelas teori dan kelas amali. Terdapat juga perbezaan yang signifikan untuk tiga kategori respons – respons bagi keseluruhan kelas, individu pelajar dan guru. Min masa menunggu adalah seperti dapatan kajian yang lepas. Namun, masa menunggu untuk pembelajaran sains bagi pelajar Brunei yang tidak berdwibahasa meliputi komponen penterjemahan bahasa. Kajian lanjutan dicadangkan untuk (a) menilai masa menunggu optimal di bawah keadaan kelas sains di Brunei dan (b) mengubahsuai model atau membina model baru untuk menerangkan pembinaan pengetahuan dan pembinaan semula dalam kelas di mana pelajar bukan dwibahasa belajar sains dengan bahasa kedua.

Kata kunci: masa menunggu, membina dan membina semula pengetahuan, model pemprosesan maklumat

INTRODUCTION

Wait-time is essentially the time required for the central nervous system to complete multiple cognitive tasks. Students require uninterrupted lengths of time to process the information posed in questions – i.e., to reflect on what has been said, observed or done before choosing their responses (Stahl, 1990, 1994). The nature of these cognitive processes and how they operate are not clearly understood. The cognitive processes include distinguishing between questions, which require a response, and statements, which do not. There are several cognitive models of human learning, including mathematical models (Aldridge, 1983; Anderson, 1983; Dhindsa and Anderson, 1992), which have been proposed to explain some of these processes and their role in human learning. In an information-processing model of learning (Stewart & Atkin, 1982), the stimuli used to cue learners to particular cognitive processes are important components of the learning environment. However, researchers who employ human information-processing models have not yet considered the importance of wait-time as a component of the time required to complete cognitive processes, although they use these models to explain learning as the processing of incoming information. Thus, they consider the information processing that corresponds to the construction of knowledge but not the reconstruction of knowledge involved in producing a response. However, Anderson and Demetrius (1993) published a knowledge construction and reconstruction model that may be used to explain the importance of wait-time in terms of one of the latest fashionable theories of learning – viz. constructivism. They consider information construction and reconstruction, resulting from the interaction between the context and information stored in memory, an additional dimension of human information processing.

In a classroom, wait-time may be defined as the period of time a teacher allows to elapse after posing a question and before a student begins to speak. Researchers of questioning strategies discuss two types of wait-time – viz. "wait-time 1", the time the teacher allows to elapse after posing a question and before a student begins to speak, and "wait-time 2", the time a teacher waits after a student has stopped speaking before saying anything else (Rowe, 1972, 1987). Previous research has focused more on " wait-time 1" than " wait-time 2". The focus of the study reported in this paper is also wait-time 1. The existing literature has suggested a mean wait-time threshold of 3.0 to 4.5 seconds. Any wait-time beyond the upper limit of this range is not thought to produce a detectable change in the level of the outcome variables (Riley II, 1986). According to Rowe (1972), wait-time periods rarely last more than 1.5 seconds in typical classrooms. However, she observed that periods of silence of at least 3 seconds resulted in an increase in the length and correctness of student responses, the number of volunteered appropriate answers by a larger numbers of students, and the scores of students on academic achievement tests as well as a decrease in the number of "I don't know" and no answer responses. To attain these benefits, teachers were urged to wait in silence for 3 seconds or longer after posing a question as well as after students completed their responses (Casteel & Stahl, 1973; Rowe 1972; Stahl 1990; Tobin 1987). Students perceived by teachers to be slow or poor learners may even be given less wait-time than those viewed as more capable! Stahl (1994) introduced the concept of "think-time," defined as a distinct period of uninterrupted silence by the teacher and students that allows for the completion of appropriate information-processing tasks, feelings, oral responses, and actions. He reported eight categories of think-time between the teacher's question and a student response, and the end of the student response or further initiation of responses by the classroom teacher or other students.

Most of the wait-time data reported in the literature concerns instruction in a native language and not in a second or third language. The language of instruction in Bruneian secondary schools is English, which is the students' second or third language. According to Heppner**,** Heppner and Leong (1997), students' command of the English language is poor. They estimated that only 15% of Bruneian Form 6 (US grade 12) students were confident in reading at the US 9th grade level and approximately 50% of them read US 7th grade material at frustration level. Understanding the text is more complex than reading alone. The author has often observed teachers explaining information to students in the Malay language. These findings indicate that not all of the upper secondary students are bilingual. A child defined as bilingual can process information efficiently in two languages, without requiring translation. Students who are not bilingual typically translate the information delivered in English to Malay during construction, and then they reconstruct their response in Malay and translate it back to English. This translation requires additional wait-time. The necessity of translation from a second language into the mother tongue and back for students who are in the process of becoming bilingual has been highlighted in the literature (Johnson-Laird, 1995; Darwish, 2004).

An analysis of the definition of " wait-time 1" reveals that it includes two sets of data: – viz. (a) the wait-time a teacher intends to allow students after posing a question and (b) the fraction of wait-time a student uses to answer the question. The first is in the teacher's control, but the second is not. A teacher may intend to provide a certain amount of wait-time following a question, but how much of this intended time is used depends upon the student. The wait-time needed by students depends upon the nature of the question and the student (Tobin, 1984). A high-ability student may require little of the intended wait-time if the question is easy, whereas the wait-time for the same student is expected to increase if the question is difficult. However, a low-ability student may take more of the intended wait-time than a high-ability student, regardless of the difficulty of the question. Thus, "wait-time 1" can be one of two types – viz. intended wait-time controlled by the teacher and availed wait-time taken by the students. The availed wait-time is either equal to or shorter than the intended wait-time, because as soon as the intended wait-time limit is reached, the teacher may ask another student or personally respond to the question. The mean intended wait-time can be calculated for situations in which students fail to answer the question and the teacher either asks another student to answer the same question or personally answers the question. The mean availed wait-time for questions that are answered by the students can also be measured. A good indicator of the intended wait-time for questions that are answered by the students is teacher perception. When a student is unable to answer a question and the question is directed to another student, it is possible to estimate the intended wait-time for the question as well as the availed wait-time for the second student. However, the current study did not make any distinction based on the nature of the questions, as the wait-time was recorded only when the students answered the questions.

The socio-cultural values of teachers can guide their communication behaviour, including intended wait-time, in their classes (Jegede and Olajide, 1995). Wait-time is a facet of communication behaviour in general, and cultural influences on wait-time are not well understood. For example, teachers in Brunei Darussalam often ask questions to an entire class, which is not a common practice elsewhere. Thus, the availed wait-time in Brunei Darussalam can be classified according to (a) when a question is addressed to the whole class and (b) when a question is addressed to an individual student. Moreover, there are two possible ways to answer a question that is addressed to the whole class: (i) chorus response and (ii) students raising hands and vying to provide a response. In the case of chorus response, the author has observed that a student who confidently knows the answer, typically one of the high-ability students in the class, initiates the response and other students join the response either by remembering the answer or mumbling with the group. The wait-time under this condition, therefore, reflects the minimum possible expected time in a class if a high-ability student is given the opportunity to respond to the question. The second category is quite complex as students often raise hands at different time intervals. However, the second category can be collapsed into the first category by measuring the time as soon as the first hand is raised. This procedure was adopted in the present study mainly because these types of questions were not common. Most of the previous wait-time studies were conducted in developed countries (Altiere & Duell, 1991; Mansfield, 1996) and concentrated on wait-time when questions are directed to individual students. Hence, substantial wait-time data for situations in which questions are addressed to the whole class are not available.

Science teachers conduct both theory and practical lessons and ask a variety of questions in the lessons. In practical lessons, students may have a large amount of "concrete" material available, which is often not the case in theory classes. Such material may provide cues for the central nervous system to target cognitive processes that are important for the construction of knowledge in understanding the question as well as the reconstruction for a response. In the case of theory classes, the probability of receiving materials that provide visual cues is lower than that in practical classes. One may also consider whether the intended and availed wait-times differ in theory and practical lessons.

In summary, the above literature suggests that wait-time is an important but complex concept that requires attention. It is influenced by a number of classroom variables associated with the teacher, teaching, lesson type, question type, subject content and students. It would be highly ambitious to consider all of these variables in a study because a large study would be required to attain reasonable degrees of freedom in each category. The results reported here are, therefore, limited to the association of lesson type and the nature of the question to the wait-time. Future research is planned to study the association between the other variables and wait-time. Moreover, little wait-time research has been conducted in Brunei, and the author is not aware of any study in which wait-time is evaluated in terms of cognitive processes. Furthermore, there is no data on the comparison of wait-time in theory and practical science classes or on comparisons when a question is answered in chorus manner by a class, by a student or by the teacher. Therefore, this study was planned and executed to measure the intended and availed wait-time in Bruneian theory and practical science classes and to interpret wait-time in terms of cognitive processes. It is believed that the results of this study will provide valuable data for educators and educational administrators to make changes to their practices and policies.

AIMS

The aims of this study were:

1. To explain the importance of wait-time in completing various cognitive processes, using a knowledge construction and reconstruction model,
2. To compare the mean wait-times in theory and practical classes, and

3. To compare availed mean wait-times when questions are addressed to a whole class and an individual student as well as teacher intended wait-times in both theory and practical classes.

Data Source and Wait-time Computation Procedures

Data were collected over three years from 29 theory and 24 practical (a total of 53) Form 4 science classes that were conducted by 15 teachers in each category. For 54.7%, 41.5% and 3.8% of teachers, one, two, and three classes were observed. The mean number of questions observed in a 60-minute science (theory or practical) class was 18.1± 10.4, with an average of only 5.0 ± 3.8 questions directed to individual students. These data suggest that most of the questions were directed to the whole class and the large values of standard deviation suggest a substantial variation in number of questions asked in the classes, which could be due to the nature of the subject, teacher, teaching style and/or students. A data collection sheet was prepared to record the wait-time and expected response type – from the whole class or from an individual student. Using a stopwatch, wait-time was recorded in seconds for the responses to questions given by the whole class, individual students and the teachers, in both theory and practical classes.

The science lessons observed included different science subjects such as chemistry, physics, biology and combined science subjects. Hence, the content, subjects taught, teachers' teaching styles and number of students per class largely varied. During instruction, teacher talk dominated, which was more prominent during the theory classes than the practical classes. During the practical lessons, teacher talk dominated at the beginning and the end of the lesson. Since the study focused on wait-time in science classes, the merging of these classes was considered as appropriate.

The questions asked differed based on the various classes, different teachers and varied class contents, and questions asked in theory and practical classes also differed. Of course, it cannot be expected that the same questions or questions of the same difficulty will be asked in different classes taught by different teachers. Previously studies also report that the same questions were not asked in different classes (Jegede & Olajide, 1995; Rowe, 1972). Moreover, the variety of questions was not considered as a variable in the current study; therefore, this may not be a serious limitation provided. Future research should compare the wait-time for different types of questions. The mean wait-time data collected were compared for two recorders in two classes, and the agreement was 88%.

The mean wait-time per question was computed for three response types in each class: viz. by (i) the whole class (WC), (ii) individual students (IS) and (iii) the teacher (TE). The data were then averaged over the classes. The WC is the wait-time when a question was addressed to the whole class and the class answered in chorus, IS is the wait-time when a question was addressed to an individual student and the student answered, and TE is the intended wait-time (the time the teacher waited before personally providing the students with a response to the question or asking another student). The mean data were compared using ANOVA and post-hoc analysis.

RESULTS

The results are discussed under three headings that correspond to the three aims of this study, as stated in the aims section.

The Importance of Wait-time in the Completion of Various Cognitive Processes a Knowledge Construction and Reconstruction Model

The active processes of constructive encoding of information and reconstruction and reconstructive retrieval proposed by Anderson and Demetrius (1993) are shown in Figure 1. Information storage in the memory is represented as a dynamic process of constructing representations through interactions with existing information in the long-term memory and complex contextual cues in the information-rich environment, as indicated by bidirectional arrows linking context and memory storage (see left-hand side of the model). On the right-hand side, the recall of information by reconstruction also assumes an active process. Contextual cues in the environment that accompany a recall interact with stored information in memory to dynamically influence the information that is activated, how it is reassembled or modified, and the sequential patterns that will be imposed on it during exposition. Recall is viewed as a process of assembly and modification of existing information in memory to optimise the adaptative values of response in relation to internal organising frameworks and external environmental demands.

There are many factors that could influence the information-processing time for each process, but English language proficiency is one of the most important factors. Depending upon the level of English language proficiency, students can be defined as either bilingual or non-bilingual. Many Bruneian students are in the process of becoming bilingual, and they translate languages through serial processing, parallel processing or both, as discussed below.

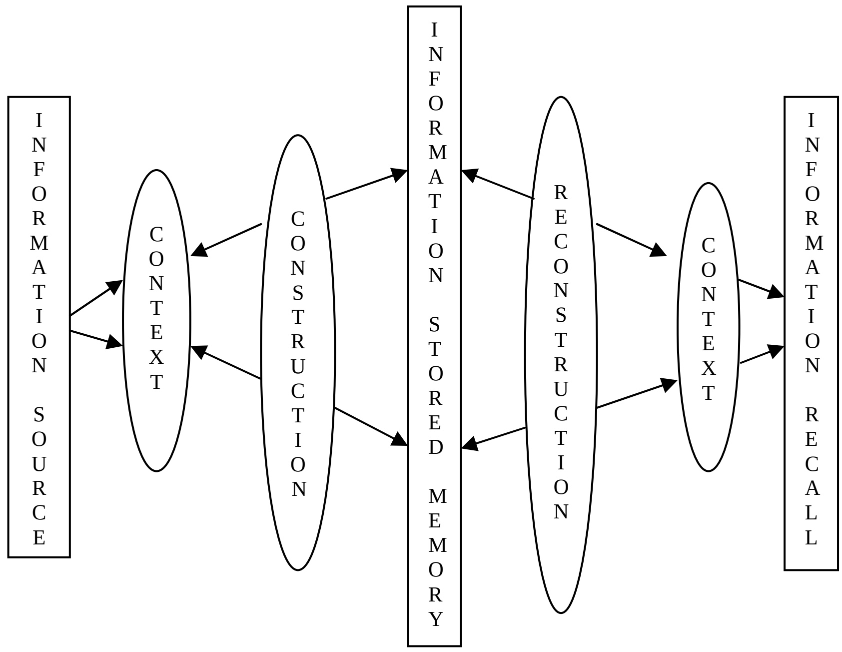

Figure 1. Information construction and reconstruction model (Anderson & Demetrius, 1993)

Serial processing

When a question is posed by a teacher, students construct information by active interactions between contextual cues and their stored information. The central nervous system must first identify a cue that highlights the need to reconstruct a response. The cue may come in the form of a signal from their sense organs or from somewhere unknown. Since the reconstruction of the response might require some information that was stored in memory and constructed some time ago, the students may first clear any backlog from their short-term memory before putting the question through the construction of information phase to understand it. Then, after the construction process ends, they may begin the reconstruction process. Thus, their response to a question involves cognitive processes dealing with the (a) identification of cues in the incoming information to identify a question that requires a response, (b) construction of information in the question, and (c) clearing of information irrelevant to the question response from short-term memory. These processes require time, and are all included in the wait-time before the reconstruction process begins. There is the activation of relevant information from long-term memory and its transfer into short-term memory, organisation of the activated information into the form of a response, evaluation of the reconstructed response in terms of the required context, and modification of the information or its context to add suitable context, followed by transmission of the information in writing or verbal response. These reconstruction processes require additional time, which is also included in the wait-time. Thus, the total wait-time is the sum of the time required during the construction and reconstruction processes, and depends upon the nature of the learner, question and response required. This model clearly posits that wait-time is required for the construction and reconstruction process.

Parallel processing

Almost all students should be able to engage in parallel processing to some extent. A nearly bilingual student may be capable of parallel processing the construction and reconstruction processes, although we do not know how the brain temporally regulates them. The two processes may be mediated by different functional modules in the brain, and working memory may have component sub-modules. Many people refer to working memory, rather than short-term memory, to more clearly represent dynamic information processing that is not simply storage but involves the management of information flow, etc. For a high-ability or more facile student, during the information processing, the brain may work with these two processes as well as with translation in parallel. Thus, the brain is known to be a parallel information processor (not solely serial), although there is some evidence that the frontal region is more serial and the posterior region more parallel. Anderson (private communication) suspects that there is phasing of these two processes in "executive management functions", likely located in the frontal lobe area of the brain, and that the extent to which parallel activity occurs between construction and reconstruction may vary between individuals. The complexity and amount of information involved in the task may also be important. If the information requires more in-depth processing, is more complex or particularly dense in information content, this may determine the amount of the working memory capacity that must be devoted to either construction or reconstruction. Another possibility is that the brain alternates rather rapidly

Table 1. Mean wait-time in theory and practical science classes

Question	Wait-time type	Class type	No. of classes	Mean Wait-time (seconds)		Theory vs. Practical	
				Mean	SD	F	P [ES]
Answered by whole class	Availed Wait-time	Theory	29	2.2	1.5	0.045	.833
		Practical	23	2.1	1.7		
		TP*	52	2.2	1.6		
Answered by individual student	Availed Wait-time	Theory	23	5.6	5.1	6.860	.013
		Practical	14	2.0	0.9		[0.88]
		TP	37	4.2	4.4		
Answered by teacher	Intended Wait-time	Theory	23	6.2	5.7	1.134	.295
		Practical	11	4.2	3.3		
		TP	34	5.6	5.1		

*TP reports the mean overall wait-time in theory and practical science classes; ES = effect size.

between the two functions of construction and reconstruction when presented with challenging information-processing tasks. Thus, rapid thinkers may integrate alternation between construction and reconstruction phases in a dovetailed manner more efficiently than may less rapid thinkers. This may be a strategy that is used when parallel processing is not possible, perhaps due to the complexity or depth of demand of the information. Whatever the case, it can be postulated that students who are not bilingual might require extra wait-time.

Comparison of the Mean Wait-time in Both Theory and Practical Classes

Questions addressed to the entire class

The mean availed wait-time for a question addressed to the whole class was 2.2±1.6 seconds (Table 1). The mean availed wait-times in theory and practical classes were not statistically significantly different. The mean time of 2.2 seconds appears to be reasonable because the students who know the answer to the question may begin answering it and the remainder of the class may mumble along with them. The standard deviation of 1.5 seconds suggests a relatively large range in availed wait-time by the class, which may be associated with the nature of the questions asked. Since the mean wait-time for theory (2.2 ± 1.5 s) and practical (2.1 ± 1.7 s) lessons was not significantly different, it was concluded that the mean wait-time and standard deviation data are not influenced by the nature of the lesson (whether theory or practical). The lack of significant difference in wait-time values between theory and practical lessons can be explained on the basis that questions addressed to the whole class are answered by a student who knows the response (typically one of the most able students).

Questions addressed to an individual student

The mean availed time for a question addressed to individual students was 4.2 seconds (Table 1), with a standard deviation of 4.4 seconds. The large standard deviation suggests a large range in availed time by individual students, associated not only with the nature of the question but also with the nature of the student chosen by the teacher to answer the question. There was a statistically significant difference (p = .013) in the mean availed time for the students in theory (5.6 ± 5.1 s) and practical (2.0 ± 0.9 s) classes (Table 1). The effect size of 0.88 suggests that the level of difference in wait-time between theory and practical classes was large (cf. classification by Cohen, 1969). Students in theory classes used longer mean wait-times compared to students in practical classes, likely due to the concrete material available in practical classes that provides additional cues during the construction and reconstruction phases, as mentioned earlier. Conversely, in theory classes, the absence of such material might increase the difficulty of the more abstract questions in particular.

Intended wait-time by the teachers

The mean wait-time that teachers intended to give to their students was 5.6 ± 5.1 seconds; the large standard deviation suggests a large range in the intended wait-time. Thus, in some cases, very little wait-time was given to students, consistent with findings reported by Rowe (1972). The intended wait-time depends on the nature of the question and the individual teacher. A comparison of mean intended wait-time in theory (6.2 ± 5.7 s) and practical (4.2 ± 3.3 s) classes revealed that these times were not statistically significantly different. These data suggest that the intended wait-time was not influenced by the nature of the lesson (i.e., whether theory or practical). However, it is important to consider whether the intended wait-time was statistically significantly different from the availed wait-times.

Comparison of Mean Availed Wait-times when Questions are Addressed to a Whole Class (WC) and Individual Students (IS) as well as Teacher Intended (TE) Wait-time in Both Theory and Practical Classes

The availed wait-times for a question posed to the whole class (WC) or to an individual student (IS) as well as the intended wait-time a teacher planned to allow the class (TE) are shown in Table 2. The values for these sets of data were statistically significantly different. A comparison of WC, IS and TE in science classes (see data under Overall in Table 2) reveals wait-time for WC to be statistically significantly lower than for IS ($p < .01$; ES = 0.65) and also for TE ($p < .005$; ES = 0.99). The effect size data suggest that differences are large and, therefore, of educational importance. These differences may be attributed to the nature of the students, who respond to the questions differently – under IS, a teacher selects the respondent, whereas under WC, students are free to initiate the response. Moreover, the difficulty of questions asked largely varied. However, the mean availed wait-time of students (IS) was not statistically significantly lower than the mean intended wait-time of the teachers (TE). These results suggest that students used nearly all of the intended wait-time, and that the teachers had quite a good idea of the duration of wait-time they must allow their students.

A comparison of wait-time for WC, IS and TE in theory classes revealed a similar trend to that observed in the overall data. The mean availed wait–time when the question is addressed to the whole class (WC) was statistically significantly lower than that for IS ($p < .005$; ES = 0.90) and TE ($p < .005$; ES = 1.01) categories. However, the mean availed wait-time of students (IS) was not significantly lower than the mean intended wait-time of the teachers (TE). These results show that teachers have quite a good idea of the wait-time they must provide to their students in theory classes. However, in practical classes, the TE wait-time was statistically significantly higher than that for WC ($p < .05$; ES = 0.90) and IS ($p < .05$; ES = 0.97).

Table 2. Comparison of wait-time in three response categories in theory as well as in practical classes

Wait-time in	Variables	Response Category			Significance (post-hoc data)		
		WC	IS	TE	WC vs. IS	WC vs. TE	IS vs. TE
Theory	WT	2.2	5.6	6.2	< .005*	< .005	ns
	SD	1.5	5.1	5.7	[0.95]	[1.01]	[0.11]
	N	29	23	23			
Practical	WT	2.1	2.0	4.2	ns	< .05	< .05
	SD	1.7	0.9	3.3	[0.07]	[0.90]	[0.97]
	N	23	14	11			
Overall	WT	2.2	4.2	5.6	p < .01	< .005	ns
	SD	1.6	4.4	5.1	[0.65]	[0.99]	[0.29]
	N	52	37	34			

Notes: WT = Wait-time (seconds); SD = Standard deviation (seconds), *N* = Sample size; WC = question to the whole class; IS = question to individual students; TE = question answered by teacher; * *p*-values; ns = non-significant; Effect size in [].

DISCUSSION AND CONCLUSION

Based on the definition of "wait-time 1" by Rowe (1972, 1987), the computed mean wait-time in this study was approximately 3.7 seconds. The research literature on wait-times has suggested the existence of a mean wait-time threshold between 3.0–4.5 seconds (Riley II, 1986). Thus, the wait-time of 3.7 seconds falls within the wait-time threshold range, at approximately the mid-point of this range, and may or may not imply that the mean wait-time of 3.7 seconds in Bruneian schools is appropriate. Most of the research reported on wait-time has been conducted in the western world, where students are taught in their native language. In Brunei, the teaching in secondary science classes is in English (a second language), and the students' command of the language is poor (Heppner**,** Heppner and Leong, 1997). They estimated that only 15% of Bruneian Form 6 (US grade 12) students were confident in reading at the US 9th grade level and approximately 50% of them read US 7th grade material at frustration level. Most of the secondary students are not bilingual. A child defined as bilingual can efficiently process information in two languages, without requiring translation. Although some Bruneian high school students are in the process of becoming bilingual, they typically translate the information delivered in English to Malay during construction, and then reconstruct their response in Malay and translate it back to English. The necessity of translation from a second language into the mother tongue and back for students who are in the process of becoming bilingual has been highlighted in the literature (Johnson-Laird, 1995; Darwish, 2004). This translation period is included in their wait-time but is not accounted for in the definition of the threshold wait-time range, which is based on research in western countries. Moreover, due to their poor command of the English language, many Bruneian students use linear processing during translation, which is less time-efficient than parallel processing. They must complete one process before they initiate a second one; therefore, they cannot utilise parallel processing. From the Heppner et al. (1997) study, it appears as though few of the students can use parallel processing, which requires less time, for translation. This further highlights the need for students in Brunei Darussalam (or in other countries where teaching is done in a second language) to receive more wait-time, as many students are not yet bilingual, as compared to students who are bilingual or receive instruction in their native language.

The procedure for measuring wait-time reported in the literature involves preparing videos of actual teaching in the classes, followed by the analysis of these videos for wait-time. To avoid this expensive exercise, using a stopwatch, the wait-time in this study was measured in seconds while observing the classes taught by the teachers. This technique is less accurate; however, the author suggests that the mean over a large number of questions and classes should minimise the error and provide fair data. However, there is a need to validate this technique against other available techniques. The most important task for future research is to evaluate how much additional wait-time should be provided to non-bilingual students who are learning science in a second language. It is also important to evaluate the optimum wait-time in those classes in which the teacher addresses a question to the whole class. The data collected in this study revealed a relatively large range around the mean wait-time, with the standard deviation approximately the same size as the mean. Wait-time data for when a teacher addresses a question to the whole class is not available elsewhere for comparison, as this is not a common practice in developed countries. No research on wait-time 2, the pause between the end of a response and the initiation of further communication in the class, has been completed in Brunei Darussalam. This wait-time is important for students because it allows them time to construct the knowledge needed in their response to the question. The evaluation of wait-time 2 for the three different types of wait-time (as considered in this study), in theory and practical classes, might shed light on student learning. Moreover, the wait-time analysis for various types of questions (recall, understanding, application, etc.) is also an important area of research for Brunei.

The model of knowledge construction and reconstruction used in this study to explain the processes that require time for students to process the knowledge in the question and prepare a response is useful in highlighting the importance of wait-time during learning. However, a major limitation of this model is that it makes an undisclosed assumption that either teaching is done in the students' own language or the students are bilingual. The model does not account for instructions to non-bilingual students in a second language. It is, therefore, important to modify the model by including a translation component to remove this limitation and extend its application to teaching in situations in which non-bilingual students learn science in their second language.

Significant differences in wait-time in theory and practical classes were found in this study. Moreover, the wait-time in both theory and practical classes varied significantly by the three types of responses (WC, IS and TE) to the questions. The mean wait-time data collected show that wait-time provided in science classes is within the threshold wait-time of 3.0 – 4.5 seconds reported in the literature (Riley II, 1986). However, this amount of time does not appear to be sufficient for Bruneian students as non-bilingual students learning science in a second language must deal with an additional process – i.e., translation during the construction and reconstruction of knowledge. Further research is recommended to evaluate wait-time under various conditions in Bruneian science classes and to identify a satisfactory existing information-processing model or to develop new models to explain knowledge construction and reconstruction in classes where non-bilingual students learn science in a second language.

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