Wait-Time and Multiple Representation Levels in Chemistry Lessons

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ABSTRACT

Wait-time is an important aspect in a teaching and learning process, especially after the teacher has posed questions to students, as it is one of the factors in determining quality of students' responses. This article describes the practices of wait-time one after teacher's questions at multiple representation levels among twenty three chemistry teachers at secondary schools in Kuala Lumpur, Malaysia and the sequences after the wait-time one practices. The study was conducted over eight months using observation as the main method of data collection. Observations were made twice for each respondent by using the Observation Instrument in Inquiry Teaching through Verbal Interaction (OIITVI). Forty six observations were audio and video recorded. Findings showed that only 6.80% of total questions at multiple representation levels were followed by wait-time one. This result showed that teachers lacked practise of wait-time. Three top sequences after wait-time one were teacher giving instruction, student's answer at macroscopic level and teacher's questions at macroscopic level. In conclusion, chemistry teachers should practise wait-time one to improve the quality of teaching and learning of chemistry.

Keywords: *wait-time one; macroscopic; submicroscopic level; symbolic level; multiple representation levels*

INTRODUCTION

Educational quality and what happens during teaching and learning depends on the teacher. In order to improve educational quality and teaching and learning processes, it is important to observe teacher's teaching practices. One aspect of teaching practices especially in the questioning process is application of wait-time. Wait-time is an important instructional variable in any teaching and learning process. It is an important dimension in research of teaching as mentioned by Rowe (1986).

Researchers have defined wait-time in numerous ways. Rowe (1974, 1986) has specifically defined two types of wait-time, namely wait-time one and wait-time two. Wait-time one was defined as the length of time a teacher pauses after asking a question. It is also known as teacher's wait-time (Rowe, 1974, 1986). Wait-time two is the amount of time a teacher waits after a pupil response before a comment is made or before another question is being asked. Another famous researcher on wait-time, Tobin (1986) defined wait-time as the length of the pause preceding any teacher utterances. In this article, the definition of wait-time will be based on Rowe's definition. She was the pioneer in wait-time and has done extensive research with regard to wait-time (Rowe, 1969, 1974, 1986). In summary, wait-time one refers to the length of time a teacher pauses after posing a question while wait time two is the length of time after student's response (Figure 1). In this article, the focus will be on wait-time one.

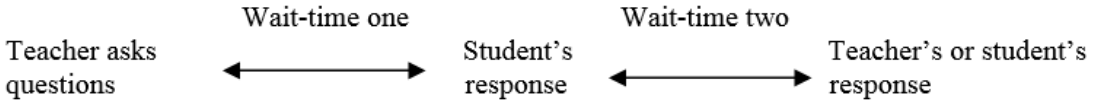

Figure 1 Summary of wait-time

As mentioned earlier, wait-time is important in teaching, especially during the questioning process. Questioning is vital during the lesson and can be considered as part of teaching process. Generally, teachers ask questions for various reasons. Questioning acts as a vital tool in any teaching and learning process as stated by Ross, Lakin, and McKechnie (2010) to link between presentation of content and student's understanding of it (Patrick & Urhievwejire, 2012). Besides that, the purpose of questioning is to check understanding, to stimulate student thinking and to seek new information.

Learning chemistry requires understanding of chemistry concept. The understanding of this concept can be viewed at multiple representation levels. This is because chemistry, by its nature, is concerned with the observable world (macroscopic) and submicroscopic to explain qualitatively those phenomena (Gilbert & Treagust, 2009). These two levels could be presented and understood further through the usage of symbols (symbolic) as stated by Gilbert and Treagust (2009) as well as Jaber and BouJaoude (2012). Therefore, in chemistry lesson, teacher's questions should be asked at multiple levels of representation to enhance students' understanding of a concept or phenomena investigated as proposed by Johnstone (1991, 2000); Treagust, Chittleborough and Mamiala (2003); Johnstone and BouJaoude (2012); and instill positive effect of appreciating chemistry among students (Jaber & BouJaoude, 2012). These three levels are also known as 'chemistry triplet' as stated by Talanquer (2011). As chemistry involves many abstract concepts, and understanding this concept needs time, we will anticipate that chemistry teachers practice wait-time one after asking questions to provide ample time for students to think of their answers. Hence, do chemistry teachers practice wait-time one after questions at multiple representation levels were asked?

Previous researches on wait-time have focused on the duration of wait-time practices of various subjects (Albergaria-Almeida, 2010; Baysen and Baysen, 2010; Harris and Williams, 2012; Patrick and Urhievwejire, 2012) and difference of wait-time in theory and practical class (Dhindsa, 2010). Besides that, previous research conducted by Tobin (1984) and Riley II (1986) were on effect of teachers' wait-time on achievement. In Malaysia, previous research (Tay, 2010) done were on practices of wait-time among primary school science teachers. Research done on wait-time at international and local context has yet to address this aspect of multiple representation level questions and wait-time. As teaching and learning chemistry involves these multiple representation levels, this study provides insight into how chemistry teachers practise wait-time one with regard to this aspect.

Previous researches have proved that application of wait-time especially after teacher's questions will have positive effects on students and teachers. As for teachers, type of questions posed will be of higher level and better questions (Rowe, 1986). On the other hand, for students, application of wait-time will increase student involvement (Mercer and Hodgkinson, 2008; Rowe, 1986), the quality of the students' answers (Mercer and Hodgkinson, 2008; Rowe, 1974; Tobin, 1984, 1987) and quality of learning (Maroni, 2011; Mitchell, 2010; Zurida, Sharifah Norhaidah and Mohd. Ali, 2005). This is because the "silence" during wait-time will allow the students to formulate their thoughts and construct their responses to questions as stated by Martin (2012). Hence, this study also probes into the possible sequence of verbal interaction after wait-time to determine the possible sequence(s) after wait-time one.

Teaching and learning in the classroom involves interactions between teacher and student or between student and other students. It is known that verbal interaction is the dominant form of classroom interaction. Maroni (2011) claimed that only a handful of classroom interaction research studies focused on wait-time although wait-time has proven to affect the quality of verbal interaction in the classroom (Tobin and Capie, 1983). Verbal interaction is used to study the process of teaching and learning chemistry in the classroom as it could provide data that could be interpreted objectively. Based on previous researches on classroom interaction, verbal interaction can be classified in terms of teacher's talk, student's talk and silence or confusion (Eggleston, Galton and Jones, 1976; Flanders, 1970; Malamah-Thomas, 1987; Mohamed Najib, 1997). Possible sequences after wait-time one is investigated in terms of teacher's talk, (teacher's question and teacher's statement), student's talk (student's questions and student's statement) and silence or confusion. Hence this study embarked into wait-time and multiple representation levels through verbal interaction.

PURPOSE AND RESEARCH QUESTIONS

This article address the following research questions:

1. What is the practice of wait-time one after teacher's questions at multiple representation levels?

2.What are the possible sequences of verbal interaction at multiple representation levels after wait-time one?

METHODOLOGY

In this section, discussion will be on the methodology, which includes the sample, instruments and data analysis that have been applied in conducting this research.

Sample

Twenty three chemistry teachers from thirteen different national secondary schools were involved in the study. They implemented the same chemistry curriculum which was developed by the Ministry of Education, Malaysia. Twenty two respondents hold bachelor degree in education and one respondent had a master degree in education. Majority of the respondents specialized in chemistry and only one respondent specialized in science. In terms of teaching experience, fourteen teachers (60.9%) have teaching experience less than five years, four respondents (17.4%) have teaching experience less than ten years, four respondents (17.4%) have teaching experience less than fifteen years, and only one respondent (4.3%) has more than twenty years of teaching experience.

Instrument

In obtaining data in this research, non-participant observation was applied. Each respondent was observed twice during laboratory sessions. A total of 46 chemistry lessons were video recorded and audio recorded. An Observation Instrument in Inquiry Teaching through Verbal Interaction (OIITVI) was used in this study. This instrument was developed based on the previous observation instruments by Flanders (1970), Eggleston, Galton and Jones (1975), Mohamed Najib (1997) and Brandon et al. (2008). Then, it was modified further to cater to the purpose of the research. In this instrument, there are five main categories to study teaching and learning process through verbal interaction in chemistry lessons. In this research, wait-time is one of the subcategories investigated under silence or confusion category. Observations were made every three seconds to ensure thorough and detailed observations as suggested by Flanders (1970) and Mohamed Najib (1997). Besides using observation instrument, semi structured interviews were carried out to investigate the reason underlying teacher's talk.

Data Analysis

Data obtained from the instrument (OIITVI) were then processed and analyzed using the Statistical Package for the Social Sciences (SPSS) PASW version 18.0. Quantitative data obtained were reported as frequency and percentage. In order to know the sequence after multiple representation levels questions were asked, the analysis was done manually based on the processed data in SPSS. Chemistry lessons and interviews recorded were transcribed verbatim to support the quantitative data findings.

FINDINGS AND DISCUSSION

The first part of discussion is on the practice of wait-time one after teacher's questions at multiple representation levels. Then, it will be followed by discussion on possible sequences of verbal interaction after wait-time one.

Questions at Multiple Representation Levels and Wait-Time One

Teachers' questions at multiple representation levels constitutes mean of 10.61% of the total verbal interaction that occurred during chemistry lessons (see Figure 2).

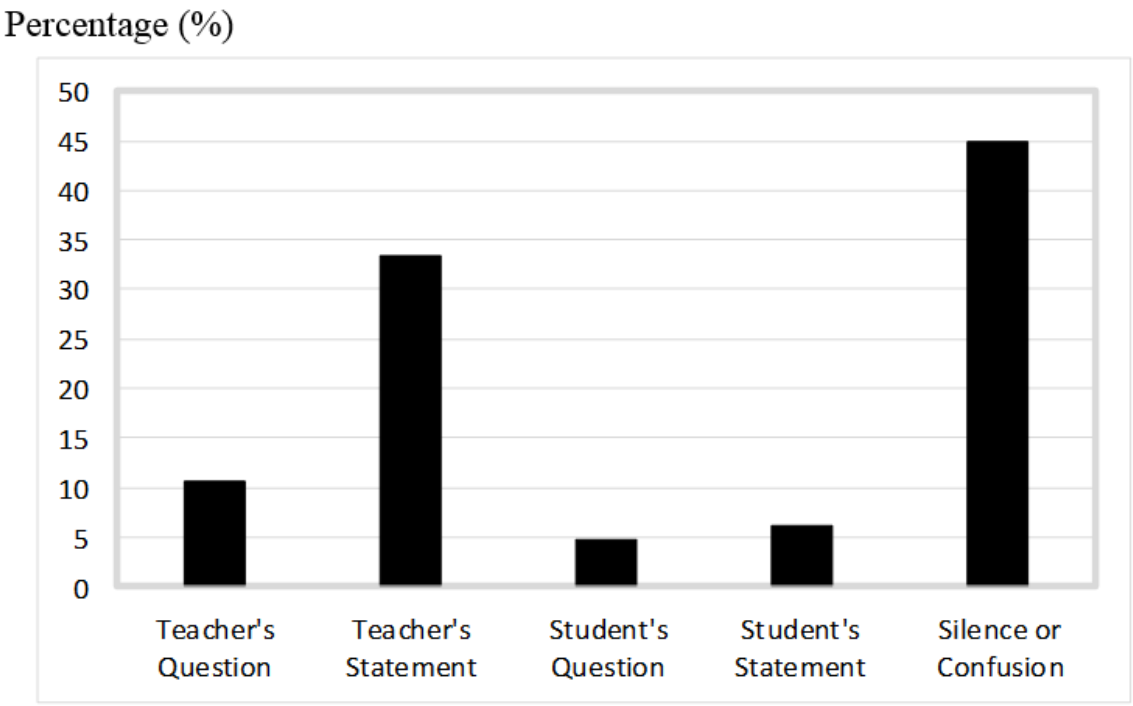

Figure 2 Main Categories of Verbal Interaction in Chemistry Lessons

Teachers' questions at multiple representation levels represent 8.26% of the 10.61%; total percentage of teacher's questions. For the purpose of this research, managerial questions for classroom management, which constitutes 2.35% were not considered and therefore were not taken into account in the analysis. A total of 4306 teacher's questions at multiple representation levels were asked during chemistry lessons observed. Most of the teacher's questions were at macroscopic levels, followed by symbolic and submicroscopic questions. Only 293 questions (6.80%) of total teacher's questions at multiple representation levels were followed by wait-time one (see Table 1).

Table 1: Teacher's Questions at Multiple Representation Levels and Wait-time One

Multiple Representation Levels	Number of teacher's questions (n)	Number of teacher's questions followed by wait-time one (n)
Macroscopic	2634	235
Submicroscopic	514	13
Symbolic	1158	45
Total	**4306**	**293**

The findings show that chemistry teachers in this study lack practice of wait-time one after questions at multiple representation levels were posed to students. This may be due to teachers' assumption that students do not know the answer; hence, they do not anticipate any answer from the students. To understand the reasons underpinning this lacking practice of wait-time, these teachers were interviewed. This could be shown from the following interview segment:

Researcher : *Are you aware of wait-time?*

Teacher : *Ah?*

Researcher : *Wait-time?*

Teacher : *What is wait-time?* [Respondent R13]

Surprisingly, these teachers have not heard of the term wait-time one as many teachers asked the researcher what is wait-time. Many of the respondents were not aware of it. Therefore, this could contribute to the lack of practice of wait-time one.

Very few teachers have heard of the term "wait-time". Even though they have heard of the term wait-time and understood it, when interviewed they gave alternative definitions to what actual wait-time is. One of the respondents defined wait-time as waiting for students to get ready for the lesson.

Example of part of the interview is shown below:

Researcher : Are you aware of wait-time?

Teacher : Yes.

Researcher : How do you apply wait-time?

Teacher : Yes. I am aware of it. But… normally, prefects in the class, after assembly, they have activities. There are students busy doing homework, so they are late to class. But I have told them, if they are late again, their names will be recorded in the e-discipline. I can't wait for them so long…

[Respondent R12]

In conclusion, chemistry teachers tend to make statements in chemistry lessons rather than asking questions to their students during chemistry lessons observed. Most of the questions posed to the students were focused mainly at macroscopic level. Findings from this study show that very few chemistry teachers are practising wait-time one when asking questions in their lessons.

Sequences of Verbal Interaction after Wait-Time One

Teacher giving instruction was the most sequence occurred after wait-time one. The second most sequence found was students' answers at macroscopic level and the third most sequence was teacher's questions at macroscopic levels. This may be due to teachers being impatient after wait-time one. Example of these scenarios are shown in the following excerpts:

Teacher: Ok… put up your hand. Raise up your hand… What is the purpose of using polystyrene cup?

(After wait-time one)

Teacher: Ok… anyone…Stand up, Amirah. (Teacher giving instruction)

[Respondent R13]

Teacher: Why yellow precipitate? Is there any colourless solution?
(After wait-time one)

Teacher: Ok, you finish, move to the next one. (Teacher giving instruction)

[Respondent R02]

Semi-structured interviews done with the teachers found that the reason for this behavior of giving instruction is due to the passiveness of the students. One example of this is given in the following segment of the transcribed interview:

Respondent 13: Normally I picked a student to answer. I know that this technique is very ineffective. I asked a question and then I will wait…but the students are not alert…. So, when I called their names, they feel that they have to provide the answer to the question asked. Secondly, because, if I don't call their names, they will not think. That is their attitude.

Second highest sequence after wait-time is students' answers at macroscopic level. From the transcribed classroom observation lesson, it was found that the quality of the students' answer was low. Students' answers were merely one or two words, without giving elaboration. They do not show effort of elaborating on the answers unless being prompted by the teachers.

Example of segment of the transcript is as follows:

Teacher: Ok… that is water bath. Ok…the level of the naphthalene is below the level of water. So, you must make sure the level of naphthalene is…?

Student : Lower. [one word]

Teacher : Why? Because naphthalene is highly…?

Student : Flammable. [one word]

[Respondent R09]

This finding is similar with finding from research done by Tay (2010). Nevertheless, this finding contradicts with what was stated in previous research (Rowe, 1974, 1986; Tobin, 1987; Mercer and Hodgkinson, 2008). Allocation of wait-time is supposed to elicit better responses from the students. However, the short responses by the students in this study were also due to the type of questions asked by the teachers, which were mostly of closed-ended questions.

The third highest sequence is wait-time one followed by teacher's questions at macroscopic level. This means that the teacher asked a question, followed by wait-time one. The teacher then asked similar questions after wait-time one. They rephrase the questions as there is no response from students. Examples of this sequence are shown in the following transcribed classroom observation excerpt:

Respondent R01: Why iron two sulphate is green? Why? Why? (Question)

(Wait-time one)

Because the colour of iron two plus is?

(Question at macroscopic level)

Respondent R18: Is it the copper that release hydrogen? (Question)

(Wait-time one)

Is the copper plate that releases the gas?

Copper plate releases the gas, isn't it?

(Question at macroscopic level)

The findings from this study revealed that the main verbal interaction occurred after wait-time one is teacher giving instruction. This might be due to insufficient duration of wait-time one allocated. These three top sequences after wait-time one revealed the chemistry teachers in this study do not practice inquiry teaching effectively.

CONCLUSION AND IMPLICATION TO CHEMISTRY TEACHING

This article described application of wait-time one after teacher's questions at multiple representation levels and sequences after teacher's questions in chemistry lessons. Only 6.80% of total questions at multiple representation levels were followed by wait-time one. Finding from this study revealed that teachers in this study lacking practise of wait-time one. Based on the interviews carried out, teachers were not aware and do not understand the term correctly. Therefore, they might not able to practice wait-time effectively in their lessons. The reason behind lack practice of wait-time was also due to teachers want to fill silence in classroom with talking, as they felt that silence is unusual and useless as mentioned by Martin (2012).

Sequence after wait-time one revealed that most of the teachers gave instruction after wait-time one. This means after wait-time one, teacher will select a student to answer the question. Based on the interviews carried out, this is due to students' passiveness and attitude. Second highest sequence after wait-time one is students' answering at macroscopic level. The students gave answers which were very short, a word or two, with no elaboration. The third highest sequence is teachers asking questions.

In conclusion, teachers should be aware and practice wait-time in their lessons, at least three seconds after asking a question to students. This duration of wait-time is as suggested by other researchers, such as Tobin (1984; 1987); Riley (1986); Chin (2004). The silence during wait-time is very important for students as they need time to digest and think before they provide the answer. Hence, it is time for chemistry curriculum developer and lecturers at higher institution level to re-look into wait-time seriously. Professional development courses for these teachers are needed to make these teachers aware and practice wait-time in their lessons.

ACKNOWLEDGEMENT

The authors would like to express deepest gratitude to the teachers and students who were involved in this research.

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