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AN IMPLEMENTATION STUDY ON A WALK APPROACH TO ASSESSING CONSTRUCTIVIST LEARNING IN MATHEMATICS

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Abstract  
This paper will describe a WALK approach to assessing students’ constructivist learning in mathematics which is aimed at tapping their ability in posing, formulating and solving mathematical problems. The implementation study was conducted in a single-sex secondary school in Singapore involving a total of 168 boys at the secondary four level. The participants completed the WALK assessment tasks in three phases and within restricted time limits – phase 1 for posing mathematical problems based on a given stimulus material, phase 2 for formulating three problems selected from problems posed in the first phase, and lastly, phase 3 for solving the problems formulated earlier. The potentials and challenges of using this WALK assessment method for a summative purpose, and for constructivist teaching and learning in classrooms of Singapore schools will be discussed.

Introduction  
Learning mathematics with understanding involves not only knowing ‘what’ but also knowing ‘when’ and ‘how’ to use ‘what’. That is, students first learn a body of mathematical knowledge and next demonstrate flexibility in applying the knowledge to solve problems in various settings which in turn brings enriched meaning of their applied knowledge. When learning is meaningful for students it promotes continual learning. For teachers, it is important that they know students’ prior knowledge of mathematical concept(s) in order to help them scaffold, apply and understand. Hence, teachers need to be equipped with both mathematical content and pedagogical knowledge and skills to facilitate a more learner-centred environment that actively engages students in thinking and problem-solving tasks, that is, a constructivist approach to mathematics learning. New assessment approaches are also needed to help inform teachers about students’ learning in a constructivist environment as conventional assessment methods using ‘mechanistic’ problem-solving questions may not be adequate and suitable for monitoring and evaluating students’ constructivist learning in mathematics.

This paper describes an approach for assessing students’ constructivist learning in mathematics for a summative purpose. This approach, termed as the WALK Assessment, was first proposed by members of the Comenius Project (Patry, 1999). The WALK approach requires teachers to prepare constructivist-based tasks for assessing students’ learning, and student responses to the tasks are analyzed and reported for a summative purpose of assessment.
Review of Literature

Choppin (1990) contends that assessment in education is a process used for determining students’ attainment of curricular goals. An assessment is formative if it provides information about the effectiveness of instruction and identifies problems in students’ understanding. The information also helps teachers in planning lessons and making decision to improve teaching which in turn, enhances students’ learning. On the other hand, assessment is summative if it provides credentials for the future and determines the level of students’ performance at the end of a course of study. Thus formative assessment is considered more informal and informative, summative assessment is more formal and judgmental.

In a constructive paradigm, formative assessment is given greater emphasis. The philosophy is for assessment to be integrated into classroom instruction (National Council for Teachers of Mathematics, 2000; Schulman, 1996; Brooks & Brooks, 1993) and not conducted at the end-of-course. However, it is also necessary to have summative information about students’ learning for grade-to-grade promotion and graduation requirements. How can this be achieved in a constructivist paradigm? Is a simple “right or wrong” analysis of students’ responses sufficient for assessing students’ constructivist thinking on a given assessment task? As Clarke (1997) aptly noted that relying solely on scoring of right answers does not provide adequate insights into students’ understanding of concepts. New approaches and tools would be needed for a summative assessment of students’ learning in a constructivist model.

In recent years, there has been a major shift in the teaching and learning of mathematics - from one that emphasizes on accumulating of facts and procedures to that on connecting and applying of mathematical concepts (National Council for Teachers of Mathematics, 1991). The National Council for Teachers of Mathematics (2000) recommends that students learn mathematics and become proficient by actively constructing new knowledge from rich experiential mathematical tasks.

The WALK Approach

The WALK Assessment proposed by the members of the Comenius Project (Patry, 1999), is an approach for assessing students’ constructivist learning for a summative purpose. Patry, one of the members, agreed that assessment of students’ constructivist learning is best to be formative but there is also a need for summative assessment of constructivist learning to determine students’ learning achievement. The acronym WALK stands for “Assessment of Latent Knowledge” with the ‘W’ representing the “W-questions”: What, Why, When, How, Where and Who. The WALK Assessment comprises three phases, namely, problem posing, problem formulating and problem solving.

This study implemented a WALK Assessment in mathematics and it was conducted in a secondary school involving a total of 168 boys at the secondary four level. The participants completed the WALK assessment tasks in three phases. For Phase 1, students had 15 minutes to pose as many problems as they could based on the given stimulus material. At the end of the 15 minutes, students performed the Phase 2 task. They were given 20 minutes to formulate three problems selected from the problems posed in Phase 1. Students who had completed formulating the problems before the specified time were allowed to proceed to solve their formulated problems in Phase 3. They had another 20 minutes for the Phase 3 task. Students’ written responses were evaluated based on a set of indicators to determine their ability at each phase. The following sections give the details of each phase.
Phase 1: Problem posing

In Phase 1 students’ problem posing ability (PPA) was assessed. The task required students to pose mathematical problems based on a given stimulus material within a restricted time. They posed problems by writing down as many keywords to describe the mathematical problems they perceived to be in the stimulus material. The indicators for measuring students’ PPA are:

1. **Total number of different problems posed** ($P_d$). This measure reflects the productivity of the student. A high score indicates high productivity in problem posing ($P_d > 0$).

2. **Total number of different topics involved** ($T_d$). This measure reflects the spread of mathematical content. A high score indicates that the student has dealt with many different topics ($T_d > 0$).

3. **Variety of topics in the problems** ($T_d / T_t$). This measure reflects the distribution of topics among the posed problems. A low ratio indicates that the student has posed problems based on the same topic(s). A ratio of 1 indicates there is no two problems involving the same topic. $T_t$ represents the total number of topics reflected in the problems ($0 < T_d / T_t \leq 1$).

4. **Complexity of the problems** ($T_t / P_d$). This measure reflects the combination of topics in problems posed. A greater ratio indicates that more topics have been included in each of the problem posed ($T_t / P_d \geq 1$).

Figure 1 shows the scoring procedure.

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**Figure 1: Scoring Procedure for Phase 1 tasks**
Phase 2: Problem Formulating

In Phase 2, each student was required to select any three problems which he had posed in Phase 1 and re-formulate them into a proper problem, that is, a problem phrased in appropriate mathematical term and language. This phase assessed the students’ problem formulating ability (PFA) which was measured by the following indicators:

1. The clarity of formulated problem $i$ ($CL_i$)
2. The accuracy of the information given in formulated problem $i$ ($AC_i$)
3. The solvability of formulated problem $i$ with respect to the information from the stimulus ($SL_i$)
4. The level of mathematical knowledge required to solve formulated problem $i$ ($MK_i$)
5. The complexity of formulated problem $i$, in terms of the number of simple or complex operations required to solve problem $i$ ($CP_i$)

The scores for these indicators were determined by checking if each formulated problem satisfied the following criteria associated with each indicator:

1. The formulated problem was clear, accompanied with relevant information
2. Accurate information with respect to the stimulus material was provided in the problem
3. The problem was solvable with the information from the stimulus material

Figure 2 shows the scoring procedure.
Phase 3: Problem Solving
Phase 3 required the students to solve the formulated problems. Only solvable problems based on the third criterion in Phase 2 were considered. In this phase, the students’ problem solving ability (PSA) was assessed based on the number of problems solved correctly. A high score indicates better problem solving ability.

Discussion
The WALK Assessment evaluates students’ ability in three areas of skills, namely, problem posing, problem formulating and problem solving. It is noted that the students in this study did not have much prior exposure and experience in problem posing and problem formulating, and thus it is not surprising that they showed relatively weak performance in the WALK Assessment. Incorporating a learning of problem posing and problem formulating skills into the mathematics curriculum would be a useful dimension for facilitating students’ problem solving ability and their critical and creative thinking. To promote a curriculum for meaningful learning, the assessment system must be better aligned to bring out the best in students. The WALK Assessment holds promise as a tool for assessing students’ constructivist learning in mathematics.

In implementing this WALK Assessment, a number of challenges are noted. One concern relates to the relatively tedious and time consuming scoring procedure. Fine-tuning of the scoring procedure would be needed for better efficiency and precision for measuring student ability. The validity and reliability of the measurement instrument must also be investigated.

Another concern relates to the stimulus material. Sourcing a suitable stimulus for a constructivist task in mathematics is not easy – the stimulus must be interesting
and contains a lot of information for students to pose mathematical problems. Subjectivity in interpreting information must be minimal so that results obtained would be more valid.

This study implemented the WALK Assessment in mathematics. It would be challenging to explore its suitability and relevance for assessing constructivist learning in other subjects. The applicability of this assessment tool for assessing project work is another area for further research.

**References**


