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Using two tier reflective multiple choice questions to cater to creative thinking

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Abstract

This paper reports on the results and implications of an exploratory study which arises from concerns that, whilst there have been many changes in the Singapore school curriculum over the past decade or more with teaching strategies specifically developed to encourage pupils to think more creatively and deeply both within and across subject domains, assessment methods and techniques have not always moved forward to address the new thinking skills that pupils have. A specific concern has been with the predominant use of traditional MCQs and, in particular, test items that might create a mis-match of perspectives between the question-setter and the test-taker. In such items, the creative test taker has no avenue to explain his/her reason for choosing a particular option as his/her choice of the answer key. The study involves the use of a modified test instrument (a "reflective" or "two-tier" MCQ) which comprises items from the traditional MCQ with an added second tier which is essentially an open-ended segment which requires pupils to explain the thinking behind their choice of the answer key. The study sample comprises two primary level classes, primary four and six. (188 words)

Introduction and background

The development of strategies to promote innovation and creativity together with problem solving skills in Singapore's schools can be traced back to 1987 with the introduction of Cort 1 (de Bono's module on the teaching of Breadth in Thinking) and Cort 4 (de Bono's module on the explicit teaching of creativity (de Bono, 1986) into the school curriculum. Explicit teaching of thinking skills have continued to evolve, resulting in the Thinking Programme (Chua and Leong, 1998), the "Thinking Schools, Learning Nation" (TSLN) drive (Goh, 1997) and the "Innovation and Enterprise" goal (Shanmugaratnam, 2003).

To realize the vision of TSLN and I&E, changes have been made in the education system. These include the introduction of IPW (Interdisciplinary Project Work), the IT (Information Technology) Master Plan and SAIL (Strategies for Independent Learning) into the classroom, the inclusion of project work as one of the university admission criteria from 2005, and changes to the school ranking system.

Under the various initiatives pupils have been taught with various creative teaching strategies including SAIL (Ministry of Education Singapore, 2004a) and MIT (multiple intelligences theory) approaches, and have been encouraged to explore, innovate and think laterally. However misalignment between teaching and assessment occurs when the majority of questions used in teacher-made tests and public examinations are of the standard or traditional multiple choice question type, which do not cater well to creative thinking.

This is because pupils, especially the creative ones, can often perceive alternative question interpretations which the question setter has not anticipated, particularly in the case of poorly crafted MCQs, and they end up selecting an answer which is valid but not the one intended by the setter (Boo, 2002, 2003a, 2003b and 2004). This is supported by Beetlestone (1998) who suggests that if pupils are divergent or creative thinkers, they are more likely to make imaginative connections which could seem odd to the conformist thinker and conformist thinking is the kind that is generally required in traditional MCQs, where there is no avenue for pupils to explain their thinking. This situation has been highlighted by Ng (2004 p. 280) in these words: "while new measures have been put in place to spur creative learning in the classroom, old measures that suppress creativity have not been removed".

In the authors' view, a significant 'old' measure that hinders the release of creativity in our pupils is the continuing and dominant use of MCQ in both teacher-made tests from primary three (P3) to primary six (P6) as well as in standardized PSLE (Primary School Leaving Examination) public examinations, which is an examination taken by all primary school pupils at the end of their six years of primary schooling and is the key determinant for secondary school placing.

The science paper at the PSLE consists only of a written paper-pencil instrument, which has two sections, section A (weighting 60%, comprising 30 multiple choice questions (MCQ), each carrying 2 marks) and section B (weighting 40%, comprising 16 open-ended questions, each carrying 2 to 4 marks) to be completed in 1 hour 45minutes. This suggests that the 30MCQs are to be completed in about 60 minutes while the open-ended questions in 45minutes. In a society where examinations hold great stakes, and where assessment could have a significant effect in driving the curriculum, the assessment mode at PSLE governs the formal assessment mode in

practically all examinations prior to the PSLE, which explains the dominant use of MCQs in teacher-crafted tests.

This is despite the encouragement given to practitioners in the primary science syllabus document and its accompanying guide to teaching and learning of primary science (Ministry of Education Singapore, 2004b) to use a variety of assessment modes in formal assessment in primary science (such as paper-pencil test, practical work, written assignments, multimedia presentations, model making, debates, drama and creative assignments which include board games, quizzes and posters).

Another reason for the concern with the predominant use of MCQ is that it may lead to an emphasis in teaching to the test, and a passivity in which one judges other people's ideas but does not propose, formulate or create ideas of one's own (Black, 1998). All in all, the predominant use of MCQs in testing may be counterproductive to our nation's vision of achieving TSLN and I &E.

One way of addressing the current misalignment between teaching approaches and assessment is to modify the science examination at the PSLE. However, suggestions to incorporate practical work and or performance assessment in the PSLE science paper involve several challenges, among which are those that concern logistics (e.g. design and construct of tasks, performance rubrics, validity and reliability issues, physical venues for testing, cost) and training of teachers and assessors and could take some time to implement.

Hence, whilst the MCQ is still seen as useful for testing in terms of its wide coverage of topics and efficiency of marking, the authors suggest the use of a modified MCQ – a two tier item, which requires pupils to reflect on, and supply, reasons for their choice of the answer key from among the four provided options.

The Exploratory Study

The primary aim of the study is to examine the feasibility of using the two-tier reflective MCQ as an efficient means for large scale testing of the understanding of science concepts while at the same time catering to pupils' creative thinking. Traditional MCQs comprise two parts: a stem that contains the question and a response set (1, 2, 3 and 4) that contains the correct answer (the key) and three plausible but incorrect options (or distracters). Among the limitations of traditional MCQs are that they do not provide effective feedback to correct errors in pupil understanding and do not allow for testing of creative thinking or synthesis skills (or pupil ability to develop, organize and present ideas in a coherent way), since there is no avenue for the test taker to explain the thinking behind their choice of a particular option as the answer key.

In a two-tier reflective MCQ, the first tier is more or less similar to the traditional MCQ, with the exception that pupils are instructed to write 'E' if they think that there is more than one possible answer or none of the options is the correct answer. The second tier is an open-ended segment that requires pupils to stop, reflect on and explain the reasoning behind their choice of the answer key in the first tier.

Forty pupils (ie. all girls) from two grade levels, 20 pupils from primary four (P4) and 20 pupils from primary six (P6), were randomly selected for the study with fairly equal representation from the high, medium and low ability groups. The data collection instrument is a pen-and-paper question set of 9 questions for P4 and 18 questions for P6. Nine questions in the P6 question set replicates those from the P4 set. No time limit was given to the pupils but they were asked to write down the time they took to complete all the questions.

Assumptions and Limitation

One assumption of the study was that the Primary 4 and 6 pupils had undergone the basic science education in school. This is a fair assumption as science taught as a core subject from Primary 3 in Singapore. Hence, P4 vis-à-vis P6 pupils were assumed to have had equal exposure to the science concepts tested in the nine questions common to both grades.

Findings and Discussion

In general, across the nine questions common to both P4 and P6 groups, there were more P4 pupils who indicated option 'E' as their responses in the first tier compared to the P6 pupils, and who provided valid alternative answers to the questions. This suggests a possible negative correlation between increasing exposure to formal science instruction and pupils' ability to think laterally or creatively, i.e., the longer the exposure to formal science instruction, the lower the ability to think laterally or creatively.

It was found that on average, each P4 pupil took approximately 15 minutes to complete the 9-question two-tier MCQ pilot instrument. The P6 pupils took an average of 30-minutes to complete the 18 question test. If the test was part of a full format 100 marks summative science paper (e.g. 60 marks for 30 MCQ with a time allocation of 60 minutes), it would seemed that additional time spent to write the reasoning may not affect the overall duration of the paper.

Both groups of pupils (P4 and P6) were able to express their reasoning clearly, albeit with a higher incidence of grammatical errors observed with the P4 pupils.

The following are some sample responses and more detailed findings taken from the study administered:

Sample Question 1

Sample question 1 was completed by both the P4 and P6 samples involved in this exploratory study. The content level is appropriate for the P4 grade level and it was assumed that the P6 samples would have been taught the relevant concepts.

Study the table below carefully.

Group	*Living things*
X	*python, guppy, seahorse*
Y	*horse, cat, squirrel*

These livings things are grouped according to _____.
(1) where they live
(2) their outer coverings
(3) how they move about
(4) the types of food they eat ( )

Explain your reasoning.

_____

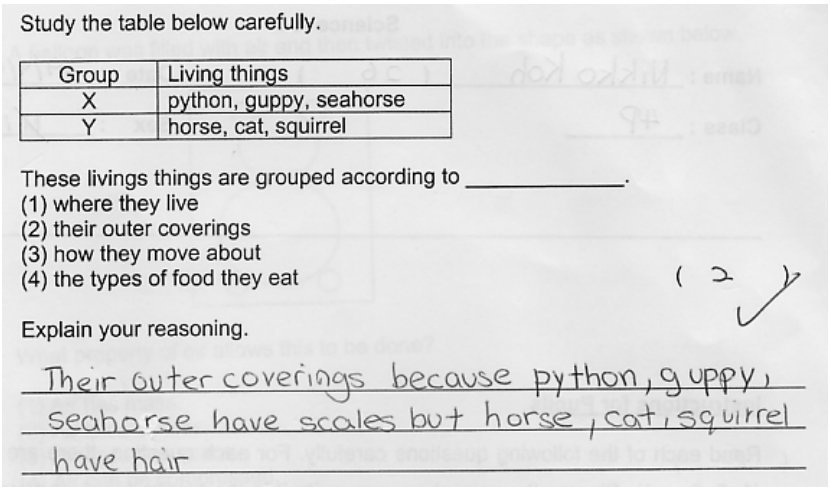
_____

The question setter's intended answer to the above question is option 2. To the setter, the answer seemed obvious – group Y comprises mammals which have an outer body covering of hair while group X comprises reptile and fish and which have an outer body covering of scales.

However, a child who is thinking laterally could choose option 3 as the answer based on the fact that the living things in group X move without legs whereas those in group Y move on legs. Option 1 could also be argued to be a possible answer since there are some pythons, such as water pythons that live in water.

Illustrative Examples: P4 Pupils' Sample Responses to Question 1

Category 1 example: where response matches intended answer, with acceptable reasoning given in the second tier



Study the table below carefully.

Group	Living things
X	python, guppy, seahorse
Y	horse, cat, squirrel

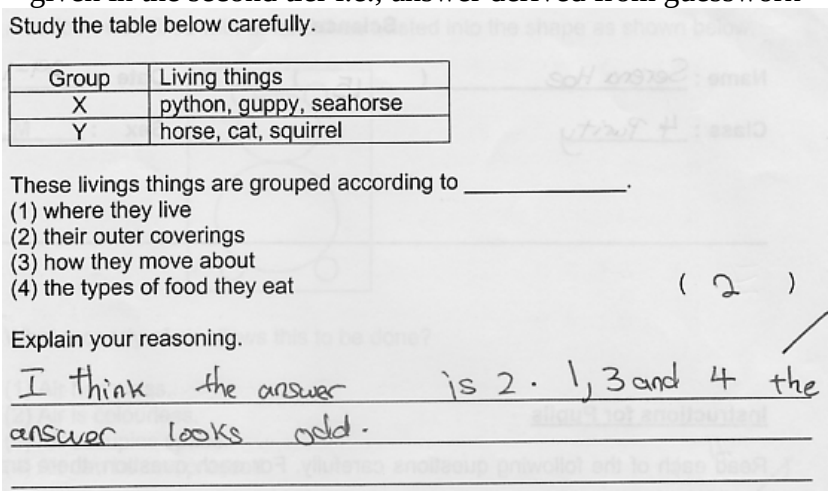
These livings things are grouped according to _____.
(1) where they live
(2) their outer coverings
(3) how they move about
(4) the types of food they eat

(2)

Explain your reasoning.

Their outer coverings because python, guppy, seahorse have scales but horse, cat, squirrel have hair

Category 2 example: where response matches intended answer, but no acceptable reasoning given in the second tier i.e., answer derived from guesswork



Study the table below carefully.

Group	Living things
X	python, guppy, seahorse
Y	horse, cat, squirrel

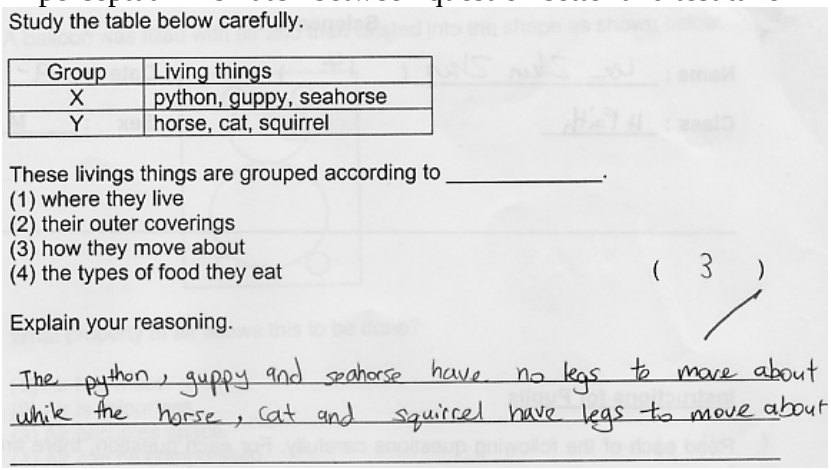
These livings things are grouped according to _____.
(1) where they live
(2) their outer coverings
(3) how they move about
(4) the types of food they eat

(2)

Explain your reasoning.

I think the answer is 2. 1, 3 and 4 the answer looks odd.

Category 3 example: where response does not match intended answer, i.e., there is a perceptual mismatch between question setter and test taker



Study the table below carefully.

Group	Living things
X	python, guppy, seahorse
Y	horse, cat, squirrel

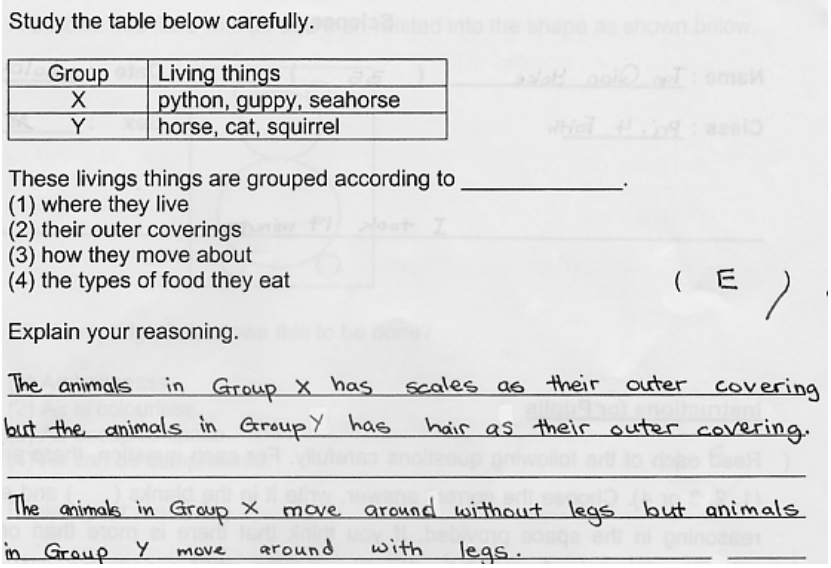
These livings things are grouped according to _____.
(1) where they live
(2) their outer coverings
(3) how they move about
(4) the types of food they eat

(3)

Explain your reasoning.

The python, guppy and seahorse have no legs to move about while the horse, cat and squirrel have legs to move about

Category 4 example: where response does not match intended answer, and there is lateral thinking in that the test taker could see more than one possible answer while the question setter did not



Study the table below carefully.

Group	Living things
X	python, guppy, seahorse
Y	horse, cat, squirrel

These livings things are grouped according to _____.
(1) where they live
(2) their outer coverings
(3) how they move about
(4) the types of food they eat

(E)

Explain your reasoning.

The animals in Group X has scales as their outer covering but the animals in Group Y has hair as their outer covering.

The animals in Group X move around without legs but animals in Group Y move around with legs.

Analysis of Option Responses to Sample Question 1

Option	Item Analysis (P4)	Item Analysis (P6)
1	15% of the pupils sampled chose this option with wrong reasoning	5% of the pupils sampled chose this option with wrong reasoning 5% of the pupils chose this option through guesswork
2	50% of the pupils sampled chose this option with correct reasoning 5% of the pupils chose this option through guesswork	85% of the pupils sampled chose this option with correct reasoning.
3	10% of the pupils chose this option with alternative acceptable reasoning (perceptual mismatch)	0
4	0	0
E	15% of the pupils indicated that both option 2 and 3 are correct, giving acceptable reasons.	5% of the pupils indicated that all the options are incorrect, without giving acceptable reasons

	5% responded that the animals are wrongly classified in the first place (perceptual mismatch) but did not supply acceptable reasoning.	
Summary	Single Tier (Correct) : 55% Two-tier (Correct) : 80%	Single Tier (Correct) : 85% Two-tier (Correct) : 85%
	Findings: - Most of the pupils were able to identify the intended classification that the animals were grouped together. - A small group of pupils obtained their answer either through guesswork or elimination of possibilities. - In general, the pupils know their work well with more P6 pupils supplying the question setter's intended answer. - P4 pupils seem to be more divergent in their reasoning as compared to the P6 pupils sampled.	

Sample Question 2

Which one of the following animals is **unlike** the others in terms of how it moves?

(1) frog
(2) kangaroo
(3) rabbit
(4) tiger

( )

Explain your reasoning

Analysis of Option Responses to Sample Question 2

Option	Item Analysis (P4)	Item Analysis (P6)
1	5% of the pupils sampled chose this option with incorrect reasoning	0
2	5% of the pupils sampled chose this option with incorrect reasoning	3% of the pupils sampled chose this option with correct reasoning.

3	0	0
4	67%	85%
E	23%; all of whom indicated that there were more than one correct response with acceptable reasoning	12%; all of whom indicated that there were more than one correct responses with acceptable reasoning
Summary	Single Tier (Correct) : 67% Two-tier (Correct) : 90%	Single Tier (Correct) : 85% Two-tier (Correct) : 97%
	Findings: - At both levels, most of the pupils gave responses that matched that of the question setter, with a - higher percentage of P6 pupils giving the intended answers than the P4s. - Almost twice as many P4 pupils compared to P6 pupils seem to be more divergent in their thinking .	

Implications for teaching and assessment

The findings of this exploratory study suggest that the use of two-tier reflective MCQ may be feasible in formal primary science assessment. It reveals that questions with potentially more than one possible answers (arising from perceptual mismatch between test taker and question setter, or from misconceptions held by the question setter) may thus be addressed by using the two-tier reflective MCQ framework with the introduction of the 'E' option. Pupils who otherwise would have been marked wrong because of perceptual mismatch were given an opportunity to explain the reasoning behind their selection of responses and were awarded marks accordingly. Study results showed that the difference could be as much as 30-40%, depending on the question involved.

The study shows that the process of encouraging pupils to reflect on, and explain the reasoning behind their answers, not only provides an avenue for creative pupils to share their alternative perceptions and/or interpretation of the question, but also a means for teachers to surface pupils' misconceptions or erroneous reasoning. The feedback provided by such two tier reflective MCQs would also be useful for remedial teaching and re-teaching. The problem of pupils getting correct answers by pure guesswork or examination- smartness could also be addressed in this two tier MCQ format. It could also be useful in surfacing the question setter's misconceptions and misconstructions of the test items as well as in promoting reflective teaching and facilitating the development of content mastery as pupils' responses challenge the teacher's understanding of science concepts and content.

Conclusion

In this preliminary study, that the use of two tier reflective MCQs in primary science investigation was investigated. It was found to have several advantages over the traditional MCQ, such as catering to creative or lateral thinking of pupils, providing insights into pupils' reasoning

and misconceptions. An extended study is in place to examine in detail the potential of such MCQs in formal science assessment at the primary level.

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