MAKING THE CONNECTION: UTILISING MULTIPLE INTELLIGENCES TO MEASURE TEACHING AND LEARNING SUCCESS IN MATHEMATICS

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ABSTRACT

Why do educators connect with some students and not others? The answer lies in the fact that each student is a unique individual with his or her own learning style who will learn best from a teacher who utilises a suitable teaching style. Is it the role of students to adapt their modes of learning to capitalise on the teacher's offerings or should the teacher be trying to connect with all students by employing a variety of teaching styles?

Howard Gardner, in his theory of multiple intelligences, asserts that everyone is intelligent and capable of learning, but that an individual will favour some modes of learning over others.

The factors influencing these modes may be genetic, environmental, or experiential, but they are beyond the teacher's control as the favoured learning style is already formed by the time the student walks into the classroom. It is therefore the responsibility of the educator to adapt his or her own preferred teaching style and use a variety of modes in order to make connections with each student.

This paper analyses various strategies utilised in the teaching, assessment and examination of the Preparatory Mathematics Course at the University of Sydney, Australia, measured with reference to the multiple intelligences.

KEYWORDS: multiple intelligences, visual / spatial, verbal / linguistic, mathematical / logical, bodily/kinesthetic, musical, intrapersonal, interpersonal, naturalist, existentialist

1. Introduction

Recent research and anecdotal evidence from personal experience suggest that Mathematics and the learning of it is one of the most challenging of all subjects and often appears most inaccessible to a large proportion of students. In the plenary lecture at ICME 9 in 2000, Mogens Niss of Denmark stated "As mathematical education was provided to new and growing groups in society it became important to cater for categories of students that, in the past, were mostly neglected or dismissed. However, …….large groups of students seemed to experience severe problems at learning and benefitting from the mathematics taught to them". One suggested reason for this is that the language of Mathematics and its presenters is so esoteric that it leaves the ordinary student bamboozled, thus allowing Mathematics to remain a subject only for the elite. This was the sentiment expressed by Garbayo-Moreno, et al, at ICTM in 1998: "In our opinion, mathematics teaching should move from the kind of topics (we) mathematicians like to teach to the kind of topics society demands as general knowledge." Another explanation may be that the learning of Mathematics will be dependent on the student's strengths and whether or not the teacher can appeal to those strengths to achieve relevance or a connection.

The author was given the task of teaching a tertiary mathematics preparation course to a group of adult learners who historically have not achieved great success in their previous study of mathematics. Traditionally, this course has a large drop-out rate as students cannot relate to standard classroom teaching strategies. The challenge for the lecturer is to utilise a broad range of teaching methods to connect with these students. The purpose of this research was to analyse the learning strengths of the students and the various teaching strategies employed throughout this course to determine the suitability of the pedagogy to the capacities of the students. Howard Gardner's theory of Multiple Intelligences was used to measure and verify the success of the course teaching and assessment strategies in appealing to the individual learning strengths.

This paper is divided into three parts. The first is a general discussion of the multiple intelligences identified by Harvard researcher Howard Gardner in his book, *Frames of Mind: The Theory of Multiple Intelligences*. The second is an analysis of the various intelligences possessed by a group of adult learners, hoping to commence tertiary study in Mathematics, using the survey developed by Walter McKenzie. The third section is a discussion and analysis of the students' responses to a questionnaire (in the appendix) provided on completion of the tertiary mathematics preparation course. The thrust of the questionnaire was to examine the teaching methods and assessments utilised in the course attended by these adult learners with a view to finding their connection with the multiple intelligences. Connections made should result in enhanced learning.

It is to be noted that a good deal of research has been done into the relationship between the multiple intelligences and children's learning of mathematics, and the multiple intelligences with adult literacy. However, research on the connection between the multiple intelligences and adult learning of mathematics appears to have been, as yet, untouched.

2. The Multiple Intelligences

Measuring intelligence has always been a challenge to psychologists and educationists. Trying to determine exactly what is being measured, the definition of intelligence, avoiding cultural or socio-economic bias often inherent in the standard IQ test, have all been aspects which detract from the value of the result. People's intelligence quotients were placed on a scale with a number, which was then used in a variety of circumstances.

Howard Gardner uses the definition of intelligence as "the capacity to solve problems or to fashion products that are of consequence in a particular cultural setting or community" and asserts that it is not so much how intelligent a person is, as described by the IQ scale, but how a person is intelligent. A person uses a "variety of intelligences working in combination to carry out different tasks, solve diverse problems and progress in various domains." Gardner's theory assumes that everyone has some measure of the nine intelligences listed below:

- **Linguistic/verbal intelligence** – the ability to use verbal or language skills to express or communicate ideas
- **Logical/mathematical intelligence** – the ability to think logically, to analyse patterns and relationships in a scientific way
- **Spatial/visual intelligence** – the ability to represent ideas in a visual or graphical way, to think visually or have an understanding of space
- **musical intelligence** – the ability to use music as a mode of expression, to appreciate rhythm, melody and pitch
- **bodily/kinesthetic intelligence** – the ability to utilise one's body to express ideas, to manipulate or create physical objects
- **interpersonal intelligence** – the ability to understand and respond to other people's feelings in an appropriate manner
- **intrapersonal intelligence** – the ability to understand oneself and have an awareness of one's own feelings, strengths and goals
- **naturalist intelligence** – the ability to appreciate and understand the environment and its relationship and importance to humanity
- **existential intelligence** – the ability to see the "big picture", having an appreciation of culture, spirituality and historical perspectives.

An individual's level of strength in these various intelligences, together with how a concept is presented, will determine how well he or she will connect with a particular concept. This is where the role of the teacher becomes crucial. The teacher must appeal to the different intelligences when trying to explain a concept in order for each individual to reach a level of understanding. For instance, a student who possesses a high level of musical intelligence, according to Gardner's theory, will respond well to learning Mathematics when it is explained in terms of musical concepts. These could be through the use of songs, patterns, rhythms, instruments, pitch or melody.

Mark Wahl notes that in the United States, the National Council of Teachers of Mathematics still supports the approach to learning Mathematics via the logical-mathematical intelligence, even though it admits there is a problem. He writes "In some students this is not the strongest asset,……We must tap the other intelligences of all the students in our quest to engender a 'felt sense' in mathematics."

The duty of the educator is therefore to analyse the various intelligences each student relies on. Then the challenge for the educator is to adapt his or her teaching style or use of examples to tap into the different intelligences so that each student can reach an understanding.

3. Student Intelligences

Gardner's philosophy, "that it is not how intelligent you are, but how you are intelligent", can be more useful in analysing how a student learns or what is relevant to him or her than the standard IQ test. Once a student's major intelligences are identified, the teacher can then alter his

or her teaching style, resources and assessment tasks to make a more appropriate connection with the student.

In the research for this paper, the current teaching practices were analysed in terms of their appropriateness related to the nine multiple intelligences, rather than setting about to teach a course based around the multiple intelligences.

Most of the students in this study were preparing for tertiary entrance into mathematical or science related fields. Others were hoping to gain entrance to Law or Arts. The common thread amongst them, however, was that they, adult learners, had not had a great deal of success in Mathematics study previously and in fact, some of them had extraordinary anxiety just at the thought of coming to lectures, let alone attempting the coursework! A sub-group of this cohort had the added difficulty of trying to learn Mathematics in English as their second language. While this sub-group tended to have had historically more success in Mathematics than their anglo-background counterparts, they were most concerned about achieving success in the course. The eleven students ranged in age from 20 to 47 years, male and female, and a number of them had not studied Mathematics for at least 20 years. Most of them did not possess organisational or study skills, nor, at the commencement of the course, did they have very much confidence in their ability to succeed.

The students were happy to be analysed in terms of their multiple intelligences using Walter McKenzie's survey. Of the nine intelligences listed in the previous section, not one of the students displayed the greatest strength in the mathematical/logical intelligence section. Their greatest strengths lay in the other intelligences. These are not the characteristics displayed by students who are successful in the traditional classroom, which favours students with major strengths in the verbal and mathematical/logical intelligences. When teaching a course involving sophisticated mathematical concepts such as logarithms, exponentials, trigonometry, differential and integral calculus to adult learners such as this group, whose strengths do not lie in the mathematical/logical realm, one would think some modification of the traditional teaching style must be necessary to make a connection with each student.

The survey revealed the following results:

Student	A	B	C	D	E	F	G	H	I	J	K
Visual	40	60	20	80	**100**	**80**	10	60	50	80	40
Verbal	10	30	30	80	90	20	10	50	20	**90**	50
Logical	50	60	60	***80***	70	60	60	60	50	***80***	50
Kinesth	70	60	20	80	80	50	50	70	**60**	70	**100**
Music	**80**	60	50	80	70	50	40	60	50	40	40
Intrapers	40	**100**	**90**	**90**	60	50	30	60	60	80	90
Interpers	80	40	20	90	80	10	10	50	50	80	20
Natural	40	30	30	70	60	40	**70**	**100**	20	50	20
Exist	80	30	70	70	90	50	20	60	40	50	80

One can see from these scores (each out of 100) that there was a large range of intelligence strengths in the class suggesting that each would respond differently to different scenarios. For instance, an example on male versus female salary scales might appeal to a student with greater existential intelligence than one with kinesthetic intelligence.

The **bold** figures indicate the highest scores for each student on the various intelligences. While these maximum scores range from 60 to 100, none of them are on the logical/mathematical intelligence. The ***italicised*** figures of 80 represent the highest scores on the logical/mathematical

intelligence. Overall, the scores indicate that, while these students may have some mathematical ability, their strengths lie in the other intelligences.

4. Analysis of Course Strategies

The preparatory mathematics course consisted of twenty-six lectures each of two hours duration given in the evenings. The students had to complete four assignments, a test and a group project chosen from a range of topics, such as "Managing your Mortgage", "Fractals", "The Greenhouse Effect". Finally the students sat a three-hour examination which, together with the other assessments, determined which tertiary course they were eligible to enrol in. Being adult learners, the students had to juggle their studies with family life, career and other commitments, so it was important for the teacher to provide a stimulating environment and enjoyable experience, otherwise they would fall asleep! The course moves at a fast pace, beginning with simple fractions and algebra, and finishing with integral and differential calculus of trigonometric, logarithmic and exponential functions.

At the end of the course the students were provided with the questionnaire in the appendix in order to evaluate the teaching strategies utilised in relation to their multiple intelligences.

In answer to Question 12, "Try to think of an example from lectures which appealed to each of the various intelligences", the following responses were forthcoming:

- **visual/spatial intelligence** – *drawing graphs and charts, volume generated by rotation, areas under curves, Euclidean geometry and Cartesian plane, unit circle, tangent to curve, numberline, the video, drawing*
- **verbal/linguistic intelligence** – *video shown in class on the history of calculus, word questions given on board, one-to-one explanations,* ***humour in lectures****, the teacher explaining concepts, , reading, writing, speaking and listening*
- **mathematical/logical intelligence** – *reasoning, problem-solving, algebra, understanding calculus from first principles, solving quadratic equations, liked the boss's logic*
- **bodily/kinesthetic intelligence** – *movement, doing questions ourselves, rotating curves around the x and y axes,* ***drawing gradients on curves by hand****, hands – on tasks, not much in this area available, the test and assignments*
- **musical intelligence** – ***the video****, did not do it, songs, series or sequences, trig, symmetry, sine waves*
- **intrapersonal intelligence** – *going through things step by step, values, project,* ***giving own opinions in project****, home study*
- **interpersonal intelligence** – *comparing notes when handing in assignments, project work meetings, working in group on project,* ***didn't like this as it was difficult with groups etc. plus I was here to do a job not really socialise***
- **naturalist intelligence** – *can't remember, library tour, exponential equations, project, none*
- **existential intelligence** –*.(integrals) big picture was good, none****, every example where the last statement in the explanation is "don't you think that's amazing?",*** *calculus – didn't realise it had revolutionised the world until now, video, could not make connection.*

It is clear from these responses that while some students were able to relate the activities to a category of multiple intelligence, others were not, possibly due to language difficulties. It is pleasing to note, however, that while the lectures appealed mainly to the verbal, mathematical and

visual intelligences, the students were able to identify instances where the other intelligences were utilised.

The two students who scored 80 on the logical/mathematical intelligence, when asked which activities appealed to them most, both replied that they liked doing the exercises, assignment questions and test. These are the traditional modes of learning and assessment in mathematics education. The other students, whose strengths did not lie in the mathematical realm, preferred the other non-traditional activities, for various reasons. The group research project proved popular: one student explained that it made use of his language skills, another felt that it enhanced his interest in the topic, while another said it enabled her to socialise, help and be helped by others and gave her a sense of comfort during the course.

Interestingly, the student who made the comment that he did not like to socialise scored only 20 on the interpersonal intelligence. It appears that the various activities did appeal to different intelligences.

Humour is not one of the multiple intelligences identified by Gardner, but the responses to Question 16, asking students what effect humour in lectures played on their learning/attitude, were enlightening. Students said it provided light relief, a break from heavy concepts, alleviated stress and aided memory as things are easier to remember if they are funny.

A marked change in attitude was evident in the response given by one of the students (who was suffering severe maths anxiety earlier in the course and achieved 90% in the final exam) to Question 9: Describe how your feelings about Mathematics have changed over the course. She commented *"I have felt everything from extreme gloom and worry, plus fear, to pleasure and elation when I felt I was getting somewhere. The past has been hard to overcome."* The responses to Question 15, where students were asked to identify which intelligences were utilised in the various aspects of the course, revealed that the assessment tasks alluded to the intrapersonal and interpersonal, while the textbook appealed to the existentialists. According to some students the project made use of all of the multiple intelligences.

These responses are encouraging because the writer's objective was to connect with students' individual learning strengths although the course was not designed specifically around Gardner's theory. Yet, according to the students' analyses, different activities utilised in the course did allude to the multiple intelligences. Upon reflection, the types of examples and questions to which students are exposed in this course tend to be drawn more from a broad diversity of practical and contextual situations than the purely theoretical or formal proof types of question. In fact, gender, ethnicity and other cultural considerations are taken into account when devising and presenting examples and questions. For instance, the concept of *linear functions* could be presented through the statistic:

Premature baldness is one of the greatest fears carried by men. By 30 years of age 30% of men are balding, and by 40 years of age 40% of men are balding. Draw a graph of percentage of men balding versus age.

Another statistic: *31% of women sleep in the nude.*

And a question on exponential decay:

A woman's uterus normally weighs 60g. During pregnancy it expands until, at birth, it weighs 1000g. It then shrinks exponentially and by the 14^{th} day weighs 350g. It keeps shrinking until it finally reaches its normal weight. Find an equation to describe this scenario.

That it is imperative for the teacher to attempt to relate examples to the multiple intelligences (or interests) of individual students is borne out by the response to Question 21, where they were invited to make additional comments, given by one of the students:

"*I was keen to do this course as a stepping stone to a degree course (possibly in Nutrition) but it is very hard to learn something when you're not directly interested. It is much easier to learn when it is directly relevant or something which you're very interested in*."

A final measure of success in enabling these students with diverse backgrounds to learn mathematics was the examination. All students performed well, with a number of them achieving High Distinctions (over 85%).

In summary, students with learning strengths in areas other than mathematics can be taught mathematics. Carefully chosen examples, tasks and assessments, which allude to specific intelligences, allow the students to be stimulated in a meaningful way, empowering them to learn and enjoy mathematics.

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APPENDIX: STUDENT QUESTIONNAIRE FOR ictm2 PAPER

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Please answer the following questions as accurately and with as much detail as required.

1. What were your reasons for enrolling in the Preparatory Mathematics course?
2. Describe the highest level of Mathematics you had studied prior to this course, and at what age?
3. How many years is it since you studied the level in Question 2?
4. Are you male or female?
5. In the past, what sort of Mathematics student would you have described yourself as?
6. What were your feelings before the course began?
7. How confident were you of success?
8. How developed were your skills before enrolling in this course?
9. Describe how your feelings about Mathematics have changed over the course.
10. Describe the skills you think you have developed over the course.
11. What sort of Mathematics student would you describe yourself as now?
12. Try to think of an example from lectures which appealed to each of the various intelligences:

- Visual/spatial (graphs, art, eye-catching, drawing) –
- Verbal/linguistic (speaking, writing, reading, listening) –
- Mathematical/logical (numbers, reasoning, problem-solving) –
- Bodily/kinesthetic (games, movement, building, hands-on tasks) –
- Musical (songs, patterns, rhythms, instruments) –

- Intrapersonal (own intuition, values, ideas, feelings) –
- Interpersonal (work with group or partner, socialise) –
- Naturalist (field trips, subtle meanings) –
- Existential (philosophical, big picture, "why is it so?") –

13. What aspects of the lectures enhanced your learning?
14. Give an example of the one of the various intelligences which could have been used in lectures to enhance your learning, giving details.
15. From the list in Question 12, choose which intelligences were utilised in

(a) the assignments –
(b) the project –
(c) the test –
(d) the exam -
(e) the handouts -
(f) the textbook –

16. What effect did humour in lectures have on your learning/attitude?
17. What were the 3 intelligences you rated most highly on?
18. Which activities in the course appealed most to these intelligences?
    Why?
19. Can you suggest an activity to add to the course which would have aided your learning experience?
20. What was your favourite activity – most meaningful to your learning experience?
    Why?
21. Please make any other comments you wish.