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THE ARTICULATION OF PRACTICE: TEACHER ACTION THEORIES AND STUDENT USE OF CALCULATORS IN UPPER PRIMARY MATHEMATICS CLASSROOMS

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Research studies have demonstrated that teachers experience difficulties in the articulation of their classroom practice and their teaching values. Attempts at articulation that have been reported suffer from inconsistencies between a teacher's espoused theory and theory of action. Research that had been completed, both locally and overseas, reflected strong early opposition to calculator use in primary schools and evidence suggested that this early opposition exerted a continuing influence in the classroom (Howard, 1992). Thus teachers may support the use of calculators in mathematics as a general principle but refrain from calculator use in their own classrooms. The early researchers, Argyris and Schon (1974) claimed behaviour was driven by individual action theories that were different from espoused theories and there were difficulties in uncovering these action theories. This study reports upon the use of a modification to the Theory of Planned Behaviour (Ajzen, 1995, 1988) in order to uncover the teacher action theories regarding the student use of calculators in primary mathematics classrooms from a selected sample of NSW upper primary teachers (*N* = 115). It will discuss these theories and their use in assisting teachers in their critical reflection and articulation of current practice.

In recent studies within the effective schools research (Sammons, Hillman, & Mortimore, 1995), the focus has moved to the influence of the teacher (Owens, 1998). Wyatt (1996) used meta-analysis of over 80 British and Dutch school effectiveness studies to suggest that only approximately 9 per cent of the total variance in student performance could be explained by the effects of attending different schools. It was claimed that most of the variance was actually explained by differences attributable to membership of individual classes, which implied that it was teachers and not schools who accounted for difference in student learning. Hill and Rowe (1996) examined school and teacher effectiveness and public examinations, and reported that differences between classes and faculties within schools were larger than differences among schools. Australian studies into school effectiveness have supported this focus on the teacher and classroom (Piper & McGaw, in McGaw, Piper, Banks, & Evans, 1992; Ayres, Dinham & Sawyer, 1998.

In recent times in England and Wales, centre or site based models for teacher training have been used as alternatives to the usual university based model with accompanying intensive short practicum periods. Trainee teachers spend the majority of their time within schools. While not wishing to evaluate the merits of this scheme, one issue that has arisen is the suitability of the classroom teacher to be the expert. There is considerable research concerning novice and expert teachers (Berliner, 1994). There is a reported difficulty that arises when expert teachers are asked to articulate their classroom behaviour and it's underlying theoretical basis. Berliner claims:

> the expert might be characterised as often arational. Experts have an intuitive grasp of the situation and seem to sense in nonanalytic and nondeliberative ways the appropriate response to be made. They show fluid performance, as most people do when they no longer have to choose their words when speaking, or think about where to place their feet when walking... When things are going smoothly, however, experts rarely appear to be reflective about their performance (p. 6021).

If experts are unable to articulate their classroom practice then there is a problem with communicating their expertise to the trainee. This reported lack of reflection is only part of the reason why teachers find it difficult to articulate what they do in the classroom. Teachers do not always say what they believe or do what they say (Thompson, 1992). There is a considerable body of research linking teacher beliefs with action (Pajares, 1992; Ajzen & Fishbein, 1980). Early researchers Argyris and Schon (1974) stated that behaviour was driven by individual action theories. They identified and described espoused theories and theories-in-use and expected individuals would not design and implement a theory-in-use which was significantly different from their espoused theory. What they discovered was quite the opposite. Not only were there significant differences between the two types of theories but "individuals develop designs to keep them unaware of the mismatch" (Argyris, 1993, p. 51). Thus, change could not occur until these theories were uncovered and made available for examination and reflection.

The inability of teachers to articulate their behaviour has manifestations in other areas. Bishop (1999) lamented a lack of research into teacher values. Values have been described as the deeply held beliefs that dispose a person to act in a certain way (Hill, 1991), or as deeper and more stable than beliefs (Seah, 1999). Bishop suggested that a reason for the lack of research was that teachers were rarely aware of their teaching values.

It is clear from this brief discussion that a vehicle is needed to assist expert, novice and other teachers to develop an awareness of their theories of action in order to assist in their articulation of values and practice. This paper reports on an attempt to uncover the theories associated with a specific teacher classroom behaviour by applying a modification to the constructs and instruments of the model titled the Theory of Planned Behaviour (TPB; Ajzen,

1985) to the student use of calculators. The results were called teacher action theories to distinguish them from Argyris and Schon's work.

While calculators have been available since 1965 their progress into schools has been slow and has attracted considerable controversy. A 1986 UNESCO study lamented the lack of Australian research focussed upon calculators (Blane & Willis, 1986). The research that had been completed, both locally and overseas, reflected strong opposition to calculator use in primary schools and there was evidence that this early opposition had tended to exert a continuing influence (Howard, 1992). Research and debate over student classroom use of calculators has ranged across issues such as: access and equity; the impact upon basic skills; and the use of calculators to enhance the teaching and learning contexts (Groves, 1996). Of interest is how have primary school teachers been influenced by this debate. What do they believe about student use of calculators, how has it affected their classroom behaviour and who has the greatest influence upon these beliefs?

In 1994, a pilot study was conducted (White, 1996) with a sample of 89 randomly selected NSW upper primary teachers. A phenomenographical approach (Marton, 1986) was used to analyse the results and to produce a set of descriptive categories which encapsulated the variety of conceptions held by the teachers indicating differences in understanding. The results of the study identified and described a range of teacher beliefs associated with allowing or not allowing student use of calculators in an upper primary classroom. However this study was unable to indicate which of these beliefs provided the basis for teacher intentions or behaviour.

THEORETICAL ISSUES

The Theory of Planned Behaviour (TPB; Ajzen, 1985, 1988) is an extension of the Theory of Reasoned Action (TRA; Ajzen & Fishbein, 1980). Both have been very successful in using a small number of beliefs to predict behaviour across a wide range of contexts and both come from an objectivist (positivist) stance. This stance has been the target of a great deal of criticism (see for example Lather, 1991) and it is beyond the scope of this paper to address this criticism. A fuller description of the model and a deeper treatment of the methodological issues can be found elsewhere (see White, 2000a, 2000b).

METHOD

TPB requires behaviour to be carefully defined. This was done by means of the scenario below which was taken from the phenomenographical pilot study (White, 1996) as it produced a high level of agreement among teachers.

> *Scenario:* You are teaching mathematics to your class at the usual time and place. You want the class to complete an exercise. You consider a range of options before insisting the students use calculators. (In this study a calculator can include any of the range of available handheld four operation models).

A questionnaire was constructed according to TPB and consisted of 28 semantic differential scales and was applied to a sample chosen randomly from across the population of primary teachers who worked at a NSW Department of School Education primary school and who taught mathematics to years 5 and/or 6. A total of 119 teachers returned the questionnaire and the data were entered into a spreadsheet and the software program Statview 4.0 was used to analyse the data. A decision was made not to include four returns because of the amount of missing data.

The questionnaire asked teachers to imagine behaving in the manner described by the scenario and to rate their response on each of the 28 scales. There was one scale for the direct measure of intention to perform the behaviour (endpoints likely/unlikely) and three for a direct measure of attitude (endpoints good/bad, beneficial/harmful, wise/foolish) which were later combined into a single index (DAI). A belief-based attitudinal index (BBAI) was also calculated. The behavioural beliefs were selected from across the continuum developed in the pilot study and are listed in Table 1.

Table 1

Teacher Beliefs concerning Student Use of Calculators.

My decision to allow my students to use calculators in the classroom:
1. would result in familiarity with their use 2. would promote laziness and dependence 3. would result in them working faster and saving time 4. would result in students just accepting answers and not thinking 5. would help them simplify complex problems and assist their problem solving 6. would make it easier for them to cheat

The strength of the belief was measured on a bipolar 7 point scale (endpoints likely/unlikely) with a score of 3 signifying a strong positive belief strength and -3 signifying the opposite. A paired evaluation outcome was also measured on a similar scale (endpoints good/bad) giving a product score range of 9 to -9. The BBAI was constructed using the summed products of the six beliefs and the resultant scores ranged from 54 which indicated a very positive attitude towards the behaviour in question to a score of -54 which indicated the opposite (refer to Table 2).

There was one scale to measure teacher perceptions of the overall influence of important others and a corresponding scale to measure teacher willingness to comply with this influence. According to the model TPB, the product of these two scales produced one direct measure of direct subjective norm (SND). A belief-based index of subjective norm (SNB) was similarly obtained by summing the products of each of four normative beliefs about salient referents (Principal/supervisor, Parents, Students, Other Teachers) with their corresponding motivations to comply. To complete the TPB model there were two scales to measure perceived behavioural control (endpoints of full-control/no-control) and self-efficacy (easy/difficult) these were to be combined to give one index (PBC). However, the results indicated that only self-efficacy should be included (SE). Finally there were four questions that gathered information on the teacher's sex, teaching experience in years, approximate age, and year level now taught.

RESULTS

The demographic results of the sample if summarised using modal characteristics indicated that the teacher was likely to be female; aged between 36 and 45; with 11 to 15 years teaching experience; and with a class of only year 6 students. The overall descriptive statistics of the constructs of TPB listed (Table 2) show that the majority of teachers intended student calculator use within the classroom. Intentions were influenced by attitudes towards the behaviour and were positive on both direct and belief-based measures. Subjective norm measures indicated that overall, the teachers perceived encouragement from their social environment. And the perceived behavioural control index suggested that teachers felt they had a high degree of control over the decision and it would be fairly easy to implement.

The teacher action theory for student calculator use in the classroom is illustrated pictorially in Figure 1 and shows the correlation between the components of the TPB model. All correlation scores were positive except an extremely weak negative linear association between intention and significant others (SND r= -0.01). The strongest correlation with intention was with attitude (DAI r = 0.75) and there was a moderate correlation with self-efficacy (SE r = 0.53). The correlation results involving the belief based measures showed moderate linear associations between the two attitude scales BBAI and DAI (r = 0.40), and between SNB and SND (r = 0.38).

Multiple regression analysis of the full sample (N = 115) revealed that taken together the variables attitude, subjective norm and perceived behavioural control accounted for 58.7% (adj $R2$) of the variance in intention to allow student use of calculators in the classroom. The partial standardised regression coefficients show a strong influence between intention and attitude towards the behaviour ($ß = 0.64$, $p < 0.0001$) in contrast to a very weak negative non-significant influence by subjective norm ($ß$ **=** - 0.03, $p = 0.660$) and a significant weaker influence by self-efficacy ($ß = 0.20$, $p < 0.05$).

Table 2

Constructs of the Theory of Planned Behaviour: Mean Values and Standard Deviations

Construct	Mean	Standard deviation
<u>Attitude toward behaviour</u>	3.95	3.58
Direct (DAI)	14.04	11.46
Product (BBAI)	0.61	2.24
<u>Subjective norm</u>	2.23	7.44
Direct (SND)	1.60	1.20
Product (SNB)	1.06	1.78
<u>Control belief (SE)</u>		
<u>Behavioural Intention</u>		

Note: The table contains both the direct measures and the summed product measures of attitude and subjective norm. For attitudes the direct measure range is -9 to 9 and the product measure is -54 to 54. The subjective norm direct measure range is -3 to 3 and the product measure range is -36 to 36. The behavioural intention range is -3 to 3. The control belief range is -3 to 3.

As attitude was the strongest contributor to intentions for the teacher action theories, the sample was divided into two groups. The high intent group (scores 3 or 2) contained 62 teachers and the low intent group (scores -1, -2, or -3) contained 25 members. In an examination of both components of attitude towards student classroom use of calculators, the high intent group revealed that they believed it was:

(a) extremely likely it would result in familiarity with calculator use and this was an extremely good outcome;

(b) quite unlikely that student calculator use would promote laziness and dependence because that would have been a slightly bad outcome;

(c) very likely it would result in them working faster and saving time which was a very good outcome;

(d) unlikely it would result in students just accepting answers and not thinking because that would have been a slightly bad outcome;

(e) very likely it would help them simplify complex problems and assist their problem solving which was a very good outcome;

(f) unlikely it would make it easier for them to cheat because that would have been a slightly good outcome.

While the subjective norm had little overall influence upon intention, nevertheless the high intent group believed they received encouragement from all four significant referents in allowing students to use calculators in class. They also believed that they had full control over the behaviour and that it was a very easy behaviour to perform.

Thus teacher action theories for those who intended classroom student calculator use indicated that teachers had a strong positive attitude towards the behaviour, felt at ease with performance and perceived positive encouragement from the social environment. They were convinced of the positive outcomes in the form of gains in: familiarity; increased speed; the simplification of complex problems; and problem solving. And they were unconcerned with the negative claims of calculator use encouraging dependency, the lack of thinking and increased cheating.

Figure 1: Basic model for teacher action (*N* = 115; *= p<0.0001).

Not surprisingly the teacher action theory of those not intending to allow calculator use was quite different. The components of attitude for the low intent group revealed they believed that it was:

(a) very likely it would result in familiarity with calculator use which was a very good outcome;

(b) only slightly unlikely that it would promote laziness and dependence, which would have been a bad outcome;

(c) likely it would result in students working faster and saving time and this was a slightly bad outcome;

(d) only slightly unlikely it would result in students just accepting answers and not thinking which would have been a very bad outcome;

(e) quite likely it would help them simplify complex problems and assist their problem solving which was a very good outcome;

(f) only slightly unlikely it would make it easier for students to cheat which would have been a bad outcome.

The social environmental influence revealed that the low intent group believed they felt a lack of support for student calculator use in the classroom and probably as a result didn't see it as being easy to promote in their classroom. They showed far less enthusiasm for the positive gains and greater uncertainty about the negative outcomes.

DISCUSSION

How can this study be used to inform current teaching practice? The stated aim of this paper was to increase understanding of teacher classroom behaviour via teacher action theories and to provide information for teacher reflection of current practice. The results of such reflection may well involve changing behaviour. In fact, some change of behaviour may be desirable. When considering the teacher action theories it becomes apparent that groups of teachers have beliefs that are contrary to the spirit of the mandatory syllabus documents. The task of encouraging teachers to alter their beliefs to mesh with the goals of the K-6 Mathematics Syllabus (DET, 1989) and more recent documents is a challenge for all teacher educators as well as educational leaders and administrators. Siemon (1989) regarded most teacher change programs as predicated on the belief that if the majority of teachers expanded their repertoire of how to teach mathematics more effectively, then a much better state of affairs would come to exist. However there was no guarantee of change. Instead she argued, change should follow the 'constructivist view' of learning. It must make sense to those who have to implement it and so must recognise the implementers as learners in their own right. This means that the implementers theories need to be recognised understood and challenged in order to facilitate effective and meaningful change. "Until these underlying beliefs, attitudes and knowledge bases are meaningfully challenged, the change effort is in real danger of becoming yet another 'bandwagon'" (p. 254).

Argyris and Schon (1974) were interested in putting theory into practice. When applying their research to how people learn, they used the terms 'single loop' and 'double loop' learning to make a crucial distinction. They provided a simple analogy to explain their distinction: "a thermostat that automatically turns on the heat whenever the temperature in a room drops below 68 degrees is a good example of single loop learning. A thermostat that could ask, 'Why am I set at 68 degrees?' and then explore whether or not some other temperature might more economically achieve the goal of heating the room would be engaging in double-loop learning" (Argyris, 1991, p. 100).

Argyris and Schon (1989) claimed that professional practitioners commonly used the single learning loop. However single loop learning was found to have problems concerning the effectiveness of those who used it and its influence upon the individual's ability to learn about their own behaviour. In fact, they claimed that single loop learning worked against effective and productive change because associated with single loop learning were a number of strategies to overcome or hide feelings of embarrassment and threat. This was true for both individuals and groups. Thus

> whenever undiscussibles exist, their existence is also undiscussible... These cover-ups, and their cover-up, are indications of organisational*defensive routines*, which may be defined as any policy or practice that prevents organizations (and their agents) from experiencing embarrassment or threat *and* at the same time prevents them from identifying and reducing the causes of embarrassment or threat (Argyris & Schon, 1989, p.621).

Single loop learning helps to explain how professionals avoid learning. It also indicates how defensive reasoning blocks learning despite a high individual commitment to learn. Argyris and Schon proposed that effective change needed a double learning loop and they offered a method to assist the transition from a single loop to a double learning loop model. They claimed their method presented a theory of action to enhance human activity, responsibility, learning, effectiveness and self-actualization. They argued that people could be taught to recognise the reasoning they used in designing and implementing certain behaviour. They proposed to help subjects identify the inconsistencies between their espoused and actual theories of action. Their method has been successfully adapted to helping successful people learn more effectively (Argyris, 1991), and promoting effective organisational change (Argyris, 1993).

While agreeing with Argyris and Schon upon change, this current paper differs with their approach in that it uses a modification of TPB to model the teacher action theories. Argyris and Schon's approach relied upon the researcher uncovering the theory through the use of observation.

CONCLUSION

The inability of teachers to articulate their current classroom practices and values is detrimental to both individual growth and the mentoring of others. Teachers are exposed to many factors that influence their classroom practice and they would benefit from self-examination. In helping current and future teachers work towards practices that are consistent with the wider goals of the educational system, teacher action theories could play an important part. Teacher action theories provide a framework for understanding and discussing teacher behaviour. Early and continued examination of teacher action theories and teaching practice in both preservice and inservice programs may provide a further strategy in improving the quality of teacher classroom practice.

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