

## **Using metaphors for investigating and reforming teachers' and students' classroom practices.**

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### Abstract

Teachers and students often possess entrenched, confined, and conservative beliefs regarding classroom practice and learning. These, often tacit, beliefs are significant barriers to classroom innovation and change. Changing teachers' and students' classroom practices requires that methods are available that enable teachers' and students' to make their tacit beliefs explicit and available for scrutiny. Metaphors are one means of exposing students' and teachers' beliefs regarding teaching and learning so they can be examined and discussed with a view to improving classroom practice and hence student learning. Recent research on the relationships between teacher and student metaphors and the teaching and learning, particularly in relation to science teaching and learning, is reviewed. The use of metaphors as a means of developing a shared understanding of learning processes between teacher and student is highlighted. The further potential use of these research findings in broader educational contexts is discussed.

Curriculum improvement has at its heart the improvement of students' learning. Central to such improvement is the assumption that improvements in students' learning follow changes to teaching practices (Baird & Mitchell, 1987). However, many well intentioned curriculum innovations have failed because insufficient attention has been afforded to changing the teaching and learning practices required for an innovation to succeed (Fullan, 1993). Yet, such failure does not seem to deter either educational policy makers or curriculum

developers. A constant procession of 'new' curriculum syllabi, national statements and profiles, and policy documents regularly appear on the Australian educational landscape. Many of these innovations are often bestowed considerable merit given the advancement of learning that they purport to undertake.

Central to the changes in many curricula over the past ten years has been a shift in their epistemological underpinnings. This shift has most often been from curricula which primarily reflect an objectivist epistemology to those reflecting a more constructivist epistemological position. A constructivist epistemology recognises the significance of individual's prior knowledge in the construction of new knowledge and contends that learners make sense of experiences through their existing conceptual structure (Tobin & Tippins, 1993). This is in contrast to the teaching and learning based on systems of objectivist semantics where the 'truth' is transferred intact from the teacher to the student, usually via a verbal conduit. Despite the merits and successes of such epistemological realignment for teachers and students (see, for example, Baird & Mitchell, 1987; Baird & Northfield, 1992; Tobin, 1990, 1993a,b; Ritchie, 1994; Tobin & Tippins, 1996), many curriculum innovations aimed at achieving such a shift have had minimal impact on classroom practice with behavioural models of teaching and learning still holding sway in the majority of classrooms (Brown, 1994).

During the initial stages of curriculum changes, teachers may be provided with the opportunity to engage in professional development activities; the belief being that they will return to the classroom and will implement the new curriculum in an unadulterated and intact form. Given the understanding that teachers must be engaged in the processes of renewal that accompany curriculum changes (Goodlad, 1990; Fullan, 1993), such initial involvement is very important. However, continuing opportunities for such teacher education seldom persist. Teachers most often return to their classrooms and continue as before. Their actions are essentially unchanged. As Sikes (1992, p. 45) suggests,

Carrying on as if nothing had happened is, indeed, perhaps one of the most common responses to most forms of change...Sometimes what teachers say suggests that changes have taken place but in reality the gap between rhetoric and practice is wide.

A teacher's practice can be considered as a set of behaviours for which there exists a referent consisting of 'a set of goals and a set of beliefs that make the behaviours viable in a given context' (McRobbie & Tobin, 1995, p. 381). Students' referents are similarly composed and they too are reflected in students' behaviours. Accordingly, changes to an individual's referential system can result in changes to their behaviours (Tobin, 1990, 1993a,b; Ritchie, 1994; Tobin & Tippins, 1996). The importance of teachers' and students' referential systems, both for understanding and altering teachers' behaviours and students' learning processes has been the focus on considerable research in the field of science education. Much of this research has involved the use of metaphor as means of tapping into individuals' often tacit referential systems and providing alternative referents for consideration.

This paper reviews research on this use of metaphor in science education. It seeks to provide a basis for understanding the principles behind the use of metaphor so that such use might be extended to reforming teaching and learning beyond the area of science education. Firstly, the nature of metaphor is explained. This is followed by a review of research conducted in the area of science education where metaphor has been extensively used.

Finally, the implications of the research findings for other areas of education are proposed and discussed.

### **The Nature of Metaphor**

Metaphor is a primary form of figurative language that is central to the way language operates (Richards, 1936; Bartel, 1983). It is used to communicate the characteristics of a difficult to conceptualize concept, the target, in terms of another, more accessible and familiar concept in the addressee's prior knowledge, the source. The addressee of a metaphor makes sense of that metaphor by identifying systematic correspondences between elements of the target and the source. These correspondences, known as mappings (Gentner, 1983) constitute the ground of the metaphor and may involve correspondences of objects, attributes, and relations. New meaning is created when those correspondences, previously unassociated with the target and surprising to the addressee (Duit, 1991), are highlighted in the target so that the target is spoken of as if it were the source. Metaphors are involved in lexical gap filling (Paris, 1988) and, as such, serve to meet the need, as cost effective devices, for marking similarities and making comparisons (Cooper, 1986).

At a broader conceptual level, Lakoff and Johnson (1980) propose that metaphors are reflections of overarching, commonly shared understandings that undergird discourse and social cognition and therefore organise people's existence. Metaphors, therefore, act as referents for action and are reaffirmed by day to day conversations between individuals who share identical or similar referential systems. In this capacity, they are used in conversation to effect or cultivate familiarity, custom or intimacy between speakers (Cooper, 1986). People's culturally accepted interpretation of specific metaphors and their shared knowledge of the use of the practice of metaphor use develops this intimacy and enables them to interpret and construct other metaphors and expressions (Cooper, 1986). Cooper also argues that people are more cohesive in their social structure by virtue of them using and accepting shared metaphorical understandings and the ideas entailed by those understandings. As such metaphors can also act as barriers to individuals shifting their behaviour or beliefs. Because metaphor pervades a culture's cognition, language and general activities, reflecting on a culture's metaphors and the entailments of those metaphors represents a means to reflect on that culture and the beliefs and actions of its members (Hawkes, 1972; Lakoff & Johnson, 1980).

Not surprisingly, therefore, as well as acting as instruments for comparison, a powerful function of metaphor is to create new social meaning. As well as defining everyday realities, metaphors create the possibility of new realities via the consideration of previously unconsidered metaphors (Lakoff & Johnson, 1980). Metaphors are said to be systematic, that is they have generative power (Cooper, 1986). Peoples' culturally determined interpretation of specific metaphors and their shared linguistic knowledge of established metaphorical practice enables them to interpret and generate new metaphors and expressions (Cooper, 1986; Lakoff & Johnson, 1980). Through consideration of new metaphors, individuals can assimilate and integrate the unknown and the dissimilar into what they already know and understand (Provenzo et al., 1989). Therefore it is possible to trigger a repackaging of old beliefs according to new structures via the consideration of a metaphor (Torangeau, 1982).

## Metaphors for Teaching and the Use of Such Metaphors

The use of metaphors to investigate, describe and alter the beliefs and practices of teachers is becoming increasingly widespread. Metaphors have been found to shape teachers' understanding of their role and their classroom practices and to describe and prescribe teachers' work and roles in the school setting (Tobin, 1990; 1993a; 1993b; 1993c; Paris, 1988; Ritchie, 1994; Gurney, 1995). Tobin's perspective on the use of metaphors with teachers is well summarized by Taylor (1993):

Tobin argues that the beliefs that shape teachers classroom roles are powerful metaphors, images and myths associated with the culture of teaching. These high level referents for thoughts and actions provide teachers with normative world-views of the teaching learning process but are not necessarily verbalized or readily available for critical assessment. (p. 286).

While teachers use metaphors to guide teaching and learning in their daily interactions with students, they often employ more than one metaphor, a metaphor set, (Tobin, 1990, 1993a). Roth (1993) adds that the metaphors through which teachers define their classroom roles are determinants of the interactions and transactions in their classrooms. Further, the metaphors which inform a teacher's behaviour are evident in their verbal and non-verbal interactions with students even if, as Taylor (1993) suggests, the metaphors are not readily articulated by the teacher. Taylor (1993) also claims, in line with the broader, social view of metaphor proposed by Lakoff and Johnson (1980), that a teacher's culturally derived metaphors are reaffirmed by day to day conversation with colleagues to the extent that they become impediments to the teacher altering their behaviour or beliefs related to teaching.

Metaphors used to describe teachers abound. For example, teachers have been referred to as motivators, coaches, scholars, taskmasters, mentors, managers, policeman, entertainer, social director, experts, and executives (Paris, 1988; Berliner, 1990; Tobin, Kahle, & Fraser, 1990; Costa, 1991). Such metaphors are frequently used in discourse between and regarding teachers. The 'teacher as expert' metaphor is a powerful and often cited occupational vision for teachers as it proposes an understanding of what a learner is and therefore establishes the structure of resultant teacher-student relationships (Paris, 1988). According to this metaphor, the teacher expert uses their knowledge and skills to transform the naive, inexperienced novices into successful performers who are adept and intent on accumulating or collecting the expert's wealth of information. Novices are often perceived as having limited understanding of the tasks they confront. Both Paris (1988) and Welker (1991) have criticized the 'teacher as expert' metaphor with Welker concluding that its effect of diminishing the moral and social responsibilities of teachers, and its demotion of students into passive receivers of expert service, make it a questionable referent for action.

In related research, student empowerment has been investigated as a function of the dominant functional metaphor sets held by teachers (Claudet & Ellett, 1990). They found that teachers' metaphor sets, reflecting the degree to which the teacher's pedagogy facilitated student empowerment regarding their learning, fell variously along a continuum from those that facilitated student empowerment to a large extent, that is transferential metaphors, to those that restricted opportunity for student empowerment, that is transactional metaphors. Transferential metaphors, for example, those that depict the

teacher as a monitor, a prober, or a facilitator, are characterized by collaborative teaching/learning relationships where power to act is transferred from teacher to student. Students are then more responsible for making sense of classroom life and constructing knowledge and understanding. Conversely, transactional metaphors, for example, those that depict the teacher as a manager, a drill master, or a routinizer, are characterized by students accepting autocratic and dictatorial teacher behaviour. The teacher maintains the position as the source of power and knowledge in the classroom.

Another metaphor which has significant influence in all facets of teaching is the 'classroom is a workplace' metaphor. Doyle (1983, 1986) championed this metaphor and highlighted strong analogies between the two referents such as effective management and control, student work, student and teacher productivity, delegation of authority, student's 'payment' for results, production schedules, quotas, bargaining arrangements, and tradeoffs. Tobin (1995) asserts that adherence to such metaphor results in teachers managing classrooms in ways that "maintain control of student thinking and behaviour" by arranging students "so that they cannot interact with one another" (p. 157). This metaphor reflects the 'Time is Money' metaphorical concept described by Lakoff and Johnson (1980). In modern Western cultures this concept is extraordinarily pervasive due to the penetrating nature of economics into social discourse and political considerations. One reason for this may be that, as House (1991) contends, the 'reality' of the micro arena, that is, the classroom, reflects the 'reality' of the macro arena which is itself determined by the prevalent metaphor of the government at that time. In House's estimation, the prevalent metaphor of governments is an economic metaphor which correlates with the 'Time is Money' metaphor. The workplace metaphor serves as a fundamental root metaphor for the everyday activities and language of classroom life, for example, 'seatwork', 'homework' and students' 'work habits' (Marshall, 1990). The metaphor goes largely unnoticed as the source of classroom discourse like, "Get back to work!" Marshall criticized adoption of this metaphor as a referent for practice on the grounds that conceptualizations based on it are deficient in emphases on autonomous student learning, cooperative classroom practice, learning for self-improvement, and the construction of knowledge. Yet this metaphor is pervasive to the extent that it remains essentially unquestioned and unchallenged in schools and in educational discourse. As such it provides a further example of the barriers to changing teachers' and students' beliefs about learning previously explained.

From a constructivist perspective, learning is a social process involving negotiation of meaning (von Glasersfeld, 1993, 1996). The constructivist science classroom assumes that students are active, reflective manipulators and assessors of new knowledge. The learner acts on data derived from active involvement in a range of activities including independent work, manipulation of laboratory equipment, discussions of ideas and problems with other students and the teacher, listening to the teacher and responding to questions of the teacher and peers (Tobin & Gallagher, 1987). To promote constructivist learning environments teachers need to shift the emphasis of their pedagogy from managerial, transmission or transactional foci to more 'facilitative,' empowering foci. Metaphors with a managerial focus in classrooms are inappropriate for allowing or facilitating student reflection on thinking processes (Hand & Treagust, 1993) and are, therefore, inappropriate for a constructivist setting.

Pedagogical reforms aimed at shifting teaching from transmission referenced didacticism to constructivist-related activities should involve teachers identifying and changing the metaphors, images, and myths that shape their personal conceptions of teaching and learning processes in so doing constrain their classroom roles (Tobin, 1993b). Metaphor has been successfully used to such effect and also to inform teachers regarding alternatives to their perceived roles in classroom situations. Tobin and Tippins (1996, p. 728) have reported that "metaphors appeal as ways of beginning conversations about teaching and learning

science and making it easier to be reflective on and in practice" and "teaching and learning can be described in terms of metaphors which can then be foci for analyses." The value of metaphors has been highlighted as a component of processes that seek to assist teachers develop vocabulary to describe their teaching behaviours (McRobbie & Tobin, 1995). This notion of language use and development is paramount in any process of reflection that aims to improve practice. Examples of such use of metaphors with teachers have steadily increased in the science education literature.

In a study of a first year chemistry teacher, Volkman and Anderson (1998) used metaphors to portray a teacher's images that "integrated her personal identity with her emerging professional identity" (p. 293). Significant research into the use of metaphor as a means of altering teachers' practice has been reported by Tobin (1990; 1993a; 1993b; 1993c). Tobin found that if a teacher changed their metaphor for teaching there followed a whole series of behavioural and belief changes that resulted in the teaching pedagogy altering significantly. The change in metaphor served as a master switch for teacher change. Teachers' guiding metaphors like "captain of the ship," 'policeman,' karate master,' 'preacher,' and 'manager,' were shifted, in consultation with teachers, to metaphors like 'researcher,' 'mentor' and 'social director.' Changes in pedagogy followed the changes in metaphor with the teachers shifting their pedagogical stance to a position more representative of constructivism. Similar findings have been reported by Ritchie (1994) who described how an experienced science teacher used the metaphor 'teacher as travel agent' to initiate and maintain constructivist practice in a year 10 science class.

The review thus far highlights the pervasive nature and often unquestioned acceptance of metaphors as referents in teaching. Metaphors are major determinants of teachers' realities. The influence of metaphors that primarily entail transmission of information has resulted in a significant reduction in the value of students' past knowledge and skills as essential determinants of, and platforms for, building new knowledge, skills and understanding. Transmission and authoritarian management metaphors infer learning processes contrary to those consistent with constructivist paradigms for student learning (Welker, 1991). If schools are to reflect constructivist paradigms for student learning the guiding metaphors for student and teacher action a need to alter. Central to such a change is a satisfactory means of explaining to students and teachers what the desired learning and teaching strategies might be. Metaphor has been used to this effect with teachers.

### **Metaphors for students, learners and learning and their influence**

A commonly used metaphor is that of teachers being shapers, formers or molders of children (Scheffler, 1991). The child, according to this metaphor, is a piece of clay with the teacher being the sole determinant of action on the clay and therefore solely responsible for the final student outcome. Consequently, students are passive recipients of teachers' wills and skills with no independent motives or expressions of choice. Scheffler criticizes the implications of this metaphor suggesting that it places students in a position where their passive acceptance of the mold selected by the teacher is their sole contribution to their learning. Also of concern is the pliable homogeneity of each student and the predetermination of the final outcome. This description of teaching focuses on the teacher's initiative, power and responsibility being the focus of a transmissive educational process as previously elucidated. The power of this metaphor is confirmed by White (1988) who insists that this metaphor for students has not significantly changed since the early twentieth century. The control of learning, according to this metaphor, resides with the teacher. Many

students find the practical implications of this metaphor comfortable and satisfactory with their focus being on simple obedience and not on thinking (White, 1988; Baird & Mitchell, 1987; Baird & Northfield, 1992). A possible extension arising from this metaphor is that the end of formal schooling marks the end of the learning process. The clay has been shaped, fired and finished. The educational process is complete.

The 'student is a piece of clay' metaphor has another counterpart, the 'student is a blank page' or 'tabula rasa' metaphor. Underpinning this metaphor is the contention that students arrive at school as a collection of uninformed, blank persons, with no significant knowledge of the topic, ready to take up whatever is presented by the teacher and store it indelibly (Osborne & Freyberg, 1985; Shapiro, 1988). This metaphor has resulted in conferring strong favour on didactic, content-based teaching regimes, and an 'assembly line view of student progress' (Shapiro, 1988), both of which are still powerful influences in today's schools. Much classroom teaching reflects an epistemology grounded in students' acceptance of knowledge supplied by the teacher, rather than knowledge constructed through constructive intellectual and social activity, that is, the school instruction is designed around the assumption that concepts must be taught to children through 'a process of transmission in which the students are treated more or less as potential receptacles of the knowledge' (Greeno, 1989, p. 137). The existence of the 'siphon' model of learning (Tobin, 1987) supports this contention. In a classroom where this model has credence through action students will be involved in unseen ways as knowledge is transferred from the teacher's head or from a textbook into the students' heads. This metaphor for teaching and learning runs counter to the constructivist perspective of learning where students come to school with already formed, possibly naive, yet functional theories they use to make sense of their experiences.

Bullough (1990), reflecting on his experiences with teacher undergraduates, suggests that the knowledge that students have of their roles as learners, like that which teachers have of theirs, is mostly tacit, embedded in our language, and hidden from scrutiny. As with the research reported with teachers, metaphor has been successfully used to assess students' views of learning and their roles as learners. Berry & Sahlberg (1996) used metaphor as part of an instrument designed to assist classroom teachers investigate their pupils' ideas about learning. The metaphor task involved students choosing one picture that they thought best described a good learning situation from a selection of four, each of which was metaphorically representative of a learning situation. The four images represented learning from experience, learning as a passive activity, learning as a cooperative activity, and learning as a process of being guided. They found that most students' ideas of learning were congruent with the transmission model of learning. Their views were congruent with those that have been found to guide teachers' actions. The interaction between students' and teachers' beliefs about teaching and learning form a self-perpetuating system where the dominant and unchallenged form of pedagogy is transmission based. The whole process of knowledge construction is occurring at a subconscious level, with the student being unaware that a transmission metaphor is governing theirs and the teacher's thinking and action within the classroom.

In recent research, Thomas and McRobbie (in press) used two detailed case studies to illustrate how students' metaphors of themselves as learners in a chemistry classroom, within which the teacher was shifting towards a more constructivist pedagogy, were congruent with their views of learning and the learning processes they employed. One student described herself as being lost in a maze within such a learning environment and lacking the necessary learning strategies to take control of her learning. She was performing below her academic aspirations and reported a low self-concept as a thinker. The other student described herself as a person eating and digesting an apple. Her metaphor was consistent with a well developed information processing view of learning. Not surprisingly,

this student was achieving high academic success and reported a high self-concept as a thinker. Importantly, the practice of asking the students to construct a metaphor to describe themselves as learners served as a metacognitive experience for students which enabled them to make their personal images and beliefs explicit and available for scrutiny. The metaphors also served as a focus for discussions about learning between the teacher and the students much as teachers' metaphors served as foci for discussion in the aforementioned research related to teacher change.

In associated research, Thomas, McRobbie and English (1998) have found that metaphor can be used as a switch to alter students' views of learning and their learning processes. A teaching intervention centred on the metaphor 'learning is constructing' was implemented with the aim of enhancing students' metacognition by providing them with an alternative referent to the transmission oriented referents that dominate most students views of teaching and learning. Students were initially found to be non-metacognitive regarding their learning processes. Their views of teaching and learning were consistent with transmission models of teaching and learning. Following the intervention some students were increasingly metacognitive and began to revise their learning processes by reflecting on, and operationalising, the metaphor's entailments. They began seeking and constructing links between chemistry concepts and ideas. Further, rather than use narrow learning strategies like rote learning to prepare for assessment tasks, they sought to use the constructions arrived at through the conscious interrelating of ideas to develop a deeper understanding of the material which they then used to assist them solve complex problems.

All of the twenty-four students in the class were able to identify the view of teaching and learning that was entailed by the metaphor. All initially intimated that they thought there would be positive outcomes for those who adopted the metaphor to guide their view of learning and their learning processes. The twelve students who chose to adopt the metaphor as a referent saw that the strategies entailed by the metaphor were plausible and intelligible, and that the use of such strategies improved their learning outcomes. Further, they were motivated students who were willing to engage in a change process. Those students who chose not to adopt the metaphor as a referent for their learning reported that, as well as a lack of motivation, a range of contextual factors like workload, extracurricular activities, the timing of the intervention in Year 11, and an unswerving view of teaching and learning prevented them from adopting the metaphor as a referent for their learning. Such contextual factors are being increasingly reported as crucial factors in changing students views of teaching and learning (Byrd, & Doherty, 1993; McRobbie, & Tobin, 1995; Hand, Treagust, & Vance, 1997). Despite not all students adopting the metaphor and its entailments to guide their learning, this research once again demonstrates the usefulness of metaphor in facilitating conceptual change.

## **Discussion and Implications**

This paper reviews research into the use of metaphors as means of investigating and altering teachers' and students' conceptions of teaching and learning. Metaphor has been used with school students in the past, however not for these purposes. For example, in research conducted by Paris and Jacobs (1984) and Paris and Oka (1986) metaphors were an important instructional feature in promoting children's understanding of reading strategies (Paris & Winograd, 1990). Metaphors like 'be a reading detective', 'tracking down the main idea', 'rounding up ideas', and 'planning your reading trip' were used to make the poorly understood and veiled mental processes of reading cognizant for 8-10 year olds by providing

tangible representations of thinking processes. These metaphors assisted in initiating discussions about strategy characteristics, their uses and functions, their implementation, and the mechanics of their use. Such use of metaphor, while valuable, is much more limited to specific learning and thinking processes and not aimed at revising the conceptual referents that ultimately shape teachers' and students' beliefs and practices. It is these beliefs that are significant barriers to curriculum and pedagogical change, as discussed previously.

Several conclusions can be drawn from the above review of the use of metaphors with respect to this broader purpose. From each conclusion implications for further use of, and research into, such a use of metaphor in all facets of education can be drawn.

1. *Metaphors can be used to describe the characteristics of teachers, learners, and learning environments.*

Educators can use metaphors to communicate the characteristics of teachers, students, others involved in education and the environments within which they operate. Metaphor enables the salient characteristics of individuals and their environments to be understood by others who are not direct observers of a situation. However, not only is it important to utilize the power of metaphor when communicating regarding such matters, it is important to understand that with the use of metaphor for such purposes comes responsibility. Those who use metaphor for such purposes need to be clear about what characteristics they seek to report and construct metaphors that report such characteristics appropriately. Equally important is the need to ensure that metaphors do not entail characteristics of individuals or organizations that are unintended, inaccurate or spurious with respect to those parties.

2. *Metaphors are powerful means of initiating reflective processes regarding all aspects of teaching and learning.*

Metaphor has the potential to act as an instrument for the development of both individual and shared understandings of teaching and learning processes between those involved in education, whether they be teachers, students or researchers. By having individuals describe their beliefs and actions using metaphors tacit understandings are made explicit and become 'objects' that can be reflected upon. The research reviewed in this paper highlights the value of such use of metaphor with respect to classroom teachers and students. Still, opportunities exist to use such a strategy throughout all facets of education. For example, the strategy could be used by university and school counselors, lecturers and teachers who seek to understand the beliefs of students, and by teachers who want to make students' views of teaching and learning explicit to the students themselves. One example of such use of metaphor has been reported by Bullough and Stokes (1994) in the United States. They report using metaphor to successfully facilitate the professional development of recent teacher graduates. In Australia such use of metaphor does not appear to be prominent and obvious possibilities for the improvement of teaching and learning, as well as for productive research, exist.

3. *Metaphors can be used to alter the referents that guide the practice of teachers and learners.*

As previously shown, the widespread use of some referents, that can be encapsulated in metaphors, creates undemocratic relationships between teachers and students and serves to perpetuate dysfunctional classroom practice where passive learning is the predominant outcome of instruction. Transmission and behaviorally oriented models of teaching and learning remain most prominent in education despite growing evidence that such models do not meet the needs of students or society. However, changing teacher practice to reflect more constructivist underpinnings remains a very difficult task. We suggest that it is important that any change process begins with the teacher. Students may be able to conceptualise their beliefs and knowledge using metaphors but they are unlikely to do so unless prompted to, and supported, by the teacher. Tobin (1995) suggests that teachers should conceptualise new roles by using metaphors. His research confirms that such conceptualisation can result in new classroom practices and beliefs about teaching and learning. Teachers wishing to challenge the passive learning practices of students can use metaphor to begin to shift students views about teaching and learning. Such a process is also not without its problems. Students may resist due to strongly held beliefs or the practices of other teachers. However, such change in students promises to empower them to become increasingly metacognitive. It is such an increase in their metacognition that might result in them becoming more effective learners.

### **Concluding remarks**

This paper began by noting that many attempts to implement innovative curricula had fallen short of their goals, and that teaching practices had remained essentially unchanged despite the promise of improved student learning resulting from such innovation. Teachers' and students' referents were identified as one reason for the lack of success of such innovations. Metaphor has been used extensively in science education, and less extensively in other areas of education, to probe, understand and, in some instances, alter teachers' and students' referents that guide their practice. Research into the use of metaphor in other areas of education is required as such research would further inform the knowledge and practice of those seeking to implement educational change.

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