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# Metaphorical Roots of Beliefs about Teaching and Learning Science and their Modifications in the Standard-Based Science Teacher Preparation Programme

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**RESEARCH REPORT**

# Metaphorical Roots of Beliefs about Teaching and Learning Science and their Modifications in the Standard-Based Science Teacher Preparation Programme

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Beliefs are psychological constructs potentially driving a teacher to make pedagogical decisions and act. In this study, the metaphor construction task (MCT) was utilised to uncover beliefs about teaching and learning science held by 110 pre-service science teachers participating in the standard-based teacher preparation programme. Overall, the participants' dominant metaphor categories were teacher as nurturer/cultivator, as knowledge provider, and as superior authoritative figure. The findings from descriptive comparisons did not show meaningful patterns of metaphors in association with the factors of gender, study major, or class level. The MCT, incorporated with in-depth interviews, revealed that out of 30 volunteers, more than half expressed a major change of metaphor after one semester's participation in the standard-based programme. The major path of metaphor change was from the teacher as nurturer/cultivator to the teacher as knowledge provider. Pre-service teachers' beliefs are metaphorically rooted and culturally influenced. The implications regarding the utilisation of MCT, modification of teacher beliefs, and science teacher education are also discussed.

Keywords: *Metaphor; Teacher beliefs; Teaching and learning; Teacher education; Pre-service science teacher*

## Introduction

One of the significant stages in the process of learning to teach science takes place in science teacher preparation programmes. According to constructivism, individuals

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are not blank slates; they come into teacher education with perspectives, knowledge, and beliefs constructed from past experiences. Numerous studies reiterate a wide range of beliefs about teaching and learning held by pre-service science teachers at different stages in teacher education. Whatever these beliefs are, they strongly impact pre-service teachers in interpreting and constructing perspectives and meanings for becoming science teachers, and, finally, for acting in classrooms. The important tasks for science teacher educators are, therefore, to identify pre-service science teachers' existing beliefs about teaching and learning and to utilise those beliefs as stepping stones to help them become effective science teachers.

Becoming a science teacher in Thailand now is more difficult than in the past. Since 2003, a teaching career has been officially accepted as a highly qualified profession according to Section 43 of the Teacher and Educational Personnel Act B.E. 2546 (Secretariat of the Cabinet, 2003). A prospective science teacher must be completely qualified with knowledge, professional experience, and ethics standards. Only a qualified person has the right to obtain a teacher professional licence (TPL), which allows him or her to legally teach in public schools. According to the Regulations of Teacher Professional Licence B.E. 2547 (National Teacher Council, 2004), prospective science teachers are required to have at least one-year experience in school. This requirement obliges teacher education agencies nationwide to revise their teacher programmes by extending student teaching from one semester to two semesters, which leads to the extension of teacher education from four to five years.

The occurrence of standard-based science teacher preparation programmes is an interesting phenomenon. However, a study of the impact of such programmes on prospective science teachers' beliefs about teaching and learning science is still limited. The central focuses of this study were to explore pre-service science teachers' beliefs about teaching and learning, which were revealed through their metaphors, and to study the impact of one semester's participation in the standard-based programme on their metaphor modifications.



## Theoretical Underpinnings

### *Beliefs about Teaching and Learning*

Beliefs are regarded as psychological constructs, including understanding, assumptions, images, or propositions a person feels to be true (Green, 1971; Kagan, 1992; Richardson, 1996) and that have a significant relation to personal, episodic, and emotional experiences (Nespor, 1987). Importantly, beliefs function as a filter that a person uses to interpret derived experience and to guide decision-making and subsequent action (Pajares, 1992).

Whether consciously or not, pre-service teachers bring a variety of beliefs with them into their teacher education. These beliefs have developed as a result of personal experiences both in and out of school (Kagan, 1992; Nespor, 1987). In particular, beliefs about teaching and learning can be classified according to extant studies into two major groups, that is, teacher-centred and student-centred. The

main characteristic of teacher-centred beliefs is knowledge transmission; a teacher delivers content to students through lectures, and students memorise that content. In contrast, student-centred beliefs emphasise knowledge construction; a teacher manages the appropriate learning environment and students construct their own knowledge. The proportion of teacher-centred and student-centred beliefs held by teachers are diverse according to context (Hancock & Gallard, 2004; Levitt, 2001; Tsai, 2002; Van Driel, Bulte, & Verloop, 2007; Weber & Mitchell, 1996).

Throughout teacher education, some teaching and learning beliefs held by pre-service teachers may be challenged and modified, whereas others may be left untouched. Science teacher educators are responsible for eliciting pre-service teachers' teaching and learning beliefs and utilising such beliefs as starting points for further professional development. However, eliciting pre-service teachers' beliefs is difficult due to the nested nature of beliefs.



### *Nested Nature of Beliefs*

Beliefs are complex and are nested within belief systems. Each belief system may consist of several belief clusters (Green, 1971). People tend to order their beliefs into clusters. Teachers, for example, may cluster general education with domain-specific beliefs (Van Driel et al., 2007). Green (1971) asserted that one person's belief clusters are, more or less, isolated from those of others. Unlike knowledge systems, belief systems do not require a general consensus. Some teachers may apparently hold conflicting belief clusters within the same belief system or combine beliefs from different clusters to form their belief systems. Many teachers seize both teacher-centred and student-centred beliefs and utilise them in different teaching situations (Gipps & McCallum, 1999; Van Driel et al., 2007).

Bryan (2003) illustrated the nestedness of Barbara's belief systems and its influences on her classroom practice. Barbara held two incompatible nests of teaching beliefs: Nest A included didactic, teacher-centred beliefs, whereas Nest B included conceptual learning-centred beliefs. Her classroom practice was predominantly guided by Nest A, yet her vision of practice was largely inspired by Nest B. Barbara's conflict of belief nests led to teacher tensions that could be resolved by gaining more professional experience and striving to reconcile belief discrepancies (Bryan, 2003; Simmons et al., 1999). Resolving a teacher's belief conflict means empowering the teacher (Briscoe, 1991).

The literature suggests metaphor construction as one effective method to unearth the complexity of beliefs about teaching and learning that are deeply rooted and nested in prospective teachers' belief systems. The following section describes the characteristics, importance, and implications of metaphor in teacher education.

### *Metaphors as Root Beliefs about Teaching and Learning*

A metaphor represents a linkage between two dissimilar ideas (concrete and abstract) or the projection of one schema (a source domain of the metaphor) onto

another schema (a target domain of the metaphor) (Lakoff & Johnson, 1980). The metaphor acts as a lens or a filter through which something is viewed, and it becomes a mental model for thinking about it in light of something else (Saban, Kocbeker, & Saban, 2007). People tend to understand their world through metaphors, which relate complex phenomena to something previously experienced. As Lakoff and Johnson (1980) stated, people seek out their personal metaphors to 'make coherent our own pasts, our present activities, and our dreams, hopes, and goals as well. A large part of self-understanding is the search for appropriate metaphors that make sense of our lives' (p. 233).

Metaphors convey richness of meanings, for example, mood, control, roles, attitudes, and beliefs that are deeply rooted in individual minds (Gurney, 1995). People sometimes hold on to metaphors, which lie beneath the surface of awareness, and use them as a frame to define experience (Hardcastle, Yamamoto, Parkay, & Chan, 1985). Accordingly, an examination of an individual's metaphors can reveal his or her tacit beliefs, mental models, cultures, and inner worldviews which literal language cannot articulate (Gurney, 1995; Moser, 2000). As Abusson and Webb (1992) found, elementary teachers verbally described their teaching and learning beliefs as student-centred, but the vast majority of their teaching metaphors were teacher-centred. Interestingly, there were only a few teachers who recognised the inconsistency of their beliefs expressed through literal language and metaphor.

Metaphors are a powerful cognitive tool for gaining holistic insights into student teachers' professional thinking (Saban et al., 2007; Tobin & Tippins, 1996). Requiring student teachers to construct teaching metaphors may help them to reveal their root beliefs about teaching and learning, to recognise the relationship between them, and to understand their complexity (Leavy, McSorley, & Bote, 2007).

Written metaphors alone may not be sufficient to understand such complex constructs as beliefs. The use of metaphor drawing can fulfil the belief elicitation task because it can express a drawer's elusive, ineffable beliefs, and their contradictions (Weber & Mitchell, 1996). It can also track the drawer's belief modifications (Hancock & Gallard, 2004). Teacher educators can ask pre-service teachers either to choose metaphor drawings from a list (see Ben-Peretz, Mendelson, & Kron, 2003) or to freely draw their own metaphors (see Weber & Mitchell, 1996).

### *Modifications of Beliefs about Teaching and Learning*

Pre-service teachers enter teacher preparation programmes with their own nest of well-established beliefs about teaching and learning that are firm and resistant to change (Abusson & Webb, 1992; Joram & Gabriele, 1998; Weinstein, 1990; Zeichner & Gore, 1990). Pajares (1992) asserted that 'teachers' beliefs generally are not easy to change, even when, based on opposing evidence, it is logical or necessary for them to do so' (p. 317). To change belief systems requires a 'conversion or gestalt shift' rather than sound reasoning (Nespor, 1987, p. 321). Changing teachers' beliefs appears to be a difficult task for teacher educators. In this case, the word 'modification' may be a more appropriate description than 'change'.

Beliefs may vary according to their ease of modification. Within a specific belief system, some beliefs may be more central than others; the more central the belief, the more difficult to modify (Rokeach, 1968). The beliefs guiding practice are also hard to modify because they are developed over a lifetime of experiences both in and out of school. In Briscoe's (1991) case study, Brad accepted the metaphor of a teacher as a giver of information for over 40 years and stated, 'it is a hard thing to let go of' (p. 196). Also, when a particular belief cluster changes, it may impact others. For example, changing teachers' beliefs about teaching and learning science may be a prerequisite for changing their beliefs about science, or vice versa (Tsai, 2002).

There were several attempts to modify pre-service teachers' beliefs about teaching and learning that took place in various characteristics and settings such as an educational psychology course (Joram & Gabriele, 1998), an introductory education course (Weinstein, 1990), a methods course and student teaching (Hancock & Gallard, 2004; Uzuntiryaki, Boz, Kirbulut, & Bektas, 2010), an intervention project (Meirink, Meijer, Verloop, & Bergen, 2009), an intervention programme (McDevitt, Heikkinen, Alcorn, Ambrosio, & Gardner, 1993), a teacher preparation programme (Abusson & Webb, 1992), and throughout the career span (Ng, Nicholas, & Williams, 2010).

Those studies asserted that beliefs about teaching and learning are, to some extent, stable and resistant to change. There were two possible directions of belief modification, from teacher-centred to student-centred beliefs, or vice versa (Hancock & Gallard, 2004; Weinstein, 1990). The basic principles to facilitate teachers to modify their beliefs include the following: (1) making teachers' beliefs explicit and taking them into account when designing intervention (Joram & Gabriele, 1998); (2) awakening teachers to be aware of their traditional beliefs, to consider and value alternative beliefs, and to project themselves into those beliefs (Briscoe, 1991); (3) requiring teachers to immerse in a student-centred learning environment (McDevitt et al., 1993; Uzuntiryaki et al., 2010); (4) diminishing false feedback and encouraging critical reflection and corrective feedback concerning classroom observations of self and others (Joram & Gabriele, 1998); (5) collaborative working with peers in exchanging teaching methods and experiences, experimenting and evaluating alternative pedagogical strategies (Meirink et al., 2009); and (6) providing direct classroom experiences to bring about a new understanding of teaching, learning, and students (Alger, 2009).

### *Teacher Beliefs and Classroom Practice*

Beliefs are mental constructions of experience that potentially guide a person's intentions for action (Hancock & Gallard, 2004) and drive his or her behaviour (Richardson, 1996; Sigel, 1985). Accordingly, beliefs are accepted as the most important determinant of human behaviour (Brown & Cooney, 1982). Human beliefs and behaviour possibly interact in an ongoing way and change in a reciprocal way (Guskey, 1986; Levitt, 2001). Nespor (1987), Samuelowicz and Bain (2001),

Bryan (2003), and Levitt (2001) supported the linkage between teachers' beliefs and classroom practice. That is, beliefs about teaching and learning strongly influence teachers when they interpret pedagogical knowledge, organise and conceptualise pedagogical tasks, and finally enact their pedagogical decisions.

Similarly, several studies (Briscoe, 1991; Buaraphan, 2007; Hardcastle et al., 1985; Martinez, Sauleda, & Huber, 2001) reported the relationship between teachers' metaphors and classroom practice. Metaphors exert powerful influences on teachers in their planning and thinking about teaching and learning. They also affect the way that teachers instruct in multiple environments. Thus, metaphors incompatible with the reform movement can impede the functioning of teachers in line with the reform. That is, teachers who view their roles as a giver of knowledge cannot function consistently with reform emphasising students to take the responsibility for their own learning (Briscoe, 1991).

Some studies, however, argued that the relationships between teachers' beliefs or metaphors and classroom behaviour were not clear-cut. Mellado, Bermejo, Blanco, and Ruiz (2007), Simmons et al. (1999), and Uzuntiryaki et al. (2010) found that many teachers held student-centred beliefs but enacted the teacher-centred pedagogy with little pupil participation. Lederman (1992) suggested that situational factors possibly interfered with teachers when they tried to transfer their teaching and learning beliefs into classroom practice. School and classroom cultures and curriculum could influence teachers, especially novice teachers, when they made pedagogical decisions and judgements (Briscoe, 1991; Mellado et al., 2007; Munby, Cunnigham, & Lock, 2000; Tobin & Tippins, 1996). Some teachers came into their classrooms with student-centred beliefs, but the reality of the school and classroom environment compelled them to use teacher-centred approaches, which were effective for classroom control and congruent with school norms (Briscoe, 1991). The amount of work required by the national curriculum and tests additionally influenced teachers to utilise a transmission mode more frequently (Gipps & McCallum, 1999).

Teachers' beliefs are widely regarded as a determinant of teachers' classroom behaviour and a factor for promoting the translation of innovative ideas into practice (Waters-Adams, 2006). Accordingly, identifying pre-service teachers' beliefs about teaching and learning potentially lead teacher educators to understand how and why they teach (Nespor, 1987). Importantly, helping pre-service teachers to cultivate teaching and learning beliefs in line with the reform movement may contribute to the success of the reform.

### *Standard-Based Science Teacher Preparation Programme*

Thailand lies at the heart of Southeast Asia and has a population of approximately 65 million. According to the Basic Education Curriculum B.E. 2544 (Ministry of Education, 2001), basic education in Thailand includes 12 years of study that are divided into four major levels: Level 1 (Grades 1–3), Level 2 (Grades 4–6), Level 3 (Grades 7–9), and Level 4 (Grades 10–12). Teacher education in Thailand was

officially established in 1892. Subsequently, a number of teacher education institutes were expanded to meet an urgent demand for teachers. However, this effort was concentrated on the quantity rather than the quality of teachers. At the present time, there is wide concern for the quality of teachers and teacher education.

In 2003, the Thai government proclaimed the Teacher and Educational Personnel Act B.E. 2546 (Secretariat of the Cabinet, 2003). 'Teaching' is officially stated in the Section 43 of the Act as a 'highly-qualified profession'. To be a teacher in basic education means to be fully qualified in accordance with the knowledge, professional experience, and ethics standards consisting of language and technology, curriculum development, teaching, psychology, measurement and evaluation, classroom management, educational research, educational technology and innovation, and teacher conduct standards. Only a qualified person has the right to hold a TPL, which legally allows him or her to be a teacher in public schools. The process of delivering, holding, and maintaining the teacher licence was subsequently proclaimed in 2004 by the Regulations of Teacher Professional Licence B.E. 2547 (National Teacher Council, 2004).

The Act and Regulations are bringing about many significant changes in Thai teacher education. Teacher preparation agencies nationwide have revised their programmes to ensure that all prospective teachers are completely qualified according to the standards and requirements. Regarding the school experience requirement, each prospective teacher must complete at least one year (360 hours) of experience in school that partially includes at least 210 hours of experience in classroom teaching. To serve this requirement, science teacher preparation programmes have extended student teaching from one semester to two semesters, and this has subsequently led to the extension of teacher education from four to five years. In general, during the first four years, pre-service teachers are required to take courses in science, education, and teaching methods and to gain experiences in classroom observation and participation. In the final year, they must perform student teaching in schools. Additionally, they must select specific problems faced in the first semester and conduct classroom action research to solve these problems in the second semester.



## The Study

### *The Setting*

This study was conducted in the first semester of the 2008 academic year at a university located in the centre of Thailand. The institution is a large, well-known university that was established in 1904. This university is one of several institutions that initiated the standard-based teacher preparation programme in 2008. There are four study majors relating to science teacher education: biology, chemistry, physics, and general science. For graduation, pre-service science teachers require at least 164 total credits: general education (30 credits), teaching profession (51 credits), specific courses (77 credits), and free elective (six credits).

*The First Phase of the Study*

The study was divided into two main phases. The first phase was conducted at the beginning of the first semester of 2008 academic year. The purposes of this phase were as follows: (1) to explore the participants' metaphors that used to describe their beliefs about teaching and learning science; and (2) to reveal the possible relationships between the participants' metaphors and their class level, gender, and study major. The participants were 110 pre-service science teachers, who were asked to complete a metaphor construction task (MCT), shown in the Appendix.

The MCT incorporates a metaphor drawing task (see Weber & Mitchell, 1996) and a written metaphor task (see Leavy et al., 2007) to strengthen the belief elicitation task. A number of extant studies (e.g., BouJaoude, 2000; Leavy et al., 2007; Martinez et al., 2001; Massengill, Barry, & Mahilos, 2008; Massengill, Mahilos, & Barry, 2005; Saban et al., 2007; Weber & Mitchell, 1996) have reported validity and effectiveness of both tasks in exploring respondents' beliefs about teaching and learning. The pilot tests were conducted with 10 undergraduate student teachers, 12 graduate student teachers, and 11 science teachers who attended the courses and workshop taught by the author. Participants took approximately 45 minutes to complete the MCT. The interviews conducted after the completion of the MCT revealed a correspondence between these respondents' written and drawn metaphors and their verbal explanations. These results presented the clarity and validity of the MCT in exploring respondents' beliefs about teaching and learning science.

Thirty participants, who volunteered to further participate in the second phase of the study, were interviewed in order to explore their belief metaphors in depth. The interview questions aimed to clarify the ambiguities that existed in the MCT. The guiding questions were: 'Which part in your metaphor or drawing represents teachers (or learners or the teaching-learning process)? Why?' and 'Do you have anything else to clarify or add in your metaphor?' The data from the interviews were significant for helping to track the volunteers' metaphor changes.

In data analysis, each metaphor was considered for its validity. The invalid metaphors were those that: (1) provided plain description without mention of a metaphor; (2) mentioned a metaphor without provision of its rationale; (3) were unclear and difficult to place under specific clear category; and (4) were idiosyncratic (Saban et al., 2007). The invalid metaphors would have been eliminated from the pool of metaphors; however, all metaphors constructed by the participants in this study were valid. This confirmed the clarity of the MCT. In addition, individuals' drawings and written responses were compared and judged by their correspondence. In this study, there was no mismatch between the participants' drawings and their written responses. After that, 10 metaphor categories proposed by Saban et al. (2007) were utilised for the framework of coding. Each metaphor was constantly read and coded into a metaphor category. The coding process led to the modification of extant metaphor categories shown in Table 1.

The modifications included: (1) changing Code 4.02 ship captain to captain/driver; (2) adding cookbook and glass into Codes 1.08 and 1.11, respectively; and

Table 1. Metaphor categories of teaching and learning science

| Category | Metaphor | Teaching and learning |
|---|---|---|
| 1. Teacher as knowledge provider (student as passive recipient of knowledge) | 1.01 Sun, 1.02 Candle, 1.03 Tree/Fruit tree, 1.04 Light, 1.05 Flower, 1.06 Computer user, 1.07 Television, 1.08 Book/ Cookbook, 1.09 Pen, 1.10 Spring, 1.11 Jug/Glass, 1.12 Fountain, 1.13 Rain, 1.14 Writer/Poet, 1.15 Shopkeeper, 1.16 Buddha, 1.17 Sky, 1.18 Wind, 1.19 Food, 1.20 Cook | • Teaching is transmission of knowledge from teacher to students.<br>• Learning occurs when students accumulate knowledge transmitted from teacher. |
| 2. Teacher as moulder/ craftsperson (student as raw materials) | 2.01 Sculptor, 2.02 Painter, 2.03 Constructor, 2.04 Baker, 2.05 Potter, 2.06 Honeybee, 2.07 Cook, 2.08 Jeweller, 2.09 Tailor, 2.10 Carpenter, 2.11 Architect, 2.12 Miner, 2.13 Weaver, 2.14 Ironworker, 2.15 Contractor, 2.16 Technician, 2.17 Mill, 2.18 Factory, 2.19 Garland maker | • Teaching is producing students as socially useful products.<br>• Learning occurs when students change as teachers intended. |
| 3. Teacher as curer/ repairer (student as defective individual) | 3.01 Doctor, 3.02 Medicine, 3.03 Mechanic | • Teaching is diagnosing and fixing students' errors or deficiencies.<br>• Learning occurs when students' errors or deficiencies are fixed. |
| 4. Teacher as superior authoritative figure (student as absolute compliant) | 4.01 Shepherd, 4.02 Captain/ Driver, 4.03 Locomotive, 4.04 Brain, 4.05 Vehicle, 4.06 Life, 4.07 Earth, 4.08 Rod, 4.09 Chef, 4.10 Container | • Teaching is totally controlled by teacher.<br>• Learning occurs when students follow instruction. |
| 5. Teacher as change agent (student as object of change) | 5.01 Fashion designer, 5.02 Scriptwriter, 5.03 Laundryman | • Teaching is changing students' lives for society's future.<br>• Learning occurs when students are transformed as envisions. |
| 6. Teacher as entertainer (student as conscious observant) | 6.01 Actor/Actress, 6.02 Stand-up comedian, 6.03 Magician, 6.04 Sportsman | • Teaching is acting for fun and to break down students' affective domain barriers.<br>• Learning occurs when students have fun, pay attention, and participate in activities. |
| 7. Teacher as counsellor (student as significant other) | 7.01 Parent, 7.02 Friend, 7.03 Psychologist, 7.04 Companion | • Teaching is advising students to be emotional and psychological well-beings.<br>• Learning occurs when students take advantage from advice. |

Table 1. (*Continued*)

| Category | Metaphor | Teaching and learning |
|---|---|---|
| 8. Teacher as nurturer/ cultivator (student as developing organism) | 8.01 Gardener, 8.02 Farmer, 8.03 Soil, 8.04 Chameleon, 8.05 Parent | • Teaching is nourishing student potential capabilities within caring environment.<br>• Learning occurs when students develop in their own paces. |
| 9. Teacher as facilitator/scaffolder (student as constructor of knowledge) | 9.01 Compass, 9.02 Lighthouse, 9.03 North star, 9.04 Flashlight, 9.05 Traffic signs, 9.06 Taxi driver, 9.07 Road map, 9.08 Torch, 9.09 Bridge, 9.10 Ladder, 9.11 Oil | • Teaching is scaffolding student.<br>• Learning occurs when students construct their own knowledge. |
| 10. Teacher as cooperative/ democratic (student as active participant in community of practice) | 10.01 Tour guide, 10.02 Coach, 10.03 Conductor, 10.04 Co-actor/Co-actress | • Teaching is coordinating learning activities in classroom.<br>• Learning occurs when teacher and students collaborate in construction of knowledge together. |



(3) adding the emerging metaphors of 1.16 Buddha, 1.17 sky, 1.18 wind, 1.19 food, 1.20 cook, 2.18 factory, 2.19 garland maker, 4.05 vehicle, 4.06 life, 4.07 earth, 4.08 rod, 4.09 chef, 4.10 container, 5.03 laundryman, 6.03 magician, 6.04 sportsman, 8.05 parent, 9.11 oil, and 10.04 co-actor/co-actress. It must be noted that similar code names could appear in different metaphor categories, such as 'parent', which appeared in Codes 7.01 and 8.05 and 'cook', which appeared in Codes 1.20 and 2.07. This situation occurred because in these instances, they expressed different teaching and learning beliefs. For example, a teacher as 'parent' metaphor in the teacher as counsellor category (Code 7.01) emphasises the major role of a parent (teacher) in providing advice to his or her child (student). However, a teacher as 'parent' metaphor in the teacher as nurturer/cultivator category (Code 8.05) emphasises the major role of a parent in raising essential capabilities in a child within a caring environment.

Three science educators, who graduated with PhDs in science education and were fluent in both Thai and English languages, were asked to independently code all metaphors into the modified categories. The experts were informed that they could assign an individual metaphor into only one category and could not leave any metaphor out. After coding was completed, the experts considered the language issue, regarding both the translation from Thai to English and vice versa. The meeting was conducted with all of the experts to resolve any disagreements according to coding and language. Finally, the inter-rater reliability of metaphor coding was established by using the Miles and Huberman (1994) formula, for example,

Reliability = Agreement/(Agreement + Disagreement). The inter-rater reliability of metaphor coding in this phase was 0.95. Miles and Huberman suggested that inter-coder agreement in qualitative data analysis should approach or exceed 0.90. The frequencies and percentages of the metaphors in each category were counted and calculated, respectively. Finally, the frequencies of those metaphors were compared across the participants' gender, class level, and study major.

### *The Second Phase of the Study*

The second phase was conducted at the end of the first semester of the 2008 academic year. The main purpose of this phase was to track how, and to what extent, the volunteers changed their metaphors after one semester's participation in the standard-based programme. The volunteers were requested to complete the MCT and to participate in individual interviews with the same set of questions mentioned earlier.

The procedure from the first phase was employed to analyse the metaphors in the second phase. The inter-rater reliability (Miles & Huberman, 1994) established by three experts in the second phase was 0.92. The frequencies and percentages of the metaphors in each category were counted and calculated, respectively. Also, the metaphors constructed by each participant at the beginning and at the end of the semester were compared, and the changes were classified into four main characteristics. That is, when the participant retained the same metaphor, metaphor category, and metaphor description, he or she was categorised as 'no change'. 'Minor change' meant that the participant held the same metaphor and metaphor category but changed their metaphor description. 'Moderate change' meant that the participant changed his or her metaphor and metaphor description, but they were coded in the same metaphor category. When the participant changed his or her metaphor, metaphor category, and metaphor description, he or she was, then, characterised as 'major change'. In the final stage, the frequency of each characteristic of metaphor change was counted.



## Results and Discussion

### *Results and Discussion Emerging from the First Phase of the Study*

*Background of participants.* There were 110 pre-service science teachers who participated in the first phase. A majority of the participants (82.73%) were female. The participants' ages ranged from 18 to 24 years old. Specifically, about one-third of them (34.55%) were 19 years old. The numbers of the participants in the first, second, third, fourth, and fifth years were 28 (25.45%), 17 (15.45%), 22 (20%), 19 (17.17%), and 24 (21.82%), respectively. Nearly half of the participants (43.90%) had studied biology, whereas the remainder had studied chemistry (23.17%), general science (18.29%), and physics (14.63%).

*Metaphors of teaching and learning science.* Table 2 shows 39 metaphors constructed by the participants. The wide range of metaphors indicated the participants' diverse thinking about teachers, teaching, and learning.

The most dominant metaphor that the participants used to describe their belief about teaching and learning science was teacher as gardener (28.18%). The other favourite metaphors were teacher as a candle or as tree/fruit tree (5.45%), and teacher as computer, captain/driver, or tour guide (4.55%). The quotes and figures illustrating these metaphors were as follows:

- Teachers as gardeners as in Figure 1: 'A teacher is like gardener. Students are like trees. The gardener grows trees. He or she helps trees thrive and grow up by watering, fertilising, and soiling.'
- Teachers as lighted candles: 'A teacher is like a lighted candle. Students are like candles without lights. The lighted candle (teacher) gives light (knowledge) to the candles without light (students). As a result, students can see things in the candle light, representing the fact that they have learned something.'
- Teachers as tree/fruit trees: 'A teacher is like a big tree. Students are like people under the tree. The big tree (teacher) gives people shade, allowing the people to take a rest and live. The tree also provides some food for survival.'
- Teachers as computer users: 'A teacher is like a computer user. Students are like a monitor. The computer user (teacher) presses a keyboard to put the information

Table 2. Metaphors of teaching and learning science ($n$ = 110)

| Metaphor | *f* | % | Metaphor | *f* | % |
|---|---|---|---|---|---|
| 1.01 Sun | 3 | 2.73 | 4.07 Earth | 2 | 1.82 |
| 1.02 Candle | 6 | 5.45 | 4.08 Rod | 1 | 0.91 |
| 1.03 Tree/Fruit tree | 6 | 5.45 | 4.09 Chef | 1 | 0.91 |
| 1.04 Light | 1 | 0.91 | 4.10 Container | 1 | 0.91 |
| 1.06 Computer | 5 | 4.55 | 5.03 Laundryman | 1 | 0.91 |
| 1.08 Book/Cookbook | 4 | 3.64 | 6.01 Actor/Actress | 1 | 0.91 |
| 1.11 Jug/Glass | 2 | 1.82 | 6.02 Stand-up comedian | 1 | 0.91 |
| 1.16 Buddha | 2 | 1.82 | 6.03 Magician | 1 | 0.91 |
| 1.17 Sky | 1 | 0.91 | 6.04 Sportsman | 1 | 0.91 |
| 1.18 Wind | 1 | 0.91 | 7.01 Parent | 1 | 0.91 |
| 1.19 Food | 1 | 0.91 | 8.01 Gardener | 31 | 28.18 |
| 2.03 Constructor | 4 | 3.64 | 8.02 Farmer | 4 | 3.64 |
| 2.07 Cook | 1 | 0.91 | 8.05 Parent | 2 | 1.82 |
| 2.08 Jeweller | 1 | 0.91 | 9.07 Road map | 1 | 0.91 |
| 2.11 Architect | 1 | 0.91 | 9.08 Torch | 2 | 1.82 |
| 2.18 Factory | 2 | 1.82 | 9.11 Oil | 1 | 0.91 |
| 2.19 Garland maker | 1 | 0.91 | 10.01 Tour guide | 5 | 4.55 |
| 4.02 Captain/Driver | 5 | 4.55 | 10.02 Coach | 3 | 2.73 |
| 4.05 Vehicle | 1 | 0.91 | 10.04 Co-actor/Co-actress | 1 | 0.91 |
| 4.06 Life | 1 | 0.91 | | | |

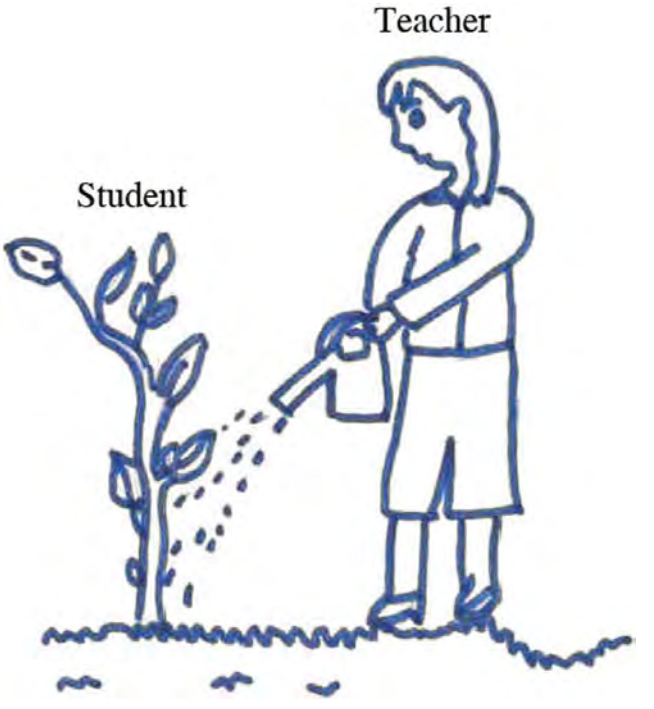


Figure 1. Teachers as a gardener

in or chooses the software to operate according to his or her purpose. The monitor (students) expresses outputs of those operations.'

- Teachers as a captain/driver: 'A teacher is like a driver. Students are like passengers. The driver (teacher) controls the vehicle, such as a bus, ship, or airplane, and brings all of the passengers (students) to the destination (objective of the lesson). The selection of the vehicle depends on characteristics of the destination.'
- Teachers as tour guides, as in Figure 2: 'A teacher is like a tour guide. Students are like a tour group. The tour guide (teacher) and the tour group (students) have the same destination and travel together. The tour guide holds a map. Both the tour guide (teacher) and the tour group must, together, manage the journey or solve the problem encountered along the path to the destination.'

Thai people generally view education as growth. They frequently regard the teacher as a gardener and students as plants. A gardener (teacher) grows plants (students) and keeps maintaining them until they yield products such as fruits or flowers (learn and have better lives). These products that emerge reveal the success of education. Hence, it is not surprising that the teacher as a gardener was dominantly presented in this study.

Some favourite metaphors presented in this study, for example, teacher as a lighted candle, as light, or as constructor, are also popular in the Thai context. Surprisingly, no one mentioned the teacher as a hired boat metaphor, which has been popular for

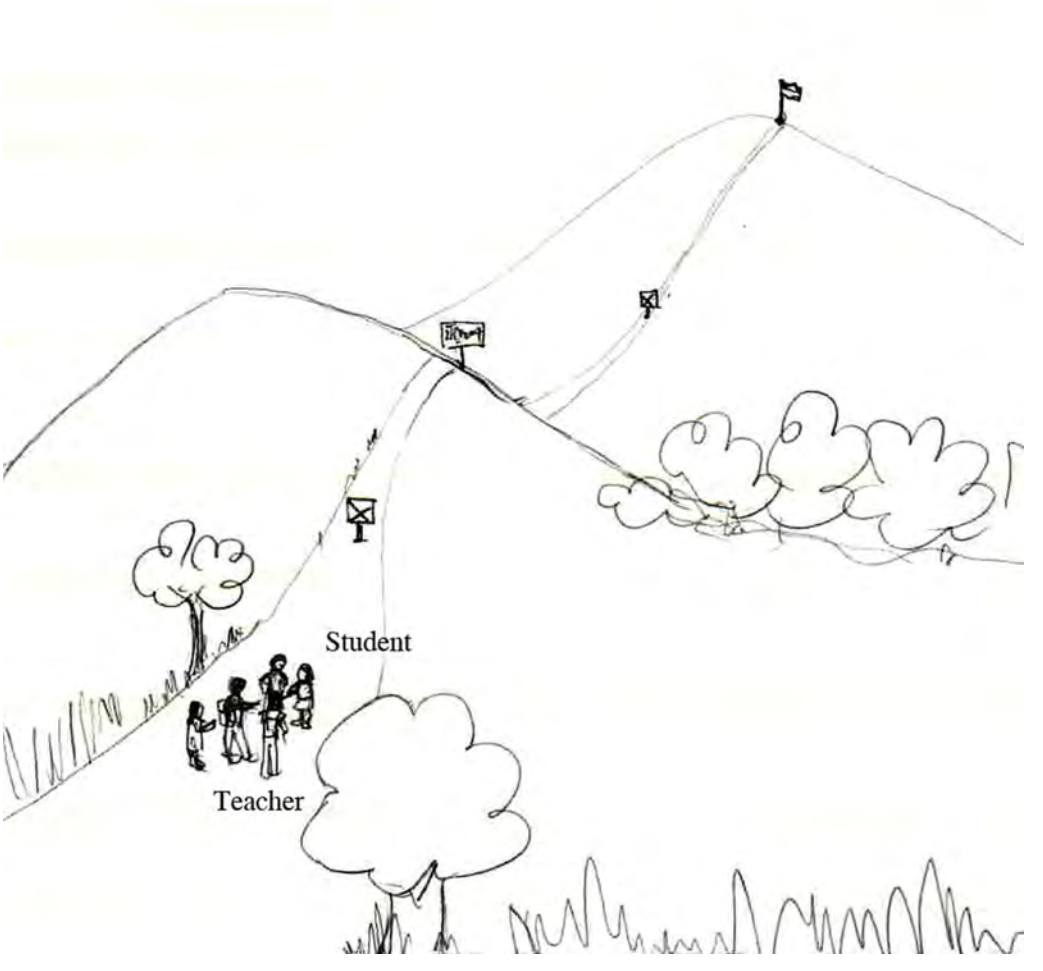


Figure 2. Teachers as a tour guide



Thai people for a long time: 'A teacher is like a boatman. Students are like the passengers. The boatman (teacher) rows and tries to deliver all passengers (students) from one shore (not learned) to the other (learned)' (see Moutbumrung, 2003; Prawichai, 2005; Roydapan, 2000). The explanation may be that, presently, Thai people, especially teachers and educators, have sparingly viewed the teacher as a hired boat metaphor because it tends to negatively present a teacher as a person who just teaches for money (be hired) and whose main duty is to make the student graduate (deliver passengers to another shore). When the student graduates (reaches the shore), the teacher–student relationship is finished.

Two new metaphors that emerged from this study, the Buddha and the garland maker, are culturally influenced metaphors. That is, a majority of Thais are Buddhists, who pray to, and pay highest respect to, Buddha. Similarly, teachers are highly respected in Thai society. Also, some participants viewed teachers as helping

students to live better lives, as Buddha did: 'The Buddha himself thinks, observes, and practices. He succeeds and can pass on his knowledge,' 'teachers are like Buddha who disseminates his knowledge and enlightens Buddhists (students) to the nirvana (knowing).' In the case of the garland maker metaphor, a garland is highly valued in Thai culture. It can be used to pray to the Buddha, monks, parents, and teachers, and is involved in several important ceremonies, such as the wedding ceremony. Thais value teachers highly in the role of garland maker, for example, a person who makes better lives for students is like a garland maker who 'designs and chooses appropriate kinds of flowers to make a beautiful garland. The beauty of garland (students) depends strongly on the maker (teachers) and the flowers (teaching)'.

All of the metaphors constructed by the participants could be categorised into nine categories: teachers as nurturers/cultivators (33.64%), as knowledge providers (29.09%), as superior authoritative figures (10.91%), as moulders/craftspersons (9.09%), as cooperative/democratic (8.18%), as facilitators/scaffolders or as entertainers (3.64%), and as change agents or counsellors (0.91%). There was no participant who chose the teacher as a curer/repairer category. This result indicated that the participants did not view students as sick people or broken objects waiting for doctors or experts (teachers) to cure or fix them. This finding differed from Saban et al. (2007), who found that 21 participants (1.8%) constructed three metaphors under the teacher as curer/repairer category. This contradiction may be a result of the different cultural contexts in which the studies took place and the smaller number of participants in this study.

Overall, the three most dominant metaphor categories for the participants were teachers as nurturers/cultivators, as knowledge providers, and as superior authoritative figures. The teacher as a nurturer/cultivator, which was predominantly found in this study, corresponded with results of Massengill et al. (2008). Similarly, 35% of the participants in Ben-Peretz et al. (2003) related the teacher to the caring image.

The teacher as knowledge provider as the second dominant category in this study is also a popular finding in the literature (Leavy et al., 2007; Martinez et al., 2001; Saban et al., 2007). Saban et al. (2007) presented five common metaphors of teacher as knowledge provider, for example, sun, lighted candle, tree/fruit tree, light, and flower. Two of these metaphors, teachers as candles and as tree/fruit trees, were also popular in this study; however, the number of participants who mentioned them (29%) was smaller than in the previously mentioned studies. Since the advent of the learning reform movement in Thailand in 1999, one major responsibility of teacher preparation agencies has been encouraging pre-service teachers to subscribe to and enact student-centred beliefs. This study, surprisingly, revealed that teacher-centred beliefs are still popular for a large number of pre-service science teachers. The long immersion in teacher-centred schooling experiences, particularly before the learning reform era, potentially influences these pre-service teachers to hold teacher-centred beliefs (Leavy et al., 2007).

The teacher as superior authoritative figure was the third metaphor most frequently raised by the participants in this study. This result indicated that these participants tended to accept and emphasise teacher control. This finding is in contrast to that of

Ben-Peretz et al. (2003), who found that teachers tended to reject a view of teaching as judgmental and controlling. In addition, the teacher as entertainer metaphor category was sparingly mentioned in this study. It is assumed that the participants viewed teaching as a serious endeavour, as found by Ben-Peretz et al. (2003).

In addition, the new metaphors that emerged from this study were mostly categorised into two main categories, the superior authoritative figure (vehicle, life, earth, rod, chef, and container) and the knowledge provider category (sky, wind, food, and cook). These emerged metaphors may imply that Thai pre-service science teachers: (1) consider teaching to be a serious endeavour (Ben-Peretz et al., 2003), and (2) have significant immersion in a teacher-centred learning environment (Leavy et al., 2007).

*Relationship between metaphors and gender, class level or study major.* From Table 3, the three most often-mentioned metaphor categories held by males were teachers as nurturers/cultivators (5 of 19), as knowledge providers (4 of 19), and as superior authoritative figures (3 of 19). Females frequently mentioned four main categories, for example, teacher as nurturers/cultivators (32 of 91), as knowledge providers (28 of 91), as moulders/craftspersons or as superior authoritative figures (9 of 91).

The most commonly chosen metaphor category, as can be seen in Table 4, for Year 1 (15 of 28) and Year 4 (7 of 22) students was teachers as nurturer/cultivator, whereas the most dominant category for Year 2 (6 of 17) and Year 5 (7 of 24) was teachers as knowledge providers. Year 3 (6 of 22), however, held the categories of teachers as knowledge providers and as nurturers/cultivators equally.

From Table 5, physics student teachers (4 of 12) most frequently mentioned both teachers as knowledge providers and as nurturers/cultivators. The dominant metaphor categories for chemistry (5 of 19), biology (13 of 36), and general science (6 of 15) student teachers were the teachers as superior authoritative figures, as nurturers/cultivators, and as knowledge providers, respectively.

Tables 3–5 show some differences in frequencies of metaphors considered by participants of various genders, class levels, and study majors. Table 4, for example,

Table 3. Gender and metaphor categories of teaching and learning science ($n$ = 110)

| | Male | | Female | |
|---|---|---|---|---|
| Metaphor category | *f* | % | *f* | % |
| 1. Knowledge provider | 4 | 3.64 | 28 | 25.45 |
| 2. Moulder/craftsperson | 1 | 0.91 | 9 | 8.18 |
| 4. Superior authoritative figure | 3 | 2.73 | 9 | 8.18 |
| 5. Change agent | 0 | 0.00 | 1 | 0.91 |
| 6. Entertainer | 2 | 1.82 | 2 | 1.82 |
| 7. Counsellor | 0 | 0.00 | 1 | 0.91 |
| 8. Nurturer/cultivator | 5 | 4.55 | 32 | 29.09 |
| 9. Facilitator/scaffolder | 2 | 1.82 | 2 | 1.82 |
| 10. Cooperative/democratic | 2 | 1.82 | 7 | 6.36 |
| Total | 19 | 17.27 | 91 | 82.73 |

Table 4. Class level and metaphor categories of teaching and learning science ($n$ = 110)

| Metaphor category | Year 1 | | Year 2 | | Year 3 | | Year 4 | | Year 5 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *f* | % | *f* | % | *f* | % | *f* | % | *f* | % |
| 1. Knowledge provider | 9 | 8.18 | 6 | 5.45 | 6 | 5.45 | 4 | 3.64 | 7 | 6.35 |
| 2. Moulder/craftsperson | 1 | 0.91 | 1 | 0.91 | 1 | 0.91 | 2 | 1.82 | 5 | 4.55 |
| 4. Superior authoritative figure | 0 | 0.00 | 4 | 3.64 | 3 | 2.73 | 2 | 1.82 | 3 | 2.73 |
| 5. Change agent | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 1 | 0.91 | 0 | 0.00 |
| 6. Entertainer | 3 | 2.73 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 1 | 0.91 |
| 7. Counsellor | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 1 | 0.91 | 0 | 0.00 |
| 8. Nurturer/cultivator | 15 | 13.63 | 4 | 3.64 | 6 | 5.45 | 7 | 6.35 | 5 | 4.55 |
| 9. Facilitator/scaffolder | 0 | 0.00 | 1 | 0.91 | 2 | 1.82 | 1 | 0.91 | 0 | 0.00 |
| 10. Cooperative/democratic | 0 | 0.00 | 1 | 0.91 | 4 | 3.64 | 1 | 0.91 | 3 | 2.73 |
| Total | 28 | 25.45 | 17 | 15.46 | 22 | 20.00 | 19 | 17.27 | 24 | 21.82 |

Table 5. Study major and metaphor categories of teaching and learning science ($n$ = 82)

| Metaphor category | Physics | | Chemistry | | Biology | | General science | |
|---|---|---|---|---|---|---|---|---|
| | *f* | % | *f* | % | *f* | % | *f* | % |
| 1. Knowledge provider | 4 | 4.88 | 4 | 4.88 | 9 | 10.98 | 6 | 7.32 |
| 2. Moulder/craftsperson | 3 | 3.66 | 4 | 4.88 | 1 | 1.22 | 1 | 1.22 |
| 4. Superior authoritative figure | 0 | 0.00 | 5 | 6.10 | 4 | 4.88 | 3 | 3.66 |
| 5. Change agent | 0 | 0.00 | 1 | 1.22 | 0 | 0.00 | 0 | 0.00 |
| 6. Entertainer | 0 | 0.00 | 0 | 0.00 | 1 | 1.22 | 0 | 0.00 |
| 7. Counsellor | 0 | 0.00 | 1 | 1.22 | 0 | 0.00 | 0 | 0.00 |
| 8. Nurturer/cultivator | 4 | 4.88 | 2 | 2.44 | 13 | 15.85 | 3 | 3.66 |
| 9. Facilitator/scaffolder | 1 | 1.22 | 1 | 1.22 | 2 | 2.44 | 0 | 0.00 |
| 10. Cooperative/democratic | 0 | 0.00 | 1 | 1.22 | 6 | 7.32 | 2 | 2.44 |
| Total | 12 | 14.63 | 19 | 23.17 | 36 | 43.90 | 15 | 18.29 |

*Note*. First-year pre-service teachers have not yet selected their study major.

indicates that Year 5 student teachers held the teacher as knowledge provider more than Years 2 and 3 student teachers. The pre-service teachers in a higher class level have a higher level of education, have taken more science courses, and have more classroom experience than those in a lower class level. Thus, the beliefs of the participants in a higher class level were assumed to be closer to student-centred beliefs than those in a lower class level. However, the findings in Table 4 contradicted this assumption. Unfortunately, $\chi^2$ could not be utilised to confirm or discount the relationships between the participants' gender, class level, and study major and their metaphors because the samples in each category were too small. A strong argument regarding the relationships between the pre-service science teachers' metaphors and their class level, gender, and study major was not established in this study.

*Results and Discussion Emerging from the Second Phase of the Study*

*Background of volunteer participants.* A majority of the 30 volunteer participants (76.67%) were female. The number of participants in first, second, third, fourth, and fifth years of study were six (20%), six (20%), five (16.67%), seven (23.33%), and six (20%), respectively. The students studied biology (29.17%), chemistry (20.83%), general science (25%), and physics (25%).

*Change of metaphors of teaching and learning science.* At the beginning of the first semester in the standard-based programme, about a quarter of the volunteers (8 of 30) constructed the teachers as gardeners metaphor to describe their beliefs about teaching and learning science. The other favourite metaphors were teachers as trees/fruit trees (3 of 30), and as the sun or candles or constructors (2 of 30). Similarly, at the end of the first semester, the most popular metaphor for nearly a quarter of the volunteers (7 of 30) was teachers as gardeners. The other favourite metaphors were teachers as trees/fruit trees (5 of 30) and as the sun (4 of 30), as shown in Table 6.

All metaphors constructed by the volunteers were categorised into seven categories. Over the course of the semester, no one chose the metaphors of teachers as curers/repairers, as change agents, or as counsellors. At the beginning of the first semester, the three most dominant metaphor categories were teachers as knowledge providers (11 of 30), as nurturers/cultivators (9 of 30), and as moulders/craftspersons (6 of 30). Similarly, the dominant categories at the end of the semester were teachers as knowledge providers (16 of 30), as nurturers/cultivators (6 of 30), and as moulders/craftspersons or cooperative/democratic (3 of 30).

There was an increased number of metaphors for teachers as knowledge providers (from 11 to 16) and as cooperative/democratic (from one to three). The metaphors

Table 6. Metaphors of teaching and learning science at the beginning and at the end of semester ($n$ = 30)

| Metaphor | Pre[a] | Post[b] | Metaphor | Pre[a] | Post[b] |
|---|---|---|---|---|---|
| 1.01 Sun | 2 | 4 | 2.18 Factory | 1 | 0 |
| 1.02 Candle | 2 | 1 | 2.19 Garland maker | 1 | 0 |
| 1.03 Tree/Fruit tree | 3 | 5 | 4.02 Captain/Driver | 0 | 1 |
| 1.04 Light | 1 | 1 | 4.07 Earth | 1 | 0 |
| 1.06 Computer | 1 | 2 | 6.02 Stand-up comedian | 1 | 0 |
| 1.18 Wind | 1 | 0 | 8.01 Gardener | 8 | 7 |
| 1.19 Food | 1 | 0 | 8.05 Parent | 1 | 0 |
| 1.20 Cook | 0 | 2 | 9.08 Torch | 1 | 1 |
| 2.03 Constructor | 2 | 3 | 10.01 Tour guide | 1 | 2 |
| 2.07 Cook | 1 | 0 | 10.02 Coach | 0 | 1 |
| 2.11 Architect | 1 | 0 | | | |

[a]Metaphor at the beginning of semester.

[b]Metaphor at the end of semester.

for teachers as superior authoritative figures and as facilitators/scaffolders were the same. In contrast, there was a decreased number of metaphors for teachers as moulders/craftspersons and as nurturers/cultivators (from six to three), as well as for teachers as entertainers (from one to zero). These findings contrasted those of Boujaoude (2000), who found that after one year of teacher education, the transmitter-type metaphors held by the prospective science teachers decreased from 66% to 41%. Similarly, Leavy et al. (2007) found minimal evidence of behaviourist metaphors, but a sharp increase in constructivist metaphors.

Table 7 presents metaphors constructed by individual volunteers at the beginning and the end of the semester.

The metaphors of nearly half of the volunteers (14 of 30) were organised into the same categories; 8 out of 14 students held the same metaphors. Three participants did not change their metaphors and descriptions. This finding supported Boujaoude (2000), who found that more than a half of the pre-service science teachers (56%) held on to their belief metaphors throughout a year. Additionally, Massengill et al. (2005) found that four out of five case studies did not change their original metaphors after a year of student teaching. Of the volunteers who changed their metaphor categories, it is significant that nearly half of them (7 of 16) changed from teachers as nurturers/cultivators to teachers as knowledge providers.

In sum, more than a half of the volunteers (16 of 30) expressed a major change in their chosen metaphors, while the others expressed a moderate change (6 of 30), minor change (5 of 30), or no change (3 of 30).

The findings of this study showed that some pre-service science teachers did change their teaching and learning beliefs during their teacher education; however, changing the pre-service teachers' beliefs was a difficult and challenging task. Based

Table 7. Change of metaphors of teaching and learning science by cases ($n$ = 30)

| Case | Pre | Post | Case | Pre | Post |
|---|---|---|---|---|---|
| 1 | 1.02 Candle | 1.02 Candle | 16 | 1.06 Computer | 1.03 Tree/Fruit tree |
| 2 | 1.02 Candle | 1.03 Tree/Fruit tree | 17 | 9.08 Torch | 10.01 Tour guide |
| 3 | 1.01 Sun | 1.01 Sun | 18 | 8.01 Gardener | 1.01 Sun |
| 4 | 2.03 Constructor | 4.02 Captain/Driver | 19 | 8.01 Gardener | 1.06 Computer |
| 5 | 8.01 Gardener | 1.06 Computer | 20 | 10.01 Tour guide | 10.01 Tour guide |
| 6 | 6.02 Stand-up comedian | 2.03 Constructor | 21 | 2.18 Factory | 2.03 Constructor |
| 7 | 8.01 Gardener | 1.03 Tree/Fruit tree | 22 | 8.01 Gardener | 1.03 Tree/Fruit tree |
| 8 | 1.18 Wind | 10.02 Coach | 23 | 1.03 Tree/Fruit tree | 8.01 Gardener |
| 9 | 1.03 Tree/Fruit tree | 1.03 Tree/Fruit tree | 24 | 1.04 Light | 1.20 Cook |
| 10 | 8.01 Gardener | 8.01 Gardener | 25 | 8.01 Gardener | 8.01 Gardener |
| 11 | 2.11 Architect | 8.01 Gardener | 26 | 2.19 Garland maker | 9.08 Torch |
| 12 | 4.07 Earth | 8.01 Gardener | 27 | 2.07 Cook | 8.01 Gardener |
| 13 | 1.19 Food | 8.01 Gardener | 28 | 1.03 Tree/Fruit tree | 1.01 Sun |
| 14 | 1.01 Sun | 1.01 Sun | 29 | 8.01 Gardener | 1.04 Light |
| 15 | 8.05 Parent | 1.20 Cook | 30 | 2.03 Constructor | 2.03 Constructor |

on experiences in the learning reform era, incorporated with one semester in the standard-based programme emphasising student-centred approaches, the number of the pre-service science teachers holding student-centred metaphors should have increased. However, after one semester of participation in the standard-based programme, teacher-centred beliefs were still common for a number of these participants and, unfortunately, tended to increase in popularity. The arrangement of courses in science teacher preparation programmes according to the knowledge, professional experience, and ethics standards in combination with the extension of teacher education from four to five years, which differs from previous programmes, may impact prospective science teachers' attributes to beliefs. Tracking the modification of the prospective science teachers' beliefs throughout such standard-based programmes may provide some guidelines for facilitating a belief modification process.

Several factors may contribute to the endurance of transmission teaching and learning beliefs. The first factor may be a long immersion in teacher-centred schooling experience as discussed earlier. The second factor may be a fact-laden, non-inquiry-oriented teaching with cookbook laboratories, which largely are employed in science courses in teacher education (Gibson & Van Strat, 2000). The third factor may be the school context and culture (Bullough, 1992; Hardcastle et al., 1985) and the self-image of the teaching profession (Ben-Peretz et al., 2003; Stofflett, 1996). The school environment plays a key role in affirming or contradicting teachers' beliefs (Massengill et al., 2005). There are several possible constraints for pre-service teachers when they try to employ student-centred beliefs in their classroom practice, such as a lack of time and classroom control or school norms (Abusson & Webb, 1992). The final factor may be the presence of false feedback and the absence of corrective feedback during classroom observation (Joram & Gabriele, 1998). For example, some pre-service teachers place quality teaching on student motivation and classroom management rather than student learning. This belief is constantly reinforced when these pre-service teachers observe and interpret lessons taught by themselves and others; they are given false feedback that afterwards strengthens their prior belief and prevents them from changing their belief. Closely aligned with the problem of false feedback is the absence of corrective feedback, which comes from teacher educators' inability to visibly point out effective and ineffective features of teaching within a particularly complicated episode of teaching.



## Implications

Metaphors are useful and serve various functions in teacher education, as Saban (2006) summarised. This study shows that metaphor construction, such as the MCT, can act as a powerful research tool to uncover a complexity of beliefs about teaching and learning science implicitly held by pre-service science teachers. Metaphorical thinking is valuable for making better sense of pre-service science teachers' beliefs.

According to constructivism, some prior beliefs that pre-service science teachers bring with them can form obstacles to their teacher education. Metaphor construction can open a communication channel between pre-service teachers and teacher educators regarding learning how to teach science. Requiring pre-service teachers to construct metaphors helps them to examine and become aware of their images of teaching and learning, and to develop their own pedagogical models. Also, metaphors constructed by pre-service teachers at different stages in their teacher education are useful for tracking their belief modification and helping them to become aware of their self-evolved beliefs. Pre-service teachers' self-understanding is helpful for understanding the process of becoming a teacher, as Leavy et al. (2007) stated:

> Teacher education must provide avenues for student teachers to understand the values, attitudes, and beliefs that they bring to pre-service teacher education and then to plot and monitor their own professional growth. Images and metaphors of teaching have the potential to provide the language of practice for student teachers and teacher educators to engage in collaborative dialog to achieve these avenues. (p. 1230)



As Saban (2006) mentioned, metaphors can function as a medium of reflection. This study showed that metaphor construction encouraged the pre-service science teachers to reflect their root beliefs about teaching and learning science. Perceptions about teaching experiences expressed through metaphor are a good source for metacognitive reflection and subsequent action (Ritchie, Aubusson, & Harrison, 2006). Metaphors can assist pre-service science teachers to become reflective practitioners who adapt science curricula to better fit reform visions and student needs (Tobin & Tippins, 1996).

Metaphorical schemas held by pre-service science teachers are sometimes mismatched with the goals of teacher preparation programmes and the learning reform movement. Teaching and learning innovations that conflict with student teachers' beliefs are often met with resistance and doubt (Levitt, 2001). One major responsibility of science teacher educators is to help student teachers' shift their metaphorical schemata to align with the goals of teacher preparation programmes and learning reform. In doing so, science teacher educators should provide ample opportunities for student teachers to critically reflect on, and become aware of, their teaching and learning beliefs, and to evaluate them in the light of the goals of learning reform. Science teacher educators must model exemplary teaching and learning for student teachers, and they must encourage students to believe that those exemplary approaches are practical, plausible, and achievable, at different stages in their lifelong teaching career (Mellado et al., 2007). This process involves student teachers changing their referents or metaphors. The new referents or metaphors allow pre-service teachers to frame problems in different ways and to obtain different alternative solutions (Tobin & LaMaster, 1995). Thus, metaphor modification is significant for pre-service science teachers in re-conceptualising their roles as a science teacher, which subsequently impacts their classroom practice (Massengill et al., 2005; Stofflett, 1996; Tobin & LaMaster, 1995).

This study provides extended metaphor categories of beliefs about teaching and learning science. Science teacher educators can use these categories for further research and to apply effective pedagogy that works productively with such beliefs. Written metaphors, in combination with drawing metaphor such as that used in the MCT, may increase the effectiveness of the science teacher educators' belief elicitation task. Inviting prospective teachers to share their constructed MCT with their peers provides an excellent forum for critical reflection and brings to light the implicit images of the cultural rootedness of teaching and learning.

This study was conducted in a country with a different cultural context than Western countries. Culture may be one important factor needing further investigation to understand prospective teachers' construction of teaching and learning metaphors. The two new metaphors of teaching and learning science that emerged from the present study, the Buddha and the garland maker, may reflect the influence of culture on metaphor construction. The same study conducted in a different cultural context might be useful to broaden metaphor categories and explain cultural influence on metaphor construction.

Hopefully, this study will lead science teacher educators around the world within different cultural contexts to consider the transferability of the findings, and to value the utilisation of an alternative technique, the MCT, as 'a springboard for change' (Saban, 2006, p. 301) in science teacher education for the better preparation of future science teachers.

Although this study has value, it still has limitations. That is, the small sample limits the generalisation of findings as well as the statistical confirmation of a relationship between the metaphors constructed by the participants and their gender, class level, and study major.



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## Appendix. Metaphor Construction Task

Instruction:
In your view, what should teaching and learning science look like? Please construct your own metaphors of teaching and learning science and describe how your metaphor represents teachers, learners, and teaching and learning process.

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In addition, please make drawing to illustrate your metaphors of teaching and learning science.