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Scientific concepts in singing: Do they belong in a student toolbox of learning?

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This article presents part of a five-year Australian study, the purpose of which was to look at learning singing in a pedagogical environment designed using sociocultural theory. The classroom environment was transformed over 5 years in consultation with other staff members and used the reflective journals that students wrote during that time as a way of refining and changing the design. Themes emerging from the journals were analysed to inform changes to the design. One of the main themes to emerge was student reflections about the scientific concepts they were taught and the ways the concepts were introduced. These reflections became the basis for the discussion in this paper. The study demonstrated that the students' acquisition of scientific concepts of singing affected both their singing performance and their ability to learn in a positive way. The study suggests that scientific concepts of singing could become part of the students' toolbox that helps develop their singing by making meaning of what they are experiencing kinaesthetically and aurally while they sing.

Introduction

This article presents part of a five-year Australian study, which aimed to develop and critically evaluate a model of vocal pedagogy influenced by Vygotskian sociocultural theories (Latukefu, 2007, 2009). The study incorporated Vygotskian notions of the zone of proximal development, socially and culturally mediated learning, co-construction of knowledge, self-regulated learning and concept formation. The focus of this paper is on the ways that the application of Vygotsky's (1986) theory of concept formation, and the development of everyday and scientific concepts, can enhance vocal training.

Most people naturally acquire singing or speaking skills and develop some level of understanding of how the voice functions (individual knowledge or 'everyday concepts' in Vygotsky's terms). However, to work professionally as a singer or actor requires vocal training in the same way that an instrumentalist is trained to play the violin or piano. Professionally established notions of how to sing or speak, which are historically developed in a particular culture or society, form the basis for such training and constitute 'scientific concepts' (Vygotsky, 1986).

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Vocal training can be arranged in different ways depending on the pedagogical views of the instructor. According to the sociocultural perspective, scientific concepts cannot be simply assimilated by the learner in a ready-made form. To obtain an individual meaning, they have to undergo development (Vygotsky, 1986). This development has to be carefully orchestrated by the instructor in close connection to the individual characteristics and experiences of the learner.

The theory of concept formation

Vygotsky's theory of concept formation is related to the theoretical view of effective learning as a socially and culturally mediated process. This process brings together the individual experience of the learner and the wealth of the theoretical knowledge accumulated in society (Vygotsky, 1986). '*Spontaneous or everyday concepts* refer to the individual practice; they are the result of spontaneous, empirical 'generalization of everyday personalised experience in the absence of systematic instruction'' (Karpov, 2005, p. 171).In pedagogical literature they are connected to the notion of prior knowledge and are often referred to as experience-based concepts (Otero, 2006). They are rich in personalised experience and well suited to working in a particular context. However, everyday concepts are inextricably tied to a learner's concrete experiences, they are unsystematic and not easily transferable to other experiences. They are hard to define in words and to operate with at will (Vygotsky, 1986). Additionally, they are likely to include misconceptions and are 'often wrong' (Karpov, 2005, p. 171). The types of misconceptions that occur in relation to vocal learning can relate to breathing and support techniques. These misconceptions may lead to throat and tongue tension and lack of breath control, which affect the vocal resonance and stamina of the singer. Shewell (2009) pointed out that in singing there is often a feeling that things are happening from a totally different place than what is scientifically possible.

Scientific concepts represent the body of knowledge that has been built up through scientific research and are also referred to as academic concepts (Ortero, 2006). Scientific concepts are acquired consciously, according to a certain system of formal instruction. They are generalised, systematic and are abstracted from concrete experience, and therefore are easily transferable from one context to another (Vygotsky, 1986). The acquisition of scientific concepts helps to mediate students' thinking and problem solving and restructure their spontaneous concepts (Karpov, 2003). It allows the learners to see spontaneous knowledge in a broader perspective and use it in a voluntary manner. 'The strength of scientific concepts lies in their conscious and deliberate nature' (Vygotsky, 1986, p. 194). Shewell (2009) characterised excellent singing teaching as being able to communicate relevant knowledge and practice of techniques that develop and protect the voice and above all 'a good knowledge of vocal anatomy and the physiological practicalities of the singing voice' (p. 8).

Vygotsky asserted that both scientific and everyday concepts are essential for effective learning. He described the intricate relationship between experience-based and scientific concepts as follows.

> In working its slow way upward, an everyday concept clears a path for the scientific concept and its downward development. It creates a series of structures necessary for

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> the evolution of a concept's more primitive, elementary aspects, which give it body and vitality. Scientific concepts, in turn, supply structures for the upward development of the child's spontaneous concepts toward conscious and deliberate use. Scientific concepts grow downward through spontaneous concepts; spontaneous concepts grow upward through scientific concepts. (Vygotsky, 1986, p. 194).

The interrelation between spontaneous and everyday concepts is part of a broader question of the role of formal instruction in learning. According to the sociocultural approach, effective teaching fosters the interactions between scientific and everyday concepts, which lead to a 'true' concept formation (Daniels, 2001). The role of the teacher in this process is paramount as it is in communication with more experienced members of society that social understanding [scientific concepts] is made available for individual understanding (Daniels, 2001, p. 51). It is the integration of scientific concepts with a student's everyday concepts that helps the vocal learners to achieve competence outside of the studio (Hedegaard, 2007).

Scientific concepts in teaching singing

In relation to vocal pedagogy, scientific concepts are related to the anatomy and physiology of the vocal tract and body, the various body parts that are important for singing, the ways that they work together to achieve good vocal skills and the techniques involved in acquiring the motor skills of singing. These might include breath management (Miller, 1986; Conable, 2000; Chapman, 2006), phonation (Titze, 1995; Watts *et al.*, 2006; Westerman Gregg & Scherer, 2006), resonance and articulation, registration (Mürbe *et al.*, 1999; Kenny & Mitchell, 2006; Oates *et al.*, 2006), acoustical measurements of good singing and what happens physiologically to achieve this (Oates *et al.*, 2006) and ventricular fold abduction and differentiated movement in the vocal apparatus (Estill, 1996; Kayes, 2004; Obert & Chicurel, 2005). Body mapping (Conable, 2000) is another example of using scientific concepts to help singing students become aware of the exact location of muscles, organs or bones that work together to create quality in singing. This awareness has implications later on when combined with the use of imagery in teaching.

There is an ongoing debate on whether, and how, these scientific concepts should be taught to enhance learning singing. Research on motor skill acquisition carried out by Verdolini-Marston and Balota (1994) showed that too much information given to students while trying to master motor skill acquisition can have a detrimental effect. On the other hand, there was a concern that singing students at various tertiary institutions were not being taught scientific concepts of singing (Callaghan, 1998). This continuing debate is still evident in a recent anecdotal observation of one of the authors as follows. In 2009 she attended a music conference in London where she witnessed a discussion amongst singing teachers about whether or not there is any value in introducing scientific concepts to singers. While the majority of teachers agreed that it was necessary for them, as teachers, to know about scientific research, some of the teachers argued that it was not necessary for students to be told this information. Recent literature suggests, that in order to progress the teaching system, the singing profession needs to bring together scientific categories from

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multidisciplinary fields and to develop a common language in order for teaching singing to be improved (Chapman, 2006).

Following Vygotsky's theory of concept formation, it is necessary to introduce scientific concepts to singing students. However, the way the concepts are introduced to the learner is essential. It would not be helpful simply to try and pass the knowledge of scientific concepts to the singing students, as 'direct instruction in concept [formation] is impossible' (Vygotsky, 1987, in Daniels, 2001, p. 54). True concept formation occurs when the teacher encourages interaction between the spontaneous knowledge of the student and scientific concepts (Vygotsky, 1986).

Approach and methodology

The conceptual model of teaching singing underpinned by sociocultural theories was created by employing development research methodology, 'a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings and leading to contextually-sensitive design principles and theories' (Wang & Hannafin, 2005, pp. 6–7).

In 2001 Music and Theatre departments in the Faculty of Creative Arts at an Australian regional university were amalgamated. This meant that teaching singing in the traditional conservatoire model of one-to-one studio lessons was no longer possible. Instead of one-to-one teaching there were now several classes each containing 10–12 students. The classroom environment was transformed and used the reflective journals that students wrote during that time, as a way of refining and changing the design. Also influencing the design was student feedback from teacher surveys conducted every session, focus groups with students and consultation with lecturers from the Education Faculty on aspects pertaining to a sociocultural theoretical framework.

Participants

Three different cohorts each of 35 students took part in the study. All students agreed to allow their journals to be retained and analysed over the three-year degree. The students were aged between 18–24 years and had differing levels of singing skill. Some students had started the degree with previous singing experience and others had no singing experience at all.

The introduction of the scientific concepts

The singing course strove at all times to ensure that there was a constant link between everyday concepts about singing and what was being introduced as a scientific concept through the embodiment of the practice of singing.

Scientific concepts were introduced in teaching singing at first year level in the form of body mapping (Conable, 2000). Most of the students had very little knowledge of anatomy and so class time was spent drawing their bodies on butcher paper and putting in the various body parts that are important for singing. The connections were explicitly

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made to the roles that each of the parts played in singing. This body mapping activity was followed by techniques in release of constriction and differentiated movement in the larynx, breathing and support and vocal resonance (C. L. Reid, 1975; Miller, 1986; Estill, 1996; Kayes, 2004; Bagnall & McCulloch, 2005; Chapman, 2006; Shewell, 2009).

The methods of data collection

Students wrote reflective journals during their three-year degree as part of their study process. These reflections were collected at the end of each session and analysed. Observations from the teacher in class, written up in her own reflective teaching journal, were also a significant source of data collection, which complemented the perceptions of the students.

The reflective journal analysis provided insight into the student's perspective of their own singing development within a social context (Smith, 1995) and, as Denscombe (2003) points out, must be seen 'as a version of things as seen by the writer, filtered through the writer's past experiences, own identity, own aspirations and own personality' (p. 213). The analysis of students' reflections had been successfully used in previous research and the practice of singing. For example, a study of Durrant and Varvarigou (2008) found that reflection was integral to choral conducting students' professional development. The authors also observed that the student reflections gave valuable insight in the development and enhancement of the inclusion of a virtual learning environment in their choral conducting course (Durrant & Varvarigou, 2008).

The reflective journals were an authentic part of the teaching method developed in this study to assist the students to become self-regulated learners in their future development as singers. The students were asked to reflect back upon their learning process and make comments on how their singing was developing.

Data analysis procedures

The student journals were analysed at the end of each session. The journals were read carefully and any entries made by students thought to be relevant to the research were highlighted (Smith, 1995; Braun & Clarke, 2006). The highlighted texts were gathered together under different themes, which were further grouped under umbrella themes. The umbrella themes summarised and captured the quality of the participants' experience of the development of their singing. They were complemented by teacher's observations captured in her notes. The themes then were mapped against the concepts of sociocultural theory such as collaborative construction of learning and multiple perspectives; identity construction and change; reflection; scientific concepts and acquisition of these concepts. This article addresses the theme of scientific concepts and their acquisition by students.

Findings and discussion

It became clear in the analysis of the reflective journals that student reactions to the scientific concepts introduced were a recurring theme. There were 20 sub-themes which included concepts such as airflow/air-pressure, basic terms/understanding/lack of, breath control,

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laryngeal constriction, text books used, voice problems and these were all grouped under the umbrella of scientific concepts. The two sub-themes most frequently mentioned were breath control and laryngeal constriction and these became the basis for the discussion in this paper.

It took time for students to develop an understanding and acquire the introduced concepts as their own. Peer learning and reflection (Latukefu, 2009) were used to encourage a meta-cognitive development in students that would help them develop understanding of the scientific concepts. These concepts were also used by students to develop descriptors of quality about their singing so 'discernment of quality becomes a key aspect of learning' (Sadler, 2008, p. 18).

It was important to be aware of the difference between teaching the skill of singing as such and teaching the scientific concepts of singing; that is, understanding of how the skill operates and develops. When Vygotsky wrote about keeping instruction moving ahead of development he also distinguished between instruction that develops concepts and that which simply trains the child in specialised technical skills:

> This is the major role of instruction in development. This is what distinguishes the instruction of the child from the training of animals. This is also what distinguishes instruction of the child which is directed toward his full development from instruction in specialised, technical skills such as typing or riding a bicycle (Vygotsky, 1987, p. 212).

In relation to singing, it is argued that teaching singing should not be simply a training of the skill but should aim to develop a conceptual understanding of the theoretical basis of singing. This would allow students to guide their own learning in refining their singing techniques. According to Daniels (2007), 'if concept development is to be effective in the formation of scientific concepts, instruction must be designed to foster conscious awareness of conceptual form and structure and thereby allow for individual access and control over acquired scientific concepts' (p. 312).

The students found that body mapping gave them a conscious awareness of parts of their body they would use when singing. This awareness allowed for a greater access and control of the motor skills they were trying to achieve. The comment below, taken from a reflective journal, written after a class on body mapping, is typical:

> I found the concept of the inner working of my body and to actively recognise where they are and what they do to control various parts was an aspect of singing that I had rarely thought of before now. This whole body engagement has put singing in a different perspective for me. I must first understand the whole body and its mechanics so I can be aware of where things are and what they do so I can control them.

Another excerpt from a student reflective journal showed that he found body mapping to be very useful because he was able to transfer the scientific concepts he was learning about his body to other acting subjects:

> The body mapping was useful and immediately transferable because now when given instructions by various teachers, I am much more readily able to visualise what they are asking me to do in relation to what my body is required to do.

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The following section presents two examples of spontaneous concepts which, when linked to scientific concepts, increase students' understanding so that they develop singing consciously and systematically.

Example 1: Breathing

A good example of a spontaneous concept paving the way for the scientific concept is breathing in singing. All singing students know how to breathe, however at an early stage of their singing they may be unaware that this act of breathing can be a controlled action. Voluntary control over breath, in time, leads to more vocal development. As students embed a more systematic and organised way of thinking into something they do unconsciously, the skill transforms into a conscious and controlled concept that can be transferred to other situations or songs. In Vygotsky's words, 'mastering a higher level in the realm of scientific concepts also raises the level of spontaneous concepts. Once the child has achieved consciousness and control in one kind of concept, all of the previously formed concepts are reconstructed accordingly' (Vygotsky, 1986, p. 191–192).

Teaching new scientific concepts needed to be grounded in the corresponding spontaneous concepts from the start. It was important, in the context of the singing class, to remind students that they already knew how to breathe and that they just needed to incorporate different strategies into an action that they were familiar with. Scientific concepts about breathing, in the form of body mapping (Conable, 2000), were introduced to singing students. The students began to understand what it meant to embed these more systematic concepts into an action that they do without thinking.

Some students had already had a variety of previous learning singing experiences when they entered the course and many of them reported on misconceptions they held. A first-year student after her first class on breathing for singing wrote:

> I have always been told to use my diaphragm when singing. I was also told to stick my stomach out so that they would know I was properly using my diaphragm. It was good to have my misconceptions corrected.

The student was happy her previous knowledge had been corrected, but she found it difficult to combine her everyday concepts of singing with the scientific concepts taught in class. She felt instead that she had to replace old concepts with new ones. She commented:

> I found that it was tricky to rid myself of my previous experiences when learning and practicing this new breathing technique. I caught myself pushing my stomach out in the beginning. When using this new breathing technique for singing I found that I had more breath with which to finish each line.

Interestingly, another student had the same prior misconception. She commented that in class she started to become aware that if she could control the action of breathing it would enhance her ability to control the phrases of a song. She also noticed that she had to practice the newly acquired approach. She wrote:

> After studying the diagrams and information in Conable's (2000) 'The Structures and Movement of Breathing', I have found it much easier to maintain breath, support and control. In the past I have actually found it quite painful as I attempted to push out

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> my stomach as far as possible. This action has been resolved as I am now simply using an excursion of the ribs and controlling the intercostal muscles between them. This outward movement of the free moving ribs allows the diaphragm to descend and expand horizontally and correct awareness of this movement will allow me to maintain control and support for my breathing. Today I have begun to practice the way to control that action. . . .when singing I need to ensure I am aware of this action so as to enhance its outcome in relation to particular phrases of song.

An important characteristic of scientific concepts is their transferability. In the following excerpt from a student reflective journal, the student began to understand the techniques taught in class. He was really excited when he incorporated the new techniques into a performance of his band outside of the singing class. This was a great example of a student finding that introducing scientific concepts into something he was doing already was helpful. He wrote in his journal:

> My voice was stronger, richer and more lively than our last gig. I was constantly aware of how I was using my voice and it greatly added to my performance. I ventured even further at times, throwing glottal pops into songs and experimenting with venturing from one extreme of my pitch to the other, swooping from my chest voice to my head voice. I am very pleased with where my vocal practice is at the moment and hope that it will continue in this vein. To summarise what I find to be the most valuable aspect of my singing progress and current practice is an increasingly deeper and more detailed awareness of my voice and my singing, which has become more instinctive.

The above example demonstrates that the introduced scientific concept of breathing put the old skill into a new perspective, which allowed for establishment of new connections and the transferability of this concept to a different context.

One first-year student wrote about a breathing class in which she developed great insight into what was needed for her to improve her breathing. This insight came partly from body mapping work where she learnt about breathing joints in the back and partly from modelling of breathing by the teacher. She wrote:

> L [the lecturer] allowed each student to place their hands either side of her ribs to demonstrate the excursion of her ribs while she breathed in and out so that we could have a better understanding of the concept. I found it incredible to feel how much L's ribs moved when she breathed in and out. I have had over ten years of instruction to breathe into my diaphragm. I have never been encouraged to breathe into my breathing joints, and I didn't even know that they existed until this lesson, so I am very eager to employ these techniques, which are new to me.

The above examples are characteristic of the rest of the participants who all found the newly taught approach to breathing through body mapping exciting and immediately useful.

Example 2: Throat tension

Another example of spontaneous concept meeting scientific concept occurs when students experience throat tension while singing. Conable (2000) describes a common

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misconception which is characteristic to spontaneous concepts in singing and sound production:

> The common and very destructive confusion concerning the location of the trachea and oesophagus and the function of the pharyngeal muscles is often accompanied by a misunderstanding of sound, which is that sound is a substance, something that a singer may, for instance, 'project'. Singers with substance fantasies are prone to use the food-moving apparatus to sing. (Conable, 2000, p. 24)

It was noted in the singing classes that the students tended to think of their throats as one large hole into which food is put in, air breathed in and sound 'projected' out. The following excerpt from the teaching journal describes what happened in class one day when the concept of breathing air without interference from the pharyngeal muscles was pointed out:

> We were talking in class about the image of projecting the voice, which Conable (2000) warns can be quite misleading. Quite a few of the students in the class felt that they used their pharyngeal muscles to help get the sound out. They also discussed how difficult it is to think of the throat as being divided into two different pipes, one for swallowing food and the other for air to move freely in and out of. Instead they mostly tended to just think of their throat as one hole in which everything happened. Martin [pseudonyms are used] got up to sing and admitted gleefully that he felt he harboured substance fantasies when he sang. The students love this phrase of Conables. He said however that he was going to really try and address this and I am looking forward to seeing if anything changes in his singing and if he does manage to bring this concept into his thinking.

The introduction of the scientific concept of moving air cleanly and without the help of the pharyngeal muscles in the throat made Martin reconsider the everyday concepts that he held about singing. He wrote:

> The first obvious improvement was, for me, a recalibration of sensual awareness to the structures of the larynx. It was particularly well observed by my vocal coaches that my projection of sound was unnecessarily forceful, and that my perception of 'creating song' was causing volatility of breath and vocal strain. And so, when asked to detail my vocal development for this session, I will admit to a notable lack of confidence in the consistency of my technique, but I remain obstinately positive. My policy of addressing the inconsistencies between sensation and function has previously been limited to basic practical awareness and an informal self-reflection. I am sure that if I consult some further anatomical diagrams I can begin to reintroduce physiological fact into my singing practice, strictly opposed to the vague guesswork that is based on singing mythology.

Interestingly, Martin referred to the limitations of his previous understanding as 'guess work' and 'myth'. The process of applying the new concepts was not easy for Martin, but he seemed confident that he could improve his singing by using the newly acquired physiological knowledge as a self-guide.

Martin was eager to further his understanding by reading about scientific concepts. He incorporated excerpts from what he was reading into his reflective journal entry. He wrote:

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> I have recently begun to appreciate the theory of sound and how it can be applied in practical ways to dispel past illusions, previous singing mythologies that once compelled me to push sound and throw it outwards, as if it were from the oesophagus. Voice is actually created in the larynx by mucosal waves, 'A rapid closing and opening of the vocal folds produce the 'sound signal'. (Kayes 3) It travels in a soundwave, a pressure-wave of colliding air particles, which over distance become clustered or spaced. If a clear, unconstricted voice was to be measured in terms of speed and pressure it would be graphed as a lovely, even, periodic, sine wave. The pitch of this note can then measured by changes in pressure or frequency (Hz), the higher the pitch, the higher the change in pressure. Furthermore … 'the vocal folds also produce a range of other frequencies above the fundamental' (Kayes 4); this is called harmonics, an elementary quality of sound. In a practical sense, voice theory provides an understanding of how laryngeal constriction prevents the symmetrical replication of frequency, a state that makes for considerable problems with pitch. This also brought me to realise the difference between '*sound*' and '*noise*'. '*Sound*' merely boosts specific parts of a soundwave to achieve dynamic control, '*noise*', however, is an aperiodic wave of widely randomised, inaudible energy. This generation of '*noise*' is one detrimental side effect to my 'substance fantasies'. I hope that this issue may soon be reconciled.

This example shows that Martin was impressed with the scientific concepts taught in the class. He continued individual reading on the subject, which allowed him to take his understanding to 'ever increasing levels of sophistication' (Wertsch, 2007, p. 191).

Using scientific knowledge in an attempt to solve a vocal problem is the beginning of understanding the 'meaning and functional significance of the sign forms' (Daniels, 2007; Wertsch, 2007, p. 186). The following excerpt from a student's reflective journal (entered after a lesson in the first half of her second year of the course) shows how she started to use scientific knowledge to try and solve a vocal problem.

> Janice Chapman and Ron Morris discuss the three uses of valves in the voice: breathy, where the vocal folds aren't meeting properly, a balance between vocal fold closure and sub-glottal air pressure and 'Hyper adducted' where the vocal folds are pressed too tightly together and there is not enough sub-glottal air pressure (62). The latter is what I think I may unintentionally do when singing louder as L suggested and it is good to have a sense of what is happening from an anatomical standpoint. By understanding things in this way and having a clear sense of why a sound is produced the way it is, I can get a clear mental picture and know what I have to do to stop it.

Even though scientific concepts were being explicitly taught to all the students, it took each student time to make sense of these scientific concepts. They needed to connect them to their unique experiences thus allowing the scientific and spontaneous concepts to merge. Students required an individual approach to assist them in making meaning of the theory. Below is an example of how the use of a humorous imagery metaphor helped a student to make sense of the scientific concept that she struggled to grasp. The teacher wrote in her journal:

> I was working in class with Tracey who is one of my more capable students and has a good voice, but somehow after 2 years has not managed to improve her tone as much as I would have expected. I know that she has a good grasp of the theory, but

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> somehow it has not transferred into the physical act of singing. I decided to give her a rather tasteless image of breathing through her bottom as she was singing and allow the breath to completely fill her pelvis, lower back, ribs so that they expand and fill with air. We joked about how after all my lectures to them about being scientifically correct all of a sudden I was using imagery that was about as unscientific as you can get. Then she closed her eyes and used the imagery and the entire class was blown away at the change in her voice. It was resonant, balanced and huge! Even she looked shocked. She said that for the first time singing felt easy.

According to Shewell, 'using images in any voice work is fine, so long as the student has an adequate sense of the physical reality of voice production to avoid damage and safely liberate new vocal power' (Shewell, 2009, p. 8). The observations of students' reactions in class in the present study suggest that students learn at their own pace and a variety of pedagogical techniques need to be used to assist the students in making individual meaning of the scientific concepts. It is important to acknowledge the different ways and styles of learning to which students relate and could be an interesting study as continuation of the present research. There is a distinct body of research which can guide such study (Gregorc, 1982; Reid, 2001; Marton, 2007; Vermunt, 2007). Phenomenological research was used by Gregorc (1982) to develop a tool to assist with identifying an individual's natural means of mediation and transaction. Marton (2007) developed variation theory to illustrate the importance of using different ways to deal with subject matter for different students. Reid (2001) discussed the variations in the levels of learning in tertiary music students and highlighted the importance of developing learning environments that assist in developing the students' expertise as learners.

Discussion and further research

The present study demonstrated that teaching students scientific concepts of singing affected both their singing performance and their ability to learn in a positive way. Not only did they become more skilful and self-confident in their singing, but also they acquired the tools for further independent learning. There was evidence in student reflections that the acquiring of scientific concepts brought about a change in their identity construction as singers (Latukefu, 2009). The introduction of scientific concepts and the integration of them into the creative practice of singing gave students the ability to reflect critically, problem solve and self-regulate in further self-development of their singing ability. Self-regulated learners 'see themselves as agents of their own behaviour, they believe learning is a proactive process, they are self-motivated and they use strategies that enable them to achieve desired academic results' (Montalvo & Torres, 2004, p. 4). Without possessing scientific concepts the students are completely reliant on their teachers to give them positive or negative feedback on their own performance.

The results indicated that the scientific concepts were learnt at an individual pace and they required time and conscious effort for their development. Some students found the body mapping and the scientific knowledge of how the body works when breathing for singing immediately useful and started to use this knowledge straight away to improve their singing in areas outside of the course such as singing in a band or a production. Others, especially some who had had previous singing training, found it more difficult to challenge

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their preconceived notions of how to breathe and sing. Nevertheless, the students reported improvement when they understood the mechanics of breathing and had mapped the position of the lungs, diaphragm and ribs.

Not all the students found it easy to challenge the preconceived ideas that they held about how to sing and the journals were a useful tool in which they discussed these issues. They tended to reject their spontaneous concepts when misconceptions were discovered. However, instead of having to totally accept or reject a position, students in a sociocultural environment were encouraged to engage in a dialogue of co-construction with the teacher. The authority of the teacher was apparent from her expertise in the area, but the student perspective in constructing meaning was considered crucial in the learning process. This is where the mingling of scientific concepts with everyday concepts can occur.

One of the greatest strengths of traditional singing teaching is that there is no singing teacher who would attempt to teach singing in a scholastic way, through verbal explanation. It is of vital importance that the practical approach to teaching singing is maintained and precautions need to be taken that teaching of scientific concepts does not turn into an attempt to directly transmit the knowledge to the students. It is crucial to integrate the scientific concepts into the authentic act of singing.

This integration of theory and practice in which students are combining their own practical experience with the practical knowledge of their teacher and the scientific theoretical concepts of singing means that students have three important sources to learn from (Vermunt, 2007).

Modelling of scientific concepts by the teacher has proved to be quite effective, as in the example of the student who was amazed at the insight she gained about breathing by feeling her teacher's ribs move when she inhaled. The modelling was successful because it fell into what Vygotsky called the Zone of Proximal Development (ZPD; Vygotsky, 1978); the idea of novices performing a range of tasks in collaboration with, and assistance of an expert. The modelling was based on the student's initial level of mastery of breathing techniques and therefore was within the learner's ZPD. As Vygotsky pointed out, 'the person can imitate only that which is within her developmental level' (1978, p. 88). The emphasis was on the shared understanding between the expert and novice and the eventual transformation of assisted performance into that of independent and self-supported learning.

The experience in singing class was that imagery is also a powerful teaching tool when combined with scientific knowledge. This concurs with findings by Marton (2007) that, learning to discern the critical features of concepts is a crucial form of learning. Discernment means first experiencing variation and these variations should be experienced simultaneously. Combining scientific concepts with imagery and metaphor helps students experience variation simultaneously (Marton, 2007). The scientific concepts stay the same, but the interpretation of how these concepts are applied in practice varies according to how students interpret the imagery.

Conclusion

This study demonstrates that it is helpful for students' self-regulation of singing when they understand how their voice works scientifically in relation to their bodies. The reflective journals that students wrote showed that once they had this knowledge they were more

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likely to develop their own strategies that would help them transfer the theory into practice. The study also found that the students did not always grasp the scientific concepts straight away. This is an expected path in the development of scientific concepts. The students gained a deeper understanding of meaning in relation to their singing as they progressed with their study and their own self-initiated practice.

The study substantiates the conclusion that scientific concepts of singing should become part of the students' toolbox that helps develop their singing by making meaning of what they are experiencing kinaesthetically and aurally while they sing. 'Vygotsky argued that the systematic, organized, and hierarchical thinking that he associated with scientific concepts becomes gradually embedded in every day referents and, therefore, achieves a general sense in the contextual richness of everyday thought' (Daniels, 2007, p. 311).

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