Pre-service Teachers' Beliefs about Motivating Students to Learn Science

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Abstract: Motivation in science learning is important, given increasing necessity for scientific and critical literacy. The purpose of this article is to examine secondary science pre-service teachers' (PSTs) beliefs about motivating students to learn science. A mixed method study was conducted with 73 secondary science PSTs across Australia. A web-based survey and interviews were used to gather data. Turner et al.'s motivation theory (2011) is used as a framework to analyse the data. The findings indicate that the PSTs believed that competence, belongingness, and meaningful learning were factors involved in motivating students. These findings are critical as they are relevant to science education and to initial teacher education and as such, this research contributes to the body of knowledge in this area.

Keywords: motivation, science, pre-service teachers, secondary school

Introduction

Motivation is an important aspect of learning for students and refers to "an enduring disposition to value learning for its own sake- to enjoy the process and take pride in the outcomes of experiences involving knowledge acquisition or skill development" (Brophy, 1983, p. 200). Students who are motivated to learn take classroom tasks seriously, finding them meaningful and worthwhile, and seek the intended benefit from them.

Students' motivation to learn science has been shown to decrease during adolescence and has been a subject of much concern among researchers and educationalists (Fortus & Touitou, 2021; Palmer et al., 2017). Additionally, there has been a severe decline in students' motivation for learning science and science-related subjects (De Silva et al., 2018). This decline is resulting in fewer students electing to pursue science subjects in senior years. Science education researchers (e.g., Pino-Pasternak & Volet, 2018) have pointed out that in Australia, students have generally lost motivation and enjoyment for science at the secondary school level and the post-compulsory school years.

This problem of declining motivation in science is important because of the significance of science to society. Science enables empirical judgements to be made and sound decisions about phenomena that an economically efficient society require. In the modern era, as dependence on science and technological advances increases, so too does the demand for more scientifically literate citizens (Udu, 2018). Therefore, it is crucial for countries to invest in

science education. Udu (2018) argues: "Science education is the engine for growth and progress of any society" (p. 24). The European Commission (2004) suggests that if there is a lack of interest and motivation among science students, countries will experience a shortage of skilled, scientifically literate persons. A more immediate reason for learning science is that it helps students to make sense of the world. It also increases knowledge and understanding of the world and helps them to develop an innovative mind (Tanwar, 2022).

Teachers play a vital role in motivating students in all school subjects. You et al. (2018) assert that: "Many educators have considered students' motivation as an important factor for successful learning" (p. 1162). When students are motivated in science, they tend to develop a deeper understanding and learning of science and better grasp of the intended learning outcomes (Palmer, 2004). Motivating students in science is of particular importance as part of the Science, Technology, Engineering, and Mathematics (STEM) focus of many countries.

It is important in supporting school students to be motivated to learn science, that PSTs reflect on, and are encouraged to develop skills and strategies in this area. Ferguson and Brownlee (2018) state that PSTs' beliefs about the nature of knowledge and knowing will likely have: "Important consequences for the nature of the content delivered to their future classrooms" (p. 94).

The discipline of science education remains under-informed regarding PSTs' perceptions about how they can motivate science students at the lower secondary school level, especially during their professional experience placement period. This article seeks to address this gap and add to the literature in a meaningful way by uncovering PSTs' beliefs about motivating students.

Theoretical Framework: Principles of Motivation

This article draws on motivational theory. Using Turner et al.'s work (2011), developed when focusing on mathematical learning, there are four aspects related to motivation, which are competence, belongingness, meaningful learning, and autonomy. In this article autonomy is not focused on as it was not evident in the data. This notion of motivation closely aligns with social constructivism where knowledge is viewed as the result of social interaction and language usage, and is a shared, rather than an individual, experience (Prawat & Floden, 1994).

Competency has been described by many education researchers (e.g., Bandura, 1997; Turner et al., 2011) and includes ways students achieve specific learning outcomes linked to confidence in their abilities in performing learning tasks. Students' academic competency for learning science concepts facilitates their general motivation for science learning in secondary school (Wood, 2019). One way students' competency can be developed is via the provision of feedback by teachers (Turner et al., 2011). Winstone et al. (2021) conceptualised feedback as a process where the learner makes sense of performance-related information that promotes their learning. To support student competence, teachers can provide feedback demonstrating that mistakes are informational. These practices are related to increased intrinsic motivation to learn (Turner et al., 1998). Furthermore, by helping students reflect on their understanding, teachers can help make them aware of their growing competence (Turner et al., 2011).

Students' sense of belongingness is an important aspect in motivating them and is this a finding of this study. Turner et al. (2011) define belongingness as "the human need to be an accepted member of a group and to have strong, stable relationships with others" (p. 721). Students' peer relationships are an important aspect of belongingness. One of the main ways

teachers foster belongingness in the classroom is by allowing students to participate in collaborative group work activities. Education researchers have conceptualised collaborative group work as a teaching strategy that promotes student achievement and socialisation (Forslund et al., 2014). Researchers have indicated that when students interact with each other and share ideas during group work, they can better construct new understandings and clarify ideas (Webb & Mastergeorge, 2003). Furthermore, Gillies (2003) asserts that students are more motivated to achieve when they work in groups, which links to the concept of social constructivism.

> *"Social constructivism can be described as socialization, a process of acquisition of skills, knowledge, and dispositions that enables the individual to participate in his or her group or society" This socialisation process consists of reciprocal interactions and joint construction of meaning by the individual and others in the social context" (Sivan, 2017, p. 211).*

Meaningful learning is referred to as the significance, purposefulness, or value that students place on their learning experience (Turner et al., 2011). As noted by Turner et al. (2011) meaningfulness has not been strongly emphasised in motivation research, but it is central to fostering a sense of purpose in instruction, for both teachers and students. Turner et al. (2011) stated that teachers could make learning meaningful to students by building on their prior knowledge and through participation in extended conversations with the teachers that builds shared understanding. It is through understanding of students' interests and background through dialogue that teachers can make learning meaningful and relevant, which can motivate students. Science education researchers such as Author et al. (2018) suggest that when students can relate to concepts being taught to their lives, learning becomes meaningful to them, and thus they are more likely to develop a long-term interest and motivation to learn science. From a social constructivist perspective, it is important that teachers give students possibilities to construct new knowledge in a situation similar to real life (Rannikmäe et al., 2020). It is the link to the real world that can make learning meaningful, which in turn can motivate students.

Literature Review

The use of feedback is an important mechanism in motivating students, which can positively affect competence. Feedback is one mechanism and is an essential component for learning (Hattie & Timperley, 2007), which if used appropriately, can lead to substantial learning gains (Plank et al., 2014). Researchers such as Edgerly et al. (2018) and Mandouit (2018) conclude that giving students quality feedback is vital as it can help them become motivated and improve their understanding of the subject matter.

Sarsar's (2018) research on motivational feedback messages was conducted with university students in the United States and showed these messages helped to increase and maintain students' motivation and confirmed that motivational feedback messages are one of the most powerful types of feedback. The impact of motivation was also observed by Levesque et al. (2004) who found that teachers' feedback positively predicted students' well-being through the mediating role of perceived competence and motivation in a study conducted with American and German university students.

An aspect linked to motivation is the sense of belonging, which can be achieved through collaborative work. According to Stoytcheva (2021), in investigating an online environment, collaborative learning is an active process aiming at progressive construction of

knowledge, using the group as a source of information and as a motivational agent, which is developed through a community. The development of a sense of belonging is one of the factors that influences the creation of an online learning community. She also suggests that to develop a sense of belonging, learners need to perceive the presence of others in the online environment and to perceive themselves in the group. This belongingness can also be supported through collaborative opportunities in face-to-face situations.

Collaborative learning is a common strategy that teachers use in the classroom to motivate students wherein they can learn through collaboration with teachers as well as through peer interaction and discussion (O'Donnell, 2006). Holmberg (2005) cited in Yates et al. (2020) suggests that teachers need to develop relationships with students, which creates a feeling of belonging in the learning community, which in turn supports motivation.

Studies have been conducted with university students illustrating the role of collaboration to support motivation. Brouwer et al. (2019) undertook a study with Netherlands university students and found that small group collaboration supported academic success. The authors stressed that "the learning environment seems to play a crucial role in feeling socially integrated which is important for being motivated for studying" (p.119). These findings were similar to findings in a study conducted by Jones et al. (2013) with students at a United States university. The findings of the study were that opportunities to select their group, opportunities to have control over some aspects of group functioning, and opportunities to interact with other students in small groups were factors that motivated them to learn.

Yates et al.'s research conducted with New Zealand school students during COVID -19 school lockdowns, found that without collaborative teacher and peer support, many students reported being unable to muster the intrinsic motivation to study. Other studies conducted during the COVID lockdown pointed to the link between collaboration and motivation. In an Australian study conducted with university students it was found peer collaboration is also important in developing and sustaining motivation (Lorenza & Carter, 2021).

One of the ways in which schools try to improve students' motivation and achievements is through making learning meaningful for students (Polemean, 2021). This aspect links to Turner et al's (2011) model. According to Jonassen et al. (2003), learning is meaningful when it is active, constructive, intentional, authentic, and cooperative or relational. Williams et al. (2018) conducted a study with 113 year 6 students and three teachers in the United States examining the issue of meaningfulness and found that middle school students could be motivated for learning through science-based teaching that was culturally meaningful and where there were connections between the students' communities and daily interests. This aspect links to Jonassen et al.'s (2003) notion of authenticity and to a social constructivist view of learning.

Another important component in making learning meaningful is for teachers' knowledge of their students which fits with the Turner et al. (2011) model. According to Dobson (2003), knowing their students helps teachers develop curriculum activities around students' developmental and social needs. Being able to plan appropriate activities can help to motivate students. Knowing students is stipulated in the Australian Professional Standards for Teachers (APSTs) (Australian Institute for Teaching and School Leadership [AITSL], 2011), which is the framework that is used to guide PSTs' learning in Australian universities. Professional knowledge is described as: "Teachers know their students well, including their diverse linguistic, cultural, and religious backgrounds. They know how the experiences that students bring to their classroom affect their continued learning. including teachers' consideration of students' social, religious, and cultural backgrounds" (p. 5).

Methodology

This study adopted a mixed-method methodology. This methodology has its advantages. "Mixed methods designs can provide pragmatic advantages when exploring complex research questions. The qualitative data provide a deep understanding of survey responses, and statistical analysis can provide detailed assessment of patterns of responses" (Driscoll, 2007, p. 26). Combining different methods is valuable as each approach provides a different perspective on the topic. The research questions asked, the data collected and the ways in which evidence is understood and interpreted complement one another Hammond, 2005). Additionally, each approach has its own limitations which can be compensated for by using different types of data (Brewer &Hunter, 1989).

A case study design was employed with PSTs undertaking a teaching degree being the case. In this study participants across different geographical sites within Australia participated. A case study design is an "an in-depth exploration of a bounded system (e.g., an activity, event, process, or individuals) based on extensive data collection" (Creswell, 2019, p. 485). A distinguishing characteristic of the case study is that it attempts to examine a contemporary phenomenon in its real-life context (Yin, 1981).

The study was devised in two stages. For stage one, participants, as a purposive sample of Australian secondary science PSTs, were invited via various social media including Facebook, Twitter, Pinterest, and Instagram to complete an online survey. The purpose of the survey was to elicit PSTs beliefs about motivating students based on their professional experience placements. Seventy-three PSTs completed the survey. The survey consisted of three Likert scale questions and 11 open ended questions. For stage two, three PSTs were interviewed about their strategies for motivating students to learn science. Three interviews were conducted with each PST and ranged from 15 to 45 minutes.

Data Analysis

Thematic analysis was used to identify, analyse, and report significant features within the qualitative data (Braun & Clarke, 2006). The data analysis was guided by the three principles of motivation set out in the theoretical framework, as set out above. Data were transcribed, which permitted themes across the two stages to be identified through consistent coding. The information obtained through the Likert scale was analysed using basic statistical analysis.

Three science educators assessed the face and content validity of the web-based survey and provided feedback based on pre-established guidelines for the study. The recommendations of the educators were implemented before the instrument was pilot tested. To pilot the survey instrument two PSTs were asked to complete the survey prior to it being administered for the study. The PSTs were asked to report any difficulties encountered while completing the web-based survey. All feedback received from the pilot testers was used to modify the survey question items and thus enhanced the validity and reliability of the study.

Results and Discussion

The survey results revealed that the majority of the PSTs indicated that they knew how to motivate students. There were two questions asked focusing on motivation as shown in Figure 1.

	STRONGLY AGREE	AGREE	UNDECIDED	DISAGREE	STRONGLY DISAGREE	TOTAL
I. I believe that I know how science students can be motivated to learn science.	14.29% 9	53.97% 34	25.40% 16	6.35% 4	0.00% 0	63
II. I believe that I know how to facilitate students' learning of science concepts in a way that will motivate them.	11.11% 7	58.73% 37	26.98% 17	3.17% 2	0.00% 0	63

Figure 1: PSTs' views of motivating students.

As illustrated in figure 1, the high number of PSTs strongly agreed or agreed that they believe they can motivate students to learn science of facilitate learning demonstrates their awareness of the importance of motivating students to learn science. The remainder of this section is organised around the three aspects of motivation theory which are competence, belongingness, and meaningful learning, where the PSTs discussed how they could motivate students.

Competence

To help develop students' competence, the PSTs discussed the provision of feedback. The survey findings revealed that of the 63 PSTs who responded to the belief scale, 52 agreed that students could be motivated to learn science most of the time or often when given personalised feedback as shown in Figure 2.

	MOST OF THE TIME	OFTEN	SOMETIMES	OCCASIONALLY	NEVER	TOTAL
III. I believe that when I provide personalized feedback on students' assessments, they will be motivated to learn science.	22.22% 14	60.32% 38	15.87% 10	1.59% 1	0.00% 0	63

Figure 2: Personalised feedback and motivation

There were benefits in providing feedback that the PSTs noted. One outcome of providing feedback was that it created a positive emotional response within the students. Respondent # 61 claimed, *"The students feel good when I give them feedback on their work."* and "*When I give students feedback, they feel happy, and that motivates them to work."* These quotes highlight the respondents' awareness of the importance of giving students feedback and the positive emotional reactions that are evoked from students when they receive it. According to Sarsar (2017), such emotional reactions are critical to motivate students to learn. It should be noted that feedback can also demotivate students if it is not provided thoughtfully, which was an aspect that not considered by the PTS in this study. Rohmah and Halim (2023) note that more proficient students can lose motivation when corrected by their teachers. Feedback is more than comments provided by teachers to students about their work. It is a process that needs active and continuing student engagement (Boud & Dawson, 2021). Building competence should be seen as dialogue rather than a one-way form of communication.

Another outcome of providing feedback, as noted by PSTs, was that it provided students with an indicator of their work, which assisted them in developing their competency. For example, respondent #38 stated that providing *"Good feedback on tasks helps ensure that the students understand the topic that was done, and that is a good way to motivate them.* This helped to dispel students' misconceptions. Respondent # 44 stated, "*I think maybe the students wanted to know their level before they continued their work, so when I gave them feedback, they continued working harder."* This feedback also provided reassurance that students were on the right track.

The aspect of helping students understand their work through providing feedback indicates that they needed a goal of the intended learning at the outset (Hattie & Timperley, 2007) so that they could then understand if they were achieving the intended outcomes by producing work at the correct level. The PSTs did not consider motivation for students who were not achieving at the expected level. For this reason, Wisniewski et al (2020) consider that feedback is more effective for cognitive outcomes than for motivational criteria. Also of significance is that lower achieving learners rarely seek or incorporate feedback in ways that will enhance their future learning (Hattie & Timperley, 2007). The comments of the PSTs reflect a limited understanding of the role of feedback and motivation.

PSTs believed that feedback helps develop students' competency by allowing them to see the value of making mistakes while learning. For instance, Respondent # 61 claimed that after giving the students feedback on their academic tasks, they are usually "*motivated to learn from their errors and continue succeeding in particular KLAs."* This quotation demonstrates an awareness that feedback is essential to help students learn from their mistakes or errors when undertaking academic tasks/assignments because it helps them develop an understanding of their work, which can motivate them to learn.

Turner et al. (2011) indicated that teachers should let students know that mistakes are informational because they allow both students and teachers to know which concepts students are having difficulty with, and by doing this, students will develop increased competency. Additionally, Leibold and Schwarz (2015) found that when teachers correct students' errors, they help students improve their performance in learning tasks and assignments. Such an improvement can lead to increased motivation. Wang et al., (2019) also reported that when students receive error correction, their motivational reactions are activated, leading to improved competency and achievement.

Belongingness

As noted by Turner et al. (2011) belongingness is the need to have a strong stable relationship with others. This forms a basis for collaboration. A significant finding from the study was that 31 out of the 52 PSTs believed that when students are engaged in collaborative group work activities, they can help each other to undertake activities associated with science.

Respondent # 29 stated she believed that by *"placing students in groups to work, students could help each other grasp the concepts being taught."* Another insight was shared by Respondent # 10, who believed that "*group work allows students to relate the content to each other. In this way, they are talking about the content rather than having the teacher direct them in a particular way."* Based on the responses, the PSTs demonstrated an understanding of the positive social dynamics that occur when students are placed in groups.

The findings concerning engaging students in collaborative group work reveal two main points. The PSTs generally believed collaborative work resulted in social interactions amongst students and their teachers creating a sense of belongingness. Through this sense of belongingness, students were more motivated to learn (Watts et al. 2020). Moreover, Brouwer et al. (2019), commenting on how group work can aid in creating a bond in the classroom, indicated that students who participate in collaborative group work activities get to know each other very quickly, and this may give them a feeling of belonging within the classroom environment. In addition to developing belongingness, when students participate in group work, they can be more motivated to achieve and learn the intended learning outcomes of a lesson (Gillies, 2003).

The PSTs also agreed that collaborative work helps create a social space where students relate content with each other and become more motivated to learn science. Respondent # 29 stated that "*They [students in their groups] were also able to relate the concepts to each other's lives*." Prawat and Floden (1994) asserted that when students engage in social negotiation within the classroom or group setting, their knowledge and social meanings about a particular concept become more refined. Brouwer et al. (2019) also noted this and added that students are more likely to collaborate with their peers and teachers when they feel as though they belong to a group in a safe learning environment. Additionally, Brouwer et al. (2019) stated that the learning environment plays a crucial role in helping the students feel socially integrated, essential for developing belongingness in the classroom and being motivated to learn.

While a large majority of the PSTs espoused various strategies to foster collaborative group work to motivate students for learning science, others suggested that collaborative group work may not be beneficial to the students. For example, Respondent # 29 stated that his collaborative group work strategy was *"not effective because they [students] prefer working with their friends (in groups)*." As noted by Turner et al. (2011) belongingness is the need to have a strong stable relationship with others. This forms the basis of collaboration. However as noted by. Crews and Allinson (2022), the notion of belonging is fluid, relational and transforms responsively over time. This is particularly true for teenagers. Teachers need to be aware of this fluidity and how the sense of belongingness can change quickly for their students which can impact on a sense of belongingness which can affect the outcome of collaborative work.

Another issue that was raised by PSTs was that of students being too comfortable with each other, which could affect their work. As noted by Respondent # 35:

> *I realised that sometimes when I place students in groups, they are not as productive as they would be when they work with a peer of their choosing because the students would be disrupting each other, going off-topic most times and not focused on the activity at hand.*

As espoused by the survey respondents, this potential lack of productivity by students when engaged in group work activity sheds a different light on the aspect of using this strategy to motivate students in the science class. Respondent # 44 stated, *"When students are in groups, they get distracted and do not work efficiently most times."* Based on these respondents' views, is it clear that the PSTs were aware that it may be counterproductive to place students in groups to work because of the distractions that students may experience as they interact with each other. This aspect reflects the inexperience of the PSTs where they had difficulties in establishing and maintaining protocols for group work.

The distractions that may occur during group work may lead to students becoming inattentive and deter the teacher from using group work as a strategy, as implied by some respondents. For example, respondent #44 said*, "I allow students to work on their individual tasks and they are less distracted than when they work with groups and make better use of their time in the classroom."* This hesitation by the respondents in using the more contemporary socially based group work strategies because of the distraction that students can experience in groups may cause the PSTs to use other strategies. One of these strategies might include individual tasks, which may not necessarily motivate students to learn science.

The findings from this research are supported by research conducted by Hofstein and Kempa (1985), who suggest that it should not be assumed that all students will be drawn to a cooperative group work way of learning. Adar (1969) indicated that cooperative group work strategies only effectively motivate students who are social in nature and that students who are not social may find it difficult to take part in cooperative group work activities and thus not be motivated to learn in those instances.

The results of this study concerning the fostering of belongingness showed that the PSTs espoused collaborative group work as an effective way of fostering belongingness in the science classroom to motivate students for learning science. This shows the importance of PSTs understanding how to create a sense of inclusion in the classroom to motivate students to learn.

Meaningful Learning

Two aspects for this category emerged through analysis of the data, which are relating content to students' everyday lives and knowing students. In considering meaningful learning, 43 out of a total of 52 respondents indicated that they often, or most of the time, related science content to the students' everyday lives as demonstrated in figure 3.

	MOST OF THE TIME	OFTEN	SOMETIMES	OCCASIONALLY	NEVER	TOTAL
I. I related the science concepts to real life.	40.38% 21	42.31% 22	17.31% 9	0.00% 0	0.00% 0	52

Figure 3: relating science to real life

In relation to linking learning to real life, respondent # 8 indicated that she makes learning meaningful to the students by showing students *"the relevance of the ideas and concepts taught to their everyday lives and how to apply these to solve real-world problems*." Respondent # 20 stated he believed that "using real-life examples brings a sense of realisation to the concepts, which help students' understanding leading to meaningful learning".

The comments espoused by the PSTs point to the connection they made with making learning pertinent to students' lives and the real world so that students can relate to the learning materials with which they engage. Priniski et al. (2018) presented similar arguments, in that when the examples used in the classroom are familiar, and of personal relevance to students, this contributes to their ability to develop better situational interests and thus become motivated to learn in the classroom. Their research indicates that relevance and meaningfulness are not mutually exclusive.

Related to the above finding was that through knowing their students, the PSTs could help to make the learning meaningful, which could help to motivate them. Respondent #8

indicated that she makes learning meaningful to the students by showing them *"the relevance of the ideas and concepts taught to their everyday lives and how to apply these to solve real-world problems."* Respondent # 20 stated he believed that "*using real-life examples brings a sense of realisation to the concepts, which help students' understanding which helps motivate them".*

The findings for the category point to specific responses that the many PSTs made about the importance of getting to know students to make learning relevant, which would then motivate them to learn science. For instance, respondent #20 stated that it was important that teachers *"know their students and what works for them."* Moreover, respondent #45 said he believed that PSTs should "*know your students, where they are at so that you could plan for them."*

This result of the web-based survey complements the findings on teacher preparation by Cochran et al. (1993), who stressed that teachers' knowledge about students should comprise the students' abilities, ages, developmental levels, attitudes, motivations, and their prior knowledge of concepts to be taught. Furthermore, the web-based survey results are supported by the findings of Qian and Lehman (2017) who stated that by knowing students and the knowledge they bring into the classroom, teachers could quickly identify misconceptions that they may have toward a particular concept and become more adept at choosing strategies to clarify those concepts.

One strategy the PSTs used to get to know their students was by encouraging the sharing of personal stories. In an interview one PST stated that the students "*had so many stories because I asked them the question; what is your first-hand experience?"* A benefit of sharing stories was that the students eventually shared personal or first-hand stories in return. Including students' own experiences as part of the classroom content helped make the learning authentic and meaningful for the students. This exchange of stories between teachers and students signified that the students felt connected to the teacher and each other, which motivated them to share their stories. The final benefit from this encouragement to tell stories was that students also learnt from each other in that way. This finding concerning storytelling is supported by the research of Fawcett and Fawcett (2011), who stated that when students participate in storytelling, they share their experience, content, and context with others.

Another way of making learning relevant to students, which one PST espoused, is by knowing the students' culture. Respondent #45 suggested that there is a *"difference in cultural backgrounds"* of the students and that students should be given *"examples that are culturally relevant"* to motivate them for learning science. Respondent #45's consideration of the students' culture and giving culturally relevant examples during teaching is vital because when teachers relate science to students' culture, the students may understand concepts more easily by seeing the connections to those concepts in their day-to-day lives because culture represents people's way of life (Goodrum, 2019). These considerations link to the APSTs where PSTs are required to understand the learning needs of students with diverse linguistic, cultural, religious and socioeconomic backgrounds. When teachers build on students' prior knowledge and experience, which has a cultural dimension, it can help make science meaningful, which can encourage students to be more motivated to learn (Williams et al., 2018). Ng et al. (2010) also found that PSTs who are willing to support the diverse needs of their students are more effective at motivating students to learn.

Conclusions

The results of this study indicate that PSTs are aware of the importance of motivating school students and reported that they understood how to motivate students to learn science. The main strategies that the PSTs suggested for motivating students were developing competence through the provision of feedback, supporting belongingness through collaborative group work, and making learning relevant by relating it to everyday life and by knowing their students.

In focusing on building competence, feedback was seen to be an important mechanism which could help motivate the students. The responses of the PSTs tended to focus on providing feedback that students would be automatically accepted by them. There was limited reflection on how feedback might demotivate students and the dialogic aspect of feedback. The PSTs also commented on the value of feedback in assisting students by providing them with indicators of the level of their work. Using feedback to correct errors was also seen as important.

In examining the aspects of belongingness that could be developed through collaborative learning, the results indicated some PSTs favoured the use of collaborative learning. Through the use of collaborative work, conditions could be created whereby students could draw on a sense of belongingness to assist in the work, which was motivating. Other PSTs preferred not to use this as a teaching strategy as they felt it was not effective. Students working with friends was seen as an ineffective use of collaborative work and rather than being motivated to learn, students would be distracted.

For the final category, meaningful learning, the aspects of relevance and knowing students were discussed. Students recognised the importance of linking science to students' everyday lives and saw this as motivating, which links to a social constructivist view of learning. The PSTs teachers also recognised the importance of knowing their students in order to motivate them. One of the ways the PSTs believed they could get to know students was by understanding their culture. This has implications for schools in Australia and other countries, which are multicultural in nature. It was found that students felt that linking to examples and people in the field that are culturally meaningful to students can be very motivating.

As has been demonstrated here, aspects relating to motivation are complex. It is important that PSTs have a solid understanding of motivation and how this impacts on pedagogical and social aspects of learning. With such an understanding, PSTs can incorporate motivational strategies into their teaching which may help stem the decline in students' involvement and enjoyment in science. It is therefore important that student engagement and motivation in science be focused on in initial teacher education.

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