Influence of the Interplay of Habitual Affective Attributes and Classroom Learning Environments on Learners’ Situational Affective Experiences in Learning Science: The Narratives of Primary Pre-Service Teachers

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Research in Science Education

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Science education researchers have found that instructional design focusing more on learners’ affective needs can be powerful in nurturing effective and exciting science learning. This paper reports a qualitative study exploring how learners’ situational affective experiences are influenced by the interplay of their habitual affective attributes and classroom learning environment. The research method adopted was semi-structured in-depth interview. The study is descriptive and retrospective in nature. Nine pre-service teachers who were taking a science method course at an Australian university took part in the study voluntarily. Each interview lasted about 1 h. Six types of interplay were identified: Self-sustained, Beyond expectation, Resonant, Adversely Overpowered, Below expectation and Irresponsive. Implications for science teaching and science teacher education are discussed in terms of the identified types of interplay.

Classroom learning environments - Habitual affective attributes - Science learning - Situational affective experiences
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Hongming Ma

Abstract
Science education researchers have found that instructional design focusing more on learners’ affective needs can be powerful in nurturing effective and exciting science learning. This paper reports a qualitative study exploring how learners’ situational affective experiences are influenced by the interplay of their habitual affective attributes and classroom learning environment. The research method adopted was semi-structured in-depth interview. The study is descriptive and retrospective in nature. Nine pre-service teachers who were taking a science method course at an Australian university took part in the study voluntarily. Each interview lasted about 1 h. Six types of interplay were identified: Self-sustained, Beyond expectation, Resonant, Adversely Overpowered, Below expectation and Irresponsive. Implications for science teaching and science teacher education are discussed in terms of the identified types of interplay.

Keywords Classroom learning environments · Habitual affective attributes · Science learning · Situational affective experiences

Introduction
Over the past decades, many developed countries have been experiencing a continuous challenge: a gap between society’s growing need for scientifically literate citizens and the declining number of students willing to select science-related study or career pathways (Boe et al. 2011; Convert 2005; Foster 2010; Organisation for Economic Cooperation and Development [OECD] 2008). Reasons for the decline are multifaceted, including curriculum, pedagogy and broader socio-cultural contexts. In reference to these issues, Tytler (2007)
argues ‘current practice in science education is that it is too heavily skewed towards the  
abstract conceptual canon of science, and too often ignores the realities of students’ own lives,  
interests and feelings’ (p.38). Although there has been growing awareness of connecting  
emotional and cognitive aspects in learning among researchers, research effort into affective  
domain is still underrepresented in the science education field (Fortus 2014). Affective domain  
broadly includes constructs such as emotion, interest, attitude and motivation. Although there  
is no consensus among researchers about the connotation of many of the constructs, it is  
widely agreed that affective factors contribute to student enjoyment and satisfaction associated  
with learning in general and science learning in particular (Alsop and Watts 2003; Renninger  
and Hidi 2011). Through a conceptual framework that connects student Situational Affective  
Experiences (SAEs), Habitual Affective Attributes (HAAs) and Classroom Learning Environ-
ments (CLEs), this study explores the combined influence of environmental factors and prior-
developed attitudes on affective learning outcomes.

Affective constructs that represent emotions stimulated and sustained by environmental  
factors are defined in this study as SAEs (a detailed explanation is given in the following  
section). This study examines SAEs as affective learning outcomes and explores factors that  
influence them. Why is studying learners’ SAEs important? Research has shown that inform-
ation process can be initiated, recalled, selected, disrupted or terminated by different  
emotional states (Pekrun et al. 2002). For example, negative affective states, such as anger,  
anxiety and boredom, can cause task-irrelevant thinking, while positive affective states such as  
enjoyment and curiosity have negative association with task-irrelevant thinking and help  
attention flow (Zeidner 1998). It is also argued that SAEs, such as situational interest, can  
be developed into more sustained individual interest if they are supported and facilitated  
continuously by the learning environment (Hidi and Renninger 2006; Palmer et al. 2017;  
Randler & Bogner 2007). The aforementioned studies are important for illustrating that SAEs  
do not just have momentary value, they also contribute to maintaining and further developing  
enduring dispositions. As a result, understanding how SAEs can be stimulated and sustained  
informs instructional strategies that promote quality learning experience (Pekrun and  
Linnewink-Gacia 2012).

Given the importance of studying learners’ SAEs, a subsequent question such as what  
factors contribute to SAEs needs to be advanced. Hascher (2010) observed that learners’  
learning processes ‘are evoked by teacher instruction, partner work, classroom discussions,  
single learning activities, achievement situations, etc., and these situations elicit a variety of  
emotions like pride, anger, frustration, happiness, and sadness’ (p. 18). Hascher’s observation  
demonstrates a strong connection between CLEs and student SAEs. A review by Dorman and  
Fraser (2009) shows that extensive studies have found positive correlation between CLEs (e.g.  
strong teacher support and productive peer relationship) and student affective outcomes (e.g.  
enjoyment and satisfaction). More specifically, research has shown that instructional strategies  
involving novelty, causing surprise, and provoking thought (Renninger and Hidi 2011) and  
inquiry learning embedded with hands-on activities (Bulunuz et al. 2012), are more likely to  
arouse situational interest among learners.

Individual interest (defined in this study as part of HAAs) is also seen as a contributor to  
SAEs. According to Hidi and Harackiewicz (2000), individual interest refers to ‘personal  
disposition that develop over time in relation to a particular topic or domain and is associated  
with increased knowledge, value, and positive feelings’ (p.152). Hidi and Harackiewicz (2000)  
found that students with individual interest in a particular topic enjoyed their involvement with  
the topic to a greater degree. Further to this, the study of Ainley et al. (2005) suggested that
individual interest is a predictor of anticipated situational interest. In line with this view, Tsai et al. (2008) argued that individual interest can be considered as a motivational resource in an everyday classroom situation. In acknowledging the interactive nature of environment and affective predictors and outcomes, this study explores how learners’ SAEs are influenced by the interplay of their HAAs and CLEs in science learning contexts. Table 1 illustrates some examples of HAAs, CLEs and SAEs. More rigorous definitions of these concepts are provided in the following literature review.

**Classroom Learning Environments and Affective Outcomes**

The classroom environment is often seen as the discourse within which teaching and learning are examined. Research on CLEs has its philosophical understanding based on Lewin’s (1936) field theory, which acknowledges that human behaviour is defined by the interaction between individual and the environment. Studies into this area have a strong tradition of developing quantitative questionnaires which have generated several well-validated and widely adopted survey instruments. In these instruments, the focus of the investigation has been the social, psychosocial and pedagogical dimensions of the CLEs—the human behaviour and interaction, such as teacher instruction and support, peer relationship and content/topic relevancy (Fraser 2012), although some also considered physical or material environment (e.g. Fraser et al. 1982, 1995). Reviews of research in this area have identified at least ten dimensions (see Dorman and Fraser 2009), one of which has been the investigation of associations between learners’ perceptions of their classroom environments and their cognitive and affective learning outcomes, which is the most relevant dimension to the present study. Overall, findings show that student affective outcomes are positive when the quality of the classroom environment is perceived positively (Dorman and Fraser 2009).

The affective outcomes refer more often to attitudes in most environment-outcome research. In most of these studies, the term attitude is loosely defined as student interest, enjoyment, satisfaction or valuing towards science and/or scientific methods. The most adopted instrument for the measurement of attitude is the Test on Science-Related Attitudes (TOSRA) developed by Fraser (1981). The conceptual framework for TOSRA is Klopfer (1971)’s six categories of attitudinal aims: attitudes to science and scientists, attitudes to inquiry, adoption of scientific attitudes, enjoyment of science learning experiences, casual interest in science and career interest in science.

Although less frequently examined, motivation is another affective outcome variable researched in the environment-outcome dimension. Motivation, according to Brophy (1987),

### Table 1 Examples of habitual affective attributes (HAAs), classroom learning environments (CLEs) and situational affective experiences (SAEs)

<table>
<thead>
<tr>
<th>HAAs</th>
<th>CLEs</th>
<th>SAEs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Already existing or no interest in science</td>
<td>Teachers</td>
<td>Focused attention or lost attention</td>
</tr>
<tr>
<td>Relevant career expectations</td>
<td>Peers</td>
<td>A feeling of excitement/boredom</td>
</tr>
<tr>
<td>Lack of confidence in science learning</td>
<td>Instructional methods/approaches</td>
<td>A feeling of enjoyment/anxiety</td>
</tr>
<tr>
<td>Value science in everyday life</td>
<td>Relevancy of topics/tasks</td>
<td>A feeling of satisfaction/disappointment</td>
</tr>
</tbody>
</table>
refers to ‘a student tendency to find academic activities meaningful and worthwhile and to try to derive the intended academic benefits from them’ (pp. 205–206). Only from the early 2000s has environment-outcome research become more specific to motivation towards science learning (e.g. Anderson et al. 2004; Spearman and Watt 2013). As part of motivational constructs, anxiety has also been explored by some studies on CLEs (e.g. Fraser et al. 1983; Koul et al. 2012).

The present study also explores the influence of CLEs on student affective outcomes; however, it is distinct from existing learning environment research in terms of the way it conceptualises the affective learning predictors and outcomes. In the present study, affective factors are distinguished into two types and treated differently in the research design. The following section focuses on the conceptualisation of the two types of affective factors.

**Habitual Affective Attributes and Situational Affective Experiences**

Affect is another important and well-recognised domain in learning. In an effort to understand, identify and evaluate educational objectives, Krathwohl et al. (1964) proposed a taxonomy that consists of three domains: cognitive, affective and psychomotor. According to Krathwohl et al. (1964), the affective objectives emphasise a feeling tone, an emotion, or a degree of acceptance or rejection. Affective objectives vary from simple attention to selected phenomena to complex but internally consistent qualities of character and conscience. … a large number of such objectives in the literature expressed as interests, attitudes, appreciations, values, and emotional sets or biases (p.7).

While Krathwohl et al.’s (1964) description of the affective domain is generally agreed upon among researchers, specific definitions and meanings of particular affective constructs have long been problematic and controversial. Take attitudinal constructs for example: Koballa and Glynn (2007) observed that ‘attitude has been defined in many ways and has unfortunately, often been used interchangeably with terms such as interest, value, motivation, and opinion’ (p.78). This is the case in many environment-outcome studies adopting TOSRA items to measure attitude. Schunk (2000) notes a similar problem in defining motivational constructs. In some studies, the terms emotion and affect are used interchangeably to refer to the general affective domain (e.g. Zembylas 2005); while in other studies, the term emotion is preferred in describing affective states that are highly situational, change rapidly and with comparatively low duration (Scherer 2005). Without consensus on the definition, researchers have been interpreting affective constructs according to their own theoretical models. The extent to which they distinguish different constructs depends on their research purposes and methods adopted.

It is beyond the purpose of this study to specify different affective constructs according to extant literature. Nevertheless, it is necessary to clarify the affective phenomena that this study focuses on. In the first place, the present study interprets the general affective domain in line with Krathwohl et al.’s (1964, p.7) description, such as emphasising a ‘feeling tone, an emotion, or a degree of acceptance or rejection’ and generally related to ‘interests, attitudes, appreciations, values and emotional sets or biases’. Further, acknowledging that affective phenomena occur on different levels, it then distinguishes affective phenomena into two categories: HAAs and SAEs. SAEs refer to affective experiences elicited by environmental stimuli, readjust rapidly to changing circumstances, with the duration depending on the
sustainability of the external stimuli. In contrast, HAA relates to a person’s relatively enduring predisposition to reengage particular content over time or the tendency of a person to activate certain emotional states more readily and frequently. For example, student individual interest (also known as personal interest in some literature) towards science can be seen as a HAA. It is also possible that a student without individual interest in science may show great interest in a particular science lesson due to teacher’s instructional strategies, which can be seen as an example of SAEs. Another example includes a student’s tendency to feel anxious towards test (habitual) and his/her feeling of anxiety in a particular test situation (situational).

The conceptualisation of the two affective phenomena is informed by research on interest. In this research area, researchers have been focusing on two types of interest: situational and individual. According to Hidi and Renninger (2006), ‘Situational interest refers to focused attention and the affective reaction that is triggered in the moment by environmental stimuli, which may or may not last over time’ (p.113), whereas ‘individual interest refers to a person’s relatively enduring predisposition to reengage particular content over time as well as to the immediate psychological state when this predisposition has been activated’ (p.113). In other words, individual interest may serve as prior affective condition in learning, just as important as prior knowledge to learning in a cognitive sense. Situational interest may form part of learning outcomes and help to identify environmental factors that can be controlled through instructional intervention.

It is worth noting that for the purpose of the present study, the concept of SAE is used to cover both situational interest and situational emotional state (such as feeling anxious when learning). The same is true with the adoption of HAA, which refers broadly to personal interest, motivation and attitudes. The focus of the research is not to distinguish these concepts from each other but rather to investigate how the already existing affective attributes interact with or are mediated by learning environment, and to what extent situational affective outcomes occur as a result of the interplay between the two.

The Innovation of the Research Design

As explained previously, this study focuses on SAE as an affective learning outcome. Much of the science education research has explored the influence of CLEs on student situational interest (e.g. Franke and Bogner 2013; Lin et al. 2013; Palmer 2004, 2009; Trobst et al. 2016). Attention was also paid to the relationship between HAAs and SAEs (Ainley and Ainley 2011; Ainley et al. 2005; Trend 2005). However, most studies in this area examined the influence of either habitual attributes or environmental factors on situational experience, which means there has been less focus on treating both factors as intertwined factors, and examining their combined effect on situational experiences.

There is, however, work conducted by Tapola and her colleagues in which the researchers examined the effect of both HAAs (subject-specific interest) and CLEs (task concreteness) on student situational interest (Tapola et al. 2013, 2014). Their studies confirmed the importance of ‘acknowledging the interaction of student and task characteristics in the arousal and maintenance of situational interest across a learning task’ (Tapola et al. 2014, p.455). Building on this work, and in an attempt to extend the learning environment to include broad psychosocial and pedagogical aspects, the present study highlights how SAEs can be influenced by the interaction between learning environment and prior developed attitudes and interest brought into the environment by individual learners.
Research Questions

Against this background, the present study aims to explore how learner SAEs are influenced by the interaction between learners’ HAAs and the CLEs. More specifically, it aims to answer the following questions:

1. What types of interplay of learners’ Habitual Affective Attributes (HAAs) and the Classroom Learning Environments (CLEs) result in positive Situational Affective Experiences (SAEs)?
2. What types of interplay of learners’ Habitual Affective Attributes (HAAs) and the Classroom Learning Environments (CLEs) hinder positive Situational Affective Experiences (SAEs)?

An affective experience is deemed as positive when the learners were interested, excited and satisfied about the experience, while an affective experience is deemed as not positive when learners felt bored, frustrated, disappointed or unsatisfied.

The Participants

Even though the research questions could be answered by working with learners of all kinds, the present study focuses on a cohort of primary pre-service teachers who do not major in science. However, they will be required to teach primary science in their future role as primary school teachers. To understand their science learning experiences will inform not only science teaching in general but also science teacher education in particular.

The participants were pre-service teachers enrolled in a primary science education method course (a 12-week course with the purpose of introducing curriculum and pedagogy of primary school science teaching) at an Australian university. The course was a compulsory second year subject in a 4-year undergraduate teacher education programme. Nine pre-service teachers—eight females and one male—volunteered to take part in the interview. Most of the participants were in their early twenties with one exception, Ruby, who was a mature-aged student in her mid-thirties. All of them had European-Australian cultural background. They had all studied general science up to year 10, but selected different science subjects for years 11 and 12. Before entering the (undergraduate) teacher education programme, none of the participants had studied science-related subjects at post-secondary level or had work experience in science-related career.

The small sample size was mainly due to the limited accessibility to the population of interest at the time of the research, which makes any generalisation unconvincing. It is for this reason that the data collected was treated as a preliminary set of data in an exploratory study. Nevertheless, with each interview lasting about 1 h, the in-depth interviews provided substantial details and examples that allowed the researcher to delve deeper in categorising the characteristics of the phenomenon, which was the aim of the study. This study focused on identifying types of interplay as themes, instead of looking for trends.

Method

The study is exploratory and descriptive in nature, and in its preliminary stage. According to Fawcett and Downs (1986), the purpose of this type of research is to explore the characteristics
of a given phenomenon. In the present study, the phenomenon was the interplay of student HAAs and the CLEs. The types of interplay were categorised in terms of whether the interplay facilitates or hinders positive SAEs.

The study examines learning processes that may be experienced by different learners differently. The learning processes as part of each participant’s life experience are too complex to be simply measured or counted quantitatively. It is more pertinent to adopt a method that allows the researcher to ‘explore in detail the experiences, motives and opinions of others and learn to see the world from perspectives other than their own’ (Rubin and Rubin 2012, p.3). Consequently, a semi-structured in-depth interview method was employed as the sole data collecting method. Kvale (1996, p.7) argues, it is ‘a strength of the interview conversation to capture the multitude of subjects’ views of a theme and to picture a manifold and controversial human world’. This method made it possible for the researcher to situate and unpack meanings of a particular topic in a certain context. At the same time, it provides the flexibility for the participants to tell their unique stories, adding innovative perspectives to a preliminary study.

One limitation of the design was that the interview protocol was on a retrospective basis, which is an issue that any research adopting self-reporting method for life experience may encounter. As the data collection required the participants to recall feelings and life stories that happened in the past, it depended on how strong a feeling was so that it can still be remembered. On the other hand, if a feeling was still remembered after a long period of time, it implied that this feeling could be very strong when it was stimulated and has the value of being studied. As being a reflective practitioner is essential for teachers as professionals, reflective skills had been part of the pre-service teachers’ education programme. By the time the interviews were conducted, the participants had already been made familiar with the reflective skills, which allowed them to explore deeper with their own life (learning) experience/stories during the interview. In essence, the study recognises that a ‘story of a life is less than the actual life, because the story told is selective, partial, contextually constructed and because the life is not yet over’ (Richardson 1997, p. 6). However, the study argues for the value of the retellings of early experiences as Richardson (1997) observes:

But the story of a life is also more than the life, the contours and meanings allegorically extending other, others seeing themselves, knowing themselves through another’s life story, re-visioning their own, arriving where they started and knowing ‘the place for the first time’. (p.6)

The Interview Protocol

The qualitative investigation adopted semi-structured in-depth interview. It asked the participants to recall their science learning experience at secondary schools, and as such, the investigation was retrospective. The interview protocol consisted of questions about the participants’ HAAs, CLEs and how these factors influenced their situational affective science learning experiences. The design of the protocol was more situation focused, in that it encouraged the participants to recall particular classroom incidences or scenarios. During the data analysis, relevant functioning factors and interplay of HAAs and CLEs were identified (for the purpose of answering the research questions). The interview protocol and rationales are explained in Table 2.
The study was conducted according to the principles outlined in the National Statement and the Australian Code for the Responsible Conduct of Research. After the research proposal was approved by the university’s ethics committee, the participants were invited to take part in the study. They had the research purposes and procedures explained to them and were also informed that their participation was entirely voluntary. The interviews were conducted on campus in the university precinct and at a time that suited both the interviewer and the interviewee. The average duration for each interview was 1 h. The interviews were audiotaped with participants’ consent and then transcribed into text. In any publication based on this set of data, a pseudonym has been given to each participant.

A thematic analysis method was employed to make sense of the data. The method included six phases as suggested by Braun and Clarke (2006). Although described below as a linear procedure, the actual process was iterative as there was a constant moving back and forward between phases during the analysis. Transcripts were read and re-read frequently for the

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<table>
<thead>
<tr>
<th>Table 2</th>
<th>Interview protocol and rationales</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>t2.1</strong></td>
<td><strong>Key interview questions</strong></td>
</tr>
<tr>
<td><strong>t2.2</strong></td>
<td></td>
</tr>
<tr>
<td><strong>t2.3</strong></td>
<td>Did you choose any science subject up to year 12 at secondary school?</td>
</tr>
<tr>
<td><strong>t2.4</strong></td>
<td>Why did you choose or not choose a science subject? (Encourage the participants to make a comparison between different stages of their schooling)</td>
</tr>
<tr>
<td><strong>t2.5</strong></td>
<td>Think about the science lessons you took when you were at secondary school. Can you remember a particular teacher’s lessons that were really impressive? What made you think that they were really good? (E.g. Topic really interesting, or because of the teacher? Or your team work with friend? The classroom setting? etc.) Follow-up questions include asking the participants to name factors that they think influence their feelings associated with science learning.</td>
</tr>
<tr>
<td><strong>t2.6</strong></td>
<td>Was there a science lesson, which you were interested at the beginning of the lesson, but felt disappointed during the lesson? What do you think made the change?</td>
</tr>
<tr>
<td>Was there a science lesson, which you were NOT interested at the beginning of the lesson, but became interested during the lesson? What do you think made the change?</td>
<td></td>
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</table>

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researcher to familiarise and engage with data. A reflexive journal was used by the researcher
to record initial ideas and thoughts. Then initial coding was conducted to identify aspects of
CLEs, HAAs and SAEs. Table 1 also provides possible examples for the coding process. Although adopted in quantitative research, some foundational aspects of CLEs from existing
instruments (Fraser 2012) also informed the coding process. The aspects of CLEs considered
in the data analysis include the student–student interaction (whether students support each
other), the teacher–student interaction (whether teacher support student cognitively and affec-
tively), cognitive environment (topic relevancy, classroom activities organised by teacher) and
the physical environment (such as availability of enough space and classroom layout). Once
individual CLEs, HAAs and SAEs were identified, their relationships were further examined
in relation to the research questions. Themes were then identified and reviewed to show
different types of interplay between HAAs and CLEs, and the effect of each type of interplay
on learner SAEs. Each theme was then given a name. The following section presents six
identified themes together with examples for each theme.

Results

Findings are organised according to the two research questions. A summary of
interplay types is listed in Table 3 (P1, P2, P3 represent types of interplay that result
in positive SAEs; N1, N2, N3 refer to types of interplay that hinder positive SAEs).
Frequency of occurrence for each theme was also provided in Table 3 to provide an
overall prevalence of the themes across the data set. However, it is worth mentioning
that due to the small sample size, high frequency of occurrence does not necessarily
mean that a theme is more crucial or more representative than others. Instead of
quantifiable measures, a theme was considered significant if it captured important
aspects about the data in relation to the research question and represented some
degree of patterned response or meaning within the data set (Braun and Clarke 2006).

P1—Self-Sustained

There are three types of interplay identified that result in positive SAEs. The first one is: P1—
Self-sustained—HAAs are strong enough to diminish or ignore the negative impact of CLEs,
leading to positive SAEs. Ruby’s scenario was a typical example.

<table>
<thead>
<tr>
<th>Name of the themes</th>
<th>Descriptions of the themes</th>
<th>Frequency of occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1—Self-sustained</td>
<td>HAAs are strong enough to diminish or ignore the negative impact of CLEs, leading to positive SAEs</td>
<td>2</td>
</tr>
<tr>
<td>P2—Beyond expectation</td>
<td>Strong CLE support exceeds the expectations set by HAAs</td>
<td>3</td>
</tr>
<tr>
<td>P3—Resonant</td>
<td>HAAs resonate with or are supported by CLEs in one way or another</td>
<td>5</td>
</tr>
<tr>
<td>N1—Adversely overpowered</td>
<td>Detrimental or conflicting CLEs outweigh HAAs that results in negative SAEs</td>
<td>4</td>
</tr>
<tr>
<td>N2—Below expectation</td>
<td>CLE does not meet the expectation set by HAAs</td>
<td>8</td>
</tr>
<tr>
<td>N3—Irresponsive</td>
<td>CLE does not respond to the requirements set by HAAs</td>
<td>5</td>
</tr>
</tbody>
</table>
Ruby saw herself as a biology-lover: ‘I love biology. I like the idea of investigating things and knowing why and how things work’. However, the learning environment for her was not a favourable one:

I didn’t really have a friend that I worked with, not in science. I wasn’t in the same home groups as my friends. … I had a really bad teacher. My teacher hated me in years 11 and 12 … she was more focused on the popular kids, so I had a really bad experience with that, but when she ignored me or I could ignore her, that’s when it was a lot better.

The aspects of CLEs highlighted here are peer relationship and student–teacher relationship. Ruby did not receive much support from peers and she had experienced a personality clash with her science teacher. However, these issues seemed not to have much impact on her emotionally in most learning situations with biology:

It was something that I liked, so I could stay committed and focused to it. … And I still have the love of science. … I just persisted because I liked it.

In Ruby’s case, self-sustained HAAs contributed significantly to her resilience in biology learning. Because her HAAs in biology were very strong, she was able to overcome the negative impact of the poor teacher and peer support.

**P2—Beyond Expectation**

The second type of interplay that resulted in positive SAEs is: P2—Beyond expectation—Strong CLE support exceeds the expectations set by HAAs. It takes time for HAAs to form and develop. By the time the students start secondary schooling, they have already developed a certain attitude towards science teaching and learning. Accordingly, they also have a certain degree of expectations about what they may experience in science classrooms. If the learning environment provides support that exceeds the student’s expectation, it may contribute to positive SAEs, such as feeling excited, amazed and interested. In this regard, Jake’s experience was typical:

Year 7, 8 and 9 [science lessons] were the ones that I can remember being impressed. Because I think coming from primary school where we did science but it was always sort of more like backyard science, … making volcanoes and stuff. … In secondary … we were playing with … sodium… where it just exploded. … I remember we had to go outside and it was a big build-up because we had to stay right back, and he [the teacher] dropped it [sodium] into a bucket of water and just sprinted away… I remember that being really stand out, that was really exciting. I was starting to see things that I wouldn’t normally see at home, and it was really fun.

Effective teaching strategies to gain student attention often had the characteristics of being novel and causing surprise, and, consequently, leading to exciting and enjoyable experiences (Renninger and Hidi 2011). Jake recalled a secondary science lesson which involved explosion and gave him a chance to see things that he would not normally see at home. It is worth noting that Jake made a comparison between this lesson and primary school science he had experienced. It is evident that this lesson exceeded Jake’s expectation about science teaching.
P3—Resonant

The third type of interplay that results in positive SAEs is P3—Resonant—HAAs resonate with or are supported by CLEs in one way or another. Most examples found among the participants relate to the cognitive aspects of the learning environment. For example:

Jessie: It was a science lesson and I liked it when we did the evolution stuff. That was interesting.

Interviewer: Was there a debate about it?

Jessie: Yeah especially with the very religious people in the class. I liked that because that’s interesting to me.

Jessie was particularly interested in the topic and the way the topic was taught also allowed her to contribute to the classroom debate. Her personal interest was supported by the cognitive learning environment, which resulted in an enjoyable situational experience. In another case, Emmy chose to do year 12 biology because she did year 11 biology and liked it. She also felt that she was confident in year 11 biology. From a point of view of HAAs, she had developed a certain degree of positive attitude towards learning biology. However, her experiences with year 12 biology were quite situation dependent. When her willingness to learn biology well was supported by peer relationship that provided a sympathetic, non-judgmental CLEs, it always led to favourable SAEs:

I wouldn’t learn a whole lot, but when we were together with eight year 12 peers, that was really good, and just being able to cooperate and collaborate with the really tough concepts. … When you get together with people that are sometimes in the same boat, or might know a little bit more about it, it’s really good just to nut out those ideas in the group.

Emmy also provided an example of a not-very-positive experience. This leads to the types of interplay that contribute to negative SAEs.

N1—Adversely Overpowered

There are three types of interplay identified that lead to negative SAEs. The first one is: N1—Adversely Overpowered—Detrimental or conflicting CLEs outweigh HAAs that results in negative SAEs. As in Emmy’s scenario:

Interviewer: … if we’re thinking about secondary school lessons, what’s an example of a bad one that you didn’t much like?

Emmy: Probably on evolution. I’m a Christian and … it was mainly the way that the teacher was teaching it, and he wasn’t really emphasising it as a theory, he was sort of stating it as fact. I found that very hard. … That was probably the one I didn’t like the most.

The above narrative shows that it was not the content itself, but the way the teacher delivered it, which irritated Emmy. Emmy had already developed her own worldview (Christian) and understanding of the nature of the particular theory (Evolution), both of which conflicted with the way in which the teaching was conducted. Emmy was therefore challenged during that lesson. Ebony’s experience also fell into this category, but related to different aspects of CLEs:

Biology… was interesting… but I had a massive personality clash with almost all of the science teachers…. I enjoyed science …. But I felt disappointed at the time and I still look back with disappointment and irritation.
Ebony’s HAAs towards science were positive (she enjoyed science). However, the attributes were not well supported in many occasions because of personality clash with the teachers. The following was a specific example:

The lesson that I remember the most clearly as being really unengaging was … with this one teacher, who I had a huge, huge issue with. … He was trying to tell us a story about genetic diversity … and I got annoyed and started talking to my friend. … And he said, “Well do you know the story?” And I said, “Yes.” And he’s like “well, do you think you could tell the story better?” And I’m like, “yes”. And then I did and I did tell the story better … and he got really aggressive about it.

The example shows that Ebony did know something about the topic; however, she was not able to contribute to the class learning in a positive way. Both Ruby (see the example provided earlier in P1) and Ebony had personality clashes with their respective teachers. While with Ebony, her HAAs were not strong enough to diminish the impact of the personality clash, which led to an undesirable classroom clash and negative affective experience.

**N2—Below Expectation**

The second type of interplay that contributes to negative SAES is: N2—Below expectation—CLE does not meet the expectation set by HAAs. Students enter the classroom with high expectation about the excitement of studying particular subjects in science. However, the CLE fail to meet the expectation, resulting in disappointment or dissatisfaction. For example:

I guess at the start of each new chapter, … you would be like ‘This is cool’ and then as you go on I just got more and more lost and couldn’t keep up with it. … Because I can learn from reading but if I’m just reading and answering questions it’s not very engaging. It’s just repetitive and boring. (Jessie)

The lack of continuing attention support (e.g. ‘just reading and answering question’) may lead to boredom and disengagement. More importantly, in Jessie’s cases, there was lack of continuing cognitive support, which resulted in too much challenge in learning and finally resulted in disengagement.

Sometimes, students have already developed a high degree of interest in science from their informal engagement (e.g. from mass media) with science. When they enter the classroom, they may feel disappointed when the new CLEs cannot provide learning experience as exciting as their previous ones. As in Jake’s case:

Forensic science was really disappointing. I know why I thought it was disappointing because I’d seen it on TV and it was not what we were doing. … I was thinking ‘this is going to be good’. … [But] the only thing I can remember we did was fingerprints.

Bella also expressed her disappointment to secondary science teaching while making a comparison between her own expectation of science being fun and magical, and high school teaching where all the fun aspects were taken out of science:

I love watching things, like biology things on National Geographic. And I love finding out about the natural world and I think it’s really interesting learning about the universe and all these science things. You didn’t get to hear about that in high school. Suddenly “you’re old enough so now we take all the fun aspects out of it”. And I think I very much
grew up believing in magic and wondering how everything came to be and I’m agnostic and I wondered about that. And it [secondary school science] just sort of stripped away all the wonder of it and made it boring.

**N3—Irresponsive**

The third type of interplay that contributes to negative SAEs is N3—Irresponsive—CLE does not respond to the requirements set by HAAs. As a result, either positive HAAs (individual interest) are not activated or detrimental HAAs (e.g. anxiety) are not well attended to. Different from the second type, in this case, students enter the science classroom but do not think highly about studying science, although they do have some level of initial motivation and interest in learning science. In most cases, the students wanted more cognitive support from the teachers or peers.

Emma wanted to become a vet and therefore chose chemistry in year 11. She had the willingness to do chemistry well. However, she did not have many productive SAEs, as highlighted by her response that ‘most of the time it was pretty dry’. The following scenario happened not just once:

The year 11–12 group that I went through with, we’d help each other out and we were very supportive of one another. The teacher was great, although not great at teaching. … he was very boring and not very engaging … He’s a friend of mine. … It was very boring and I used to fall asleep in chemistry classes and he’d throw dusters at me to wake me up. … Well we’d have a bit of a chuckle. …

It is evident that Emma had good peer and student–teacher relationships. What was lacking was the cognitive environment the teacher had established to facilitate the functioning of all the positive classroom learning factors.

Another example from Emma was also about chemistry. In this case, her situational interest was raised at the beginning, but did not last to the end of the lesson as a result of the cognitive learning environment not responding to the curiosity raised:

We made plastics and it was very interesting with doing the practical side of seeing the plastic forming. … the bit that lost me was the bit about writing out the practical what it all meant—that didn’t make any sense. … and my teacher said to me, “One day you’re going to get it and it’s just going to go ‘ding’, and you’ll know”. But I just didn’t get it in year 12, I just couldn’t grasp that.

Emma’s example shows that the practical activity successfully raised student interest. However, because of the lack of teacher’s cognitive support, she disengaged.

Only one participant, Bella, specifically mentioned anxiety specifically to science:

Science in high school, it was boring, it was confusing, I felt disengaged, I felt disappointed myself and I was afraid my mum was going to be disappointed in me, because I couldn’t understand it or I couldn’t do well enough. … For the most part, what I remember is just being bored and being disappointed and just anxious in class, or right before class anyways.

The anxiety she mentioned seemed to involve both HAAs—science learning–related anxiety (‘afraid of my mum was going to be disappointed in me’ and anxious ‘right before class’) and
situational anxiety experienced ‘in class’. Here, the lack of confidence in high school science seemed also to play a role in resulting boring and disengaging learning experiences: ‘I couldn’t understand it or I couldn’t do well enough’. Bella felt anxious before the class and continued to feel anxious in class. This implies that the CLEs did not respond well to reduce the anxiety.

Overall, six types of interplay were identified, with three leading to positive SAEs and another three causing negative experiences. The aspects of CLEs mentioned involve the student–student interaction, the teacher–student interaction and cognitive environment, though the level of impact of each aspect depended on individuals. Physical environment was mentioned by the participants. In some cases, where physical environment did influence SAEs, it was not seen as a result of directly interplaying with HAAs. Therefore, no theme related to physical environment was identified as relevant. The findings and their implications for science teaching and science teacher education are discussed in the following sections.

**Discussion**

In science education research, student prior knowledge (e.g. learners’ alternative conceptions) has been well studied. This study argues for the importance of attending/responding to prior affective factors, which has not been adequately acknowledged in both science education research and practice. Students enter the science classroom often with some degree of existing attitudes, interest or motivation, which can be seen as prior affective factors. Some students may have developed strong interest in science learning and high expectations on science teaching, while some may start to see science as irrelevant to their lives and/or a subject that is not for them. Findings of this study show that whether a student will have a favourable science learning experience is a result of the interplay of HAA as a prior factor and the CLE as a mediator. In other words, HAA or CLE alone is not an accurate predictor of SAEs. Three following observations are made based on the findings.

**Observation 1: Positive HAAs do not always lead to favourable learning experiences** On the one hand, some occurrences identified in P1 show that if the HAAs are robust enough, their influence can be very powerful and is most likely to elicit high level of situational interest and engagement (as in Ruby’s experience in P1). This is in line with findings from Ainley et al. (2005). On the other hand, although all participants in this study reported a certain level of positive attitude towards an interest in certain topics in science, many of them had negative learning experiences and some of them had repetitive negative experiences that finally caused their loss of interest. Studies, especially in developed countries, have shown a decline in students’ engagement in science across the secondary school years (Kennedy et al. 2014; Sjøberg and Schreiner 2010).

These alarming findings suggest that for many students, somehow their positive attitude and interest in science are not sustained. The decline of interest on science may start during the transition from primary to secondary schooling (Speering and Rennie 1996)—the level of wonder and excitement of science portrayed in secondary science teaching does not meet many students’ expectation (as shown in Bella’s lament in N2). Also in many cases with the participants, their positive HAAs were not strong enough to overcome the detrimental CLEs (N1) and therefore did not contribute to high level of engagement in science learning.

**Observation 2: Whether a CLE is supportive or not should be judged in terms of whether and how it responds to learners’ HAAs** Many studies have found that strong instructional
strategies, especially effective attention support strategies, such as being novel and showing enthusiasm, are consistent with the stimuli that generate strong situational interest (Hidi and Renninger 2006; Mitchell 1993; Palmer 2004, 2009; Renninger and Hidi 2011). Findings of this study show whether an environment stimulus is seen as novel or can cause surprise depends on how HAAs are mediated by the learning environment. Strong personal interest may generate high expectation for the learning environment. Once the environment support cannot meet the high expectation, it may cause the loss of interest or dissatisfaction. As in Jake’s examples (as shown in P2 and N2), Jake thought that secondary school science was more exciting as he did not have very high expectation on science teaching based on his primary school science experience. However, he thought forensic science was boring as he had a high expectation due to the impact of mass media while school science did not match the same level of excitement. In Jake’s example, strong interest caused higher level of challenge in engaging learners and the novelty of CLEs should not be taken for granted without the input of learner HAAs. Generally, once the CLE resonates/ responds well with HAAs, it is seen as supportive (P2, P3), while it is seen as not supportive if it fails to activate/respond to (N3, N2) or even negatively outweighs HAAs (N1).

Observation 3: Dissatisfaction and frustration are often experienced as a result of HAAs being ignored Ignoring learners’ HAAs may have varying outcomes depending on the type of HAAs and CLEs functioning in a specific situation. In Emma’s case in N3, the learning environment did not activate positive HAAs, such as personal interest, so the positive HAAs did not function as motivational source at the time of learning. Similarly, in N3, Emmy felt uncomfortable when her teacher taught Evolution as a fact while she was a Christian and saw it as a theory instead of fact. In this case, student’s attitudes towards science, especially about the nature of scientific theory and its relationship with her own worldview, were not well acknowledged. Conflict in worldview does not necessarily lead to negative science learning experience. However, resonating with Aikenhead and Michell’s (2011) argument, this example shows that if teachers, in delivering the scientific knowledge, do not attend to possible worldview differences, the students may experience confusion and frustration as a result of unsolved conflict. In a worse scenario, if some detrimental HAAs, such as subject-related anxiety, cannot be attended to, they may become major obstacles for learning (e.g. Bella as presented in N3).

Implications for Science Teacher Education

The current study emphasises the mediator role of CLEs. Among all the classroom factors, the role of teachers has been widely agreed as the most important one (Hattie 2003, 2008). Australian Professional Standards for Graduate Teachers developed by Australian Institute for Teaching and School Leadership (AITSL 2014) require pre-service teachers to demonstrate a range of knowledge and skills on teaching by the time they graduate. The standards include know students and how they learn and create and maintain supportive and safe learning environments. Understanding learners’ affective disposition can be seen as part of knowing the students and how they learn, while creating and maintaining supportive learning environment could involve making the learning environment more accountable for learners’ affective needs and expectations. Although being implied, the affective or emotional dimension is received limited attention in the standards. Findings of this study resonate with calls for expanding the realm of teacher professional knowledge to include understanding and responding to student affective learning needs (McCaughtry 2004; Zembylas 2007).
The National STEM (Science, Technology, Engineering, and Mathematics) school education strategy 2016–2026 (Education Council 2015) recognises ‘the primary and middle years as critical periods when students begin to cement their aspirations for, and confidence in, STEM’ (p.8). This implies that attending to student affective development and needs should be seen as a continuum, rather than as isolated stages. Initial teacher education has the advantage of providing the continuity by incorporating the understanding more explicitly into its programmes across different year levels. More research into the possible roles science teachers may play to facilitate CLEs to meet student affective needs would inform the implementation of the programs.

Conclusion, Limitations and Suggestions for Further Research

Acknowledging that both HAAs and CLEs are important to learners’ situational experience, the present study argues that it is more informative to science educators if, instead of being considered in isolation, the interplay of HAAs and CLEs is better understood and focused. Research has found that instructional design embedded with affective practices can be powerful in nurturing effective and exciting science learning (Glaser-Zikuda et al. 2005; Zembylas 2004). The affective dimension of science learning should not be underestimated. This study argues that creating enjoyable learning experiences depends on a learning environment better responding to student affective needs and expectations. Science educators should be better equipped with pedagogical approaches that help to elicit learners’ HAAs so that they can be purposefully attended to. In so doing, positive attitudes and interest can be effectively used to facilitate positive SAEs and negative attitudes or emotions (e.g. anxiety) can be well looked after to reduce their detrimental effect on learning experiences. Further research is needed to identify effective pedagogical strategies as environmental facilitators that better elicit and respond to student HAAs.

It is worth noting that the discussion and implication are based on the small sample size due to logistical reasons. Although the study does not focus on trends or statistical power, the small sample size could make the findings less conclusive and make it difficult to judge the level of significance of an identified theme. More research employing the same conceptual framework and method with a larger cohort of participants would more adequately evaluate the quality of the claims made. Furthermore, there are various aspects of learning environment (e.g. teacher support, topic relevancy and peer relationship) and the HAAs are also multifaceted (e.g. interest, confidence and attitude). The present study did not distinguish different aspects of learning environment or different subcategories of HAAs as the focus of the study was identifying possible types of overall interplay between the two constructs. How the learning environment can better support or respond to student HAAs will require a better understanding of the interaction between specific aspects of learning environment and specific HAAs. Further research that explores the interplay between HAAs and CLEs at the subcategory level would be welcomed.

References


Tapola, A., Jaakkola, T., & Niemivirta, M. (2014). The influence of achievement goal orientation and task
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AUTHOR QUERIES

AUTHOR PLEASE ANSWER ALL QUERIES.

Q1. Ref. "Randler & Bogner 2007" is cited in the body but its bibliographic information is missing. Kindly provide its bibliographic information in the list.

Q2. The citation “Bulunz et al. 2012” has been changed to “Bulunuz et al., 2012” to match the author name/date in the reference list. Please check if the change is fine in this occurrence and modify the subsequent occurrences, if necessary.

Q3. References [Allen & Potkay, 1981, Chaplin et al, 1988] were provided in the reference list; however, this was not mentioned or cited in the manuscript. As a rule, all references given in the list of references should be cited in the main body. Please provide its citation in the body text.

Q4. If applicable, please provide the access dates for reference "AITSL 2014, Education Council 2015, Hattie 2003, and Sjøberg & Schreiner 2010".