'We don't read in science' : Student perceptions of literacy and learning science in middle school

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Evaluative reading skills involve students learning to synthesize, analyse and adjudicate on a complex range of texts in science. The development of these skills is critical during the transition to middle school where the demands of discipline-specific reading in the science curriculum becomes more challenging. Explicit teaching of complex evaluative reading skills is, therefore, central to becoming a successful science student. Building on work that seeks to bring literacy instruction and student identity together, our study addresses a gap in research related to student recounts of their experiences as readers in Australian middle school science classrooms. To understand student perceptions of pedagogical approaches to reading in science, we asked 45 middle school students (aged 12 to 14) to reflect on what sort of reading participation was valued in their classroom and what they thought characterized a good learner in science. Findings show that evaluative reading is not perceived as central to learning in their science classrooms, rather a transmission pedagogic model of reading with an overreliance on fact sheets, worksheets, and PowerPoint was reported. Students also drew attention to how listening to the teacher for information and following instructions related to practical activities are integral to a ‘good science student’ identity. Findings suggest that young people’s beliefs about what is valued in science classrooms has implications for their science identities. We argue that providing teachers with access to knowledge about evaluative reading is key to advancing student learning and needs to begin with dismantling the structure of pre-service teacher education programs that isolate literacy and science preparation.

5 Keywords:

Inquiry-based pedagogy, science literacies, evaluative reading, science, learner identities

Word count 7767

Introduction

As young people transition from primary school to middle school, literacies associated with the science curriculum become more challenging (Duke, Pearson, Strachan, & Billman, 2011; Hopwood, Hay, & Dyment, 2017; Moje, 2008; Pearson, Moje, & Greenleaf, 2010; Shanahan et al., 2011) which requires substantial changed to pedagogic practice (Fang & Schleppegrell, 2010). Our research is concerned with student's experiences with reading in the science classroom and how these experiences contribute to developing their skills for reading and accessing knowledge in science (Bråten et al., 2014; Fang, 2006; Mason et al., 2014; Münchow et al., 2019; Pearson et al., 2010). How reading is perceived by students in science is an important and neglected area of study. As students engage with reading in the science classroom, pedagogies need to focus on fostering evaluative skills integral for analysis and the synthesis of sources (Bråten, Muis, & Reznitskaya, 2017; Mason et al., 2014; Yang & Tsai, 2010). So, while reading in science should heavily rely on an evaluative processes (Bråten et al., 2014; Münchow, Richter, & Schmid, 2019; Pearson et al., 2010), it must also consider how student experiences with reading and their identities as learners.

Students can be taught the skills to read and adjudicate on different knowledge sources in science (Münchow, Richter, & Schmid, 2019); however, pedagogic instruction should reinforce that all texts need to be viewed as resources for evaluation rather than as conveyors of the facts (Greenleaf, Brown, Goldman, & Ko, 2013). This article concerns students' understandings of the pedagogic approaches to reading in science they experience in middle school science classrooms (Bråten, Ferguson, Strømsø, & AnmarkrudBråten et al., 2014; Cervetti & Pearson, 2018; , Mason, Junyent, & Tornatora, 2014; Shanahan, Shanahan, & MisischiaShanahan et al., 2011). Approaches to science education have implications for how students learn to read a range of texts, and also how students come to see themselves as science students. For instance, the current focus on inquiry-based scientific investigation has privileged hands-on activities and a focus on doing practical work (Areepattamannil, 2012; Rennie, 2010) with the higher frequency of such pedagogic approaches linked to lower levels of scientific literacy (Oliver, McConney & Woods-McConney, 2019). Classroom pedagogies contribute to and foster conditions for learning (Cervetti & Pearson, 2018) and forms of participation, and in so doing also lead to learner identity formation (Grootenboer & Edwards-Groves, 2019; Wortham, 2005). As learner identities reflect school norms, practices, pedagogies and expectations (Johnston, 2004; Kim & Sinatra, 2018) students construct themselves in relation to what they perceive as valued within the institutional context. As Reay (2010) notes:

> [n]o other public institution is as crucial for the development of the identities children and young people will carry into adulthood. School norms, practices and expectations provide key symbolic materials that students draw on to make sense of their experiences and define themselves (p. 277).

In this way, identities develop in relation to experiences in educational settings (Reay, 2010), such as everyday interactions with peers, teachers, and materials in those settings that inform young people's understandings of self in relation to science (Kim & Sinatra, 2018).

Building on work that seeks to bring literacy instruction and student identity together (Jewett, 2013; Knain, 2006; Prain, 2006), our study addresses a gap in research, which related to the lack of direct student accounts of their experiences as readers in Australian middle school science classrooms. First, we ask how middle school students describe their reading practices in science classrooms. Second, we ask how middle school students describe a good science student. In exploring student perceptions of reading in their science classrooms, we are interested in what young people believe is valued and what the implications may be for their science identities, which we argue is evidenced in their perceptions of a 'good science student.' Student reports of their experiences of reading in their science classrooms provide insight into the daily teaching practices they experience, as well as normative expectations. Focusing on students at the middle school level is purposeful as it is a stage in their learning where their perceptions and their experiences as readers in science may change as the demands of discipline reading become more challenging (Fang, 2006; Hopwood et al., 2017; Mason et al., 2014). We consider how a 'good' science learner identity may be fostered or thwarted to varying degrees by the ways students perceive reading pedagogies in science.

This article progresses through four steps to explore student perceptions of reading in science and implications for their emerging identities as science learners. First, we consider what constitutes reading in science as well as teaching and learning of evaluative reading skills. We then review some significant influences on science curriculum and pedagogy along with the implications of performative agendas for fostering inquiry-based reading skills in the Australian context. Second, we outline our project, a qualitative study of 45 Year 8 students attending two middle schools in South Australia (one rural, one metropolitan) where interviews were conducted about student perceptions of a good science student and their experiences of reading in their science classrooms. Third, we discuss our findings based on two dominant themes in the data — that students 'do not read in science classrooms' and that a 'good science student listens to the teacher'. Finally, we conclude by bringing together the interview findings and current literature to make recommendations for expanding student repertoires of experience as readers in middle school science classrooms and what these broader perspectives may mean for how they understand themselves as learners of science.

Teaching and learning of evaluative reading skills

Within the discipline of science, reading involves exploration and meaning making that requires students to locate, evaluate, and adjudicate on conflicting information (Mason et al., 2014; Pearson et al., 2010). For instance, to engage in effective reading, students need to be able to select evidence to adjudicate on socio-scientific claims (Bråten et al., 2014), hypothesize, and develop an understanding of multiple concepts to describe a scientific phenomenon (Drew & Thomas, 2018). Therefore, becoming scientifically literate requires not simply learning how to read, write, and speak science texts but also the interpretation of the language of science to ascertain a deeper knowledge of science content, an epistemological stance, and discovery skills related to the Nature of Science (NOS) (Bråten et al., 2014; Norris & Phillips, 2003). For instance, the NOS specifically relates to understanding science concepts and the ability to make informed decisions about scientifically-based personal and societal issues (National Science Council, 2013).

Teachers can engage students in using evaluative pedagogies (Author et al., 2017; Bråten et al., 2017) by developing the skills needed to adjudicate on conflicting claims in science texts. Indeed, within science teaching, there are examples of many ways to draw on diverse reading experiences in science classrooms, as students use texts (e.g., textbooks, trade books, websites, science journalism, looking for argumentation in a text, and so on) to generate questions, access information, validate conclusions, communicate knowledge and understanding, and stimulate further inquiry in science (Abbey, Kerkhoff, & Spires, 2016; Fang & Schleppegrell, 2010; Poleman, Newman, Farrar, & Saul, 2012; Ritchie, Tomas, & Tones, 2011; Thier, 2010). Lupo, Strong, Lewis, Walpole, & McKenna (2018), for instance, suggest teachers choose four texts that vary in difficulty and genre, offering students opportunities to build their background vocabulary and knowledge while at the same time meeting disciplinary goals. Strategically, this would include multiple texts at varying levels of difficulty and opportunities for all students to engage in reading challenging texts (Elish-Piper, Wold, & Schwingendorf, 2014; Lupo et al., 2018).

In contrast to evaluative approaches to teaching science discipline reading, transmission models are also evident. Transmissive models are characterized by teachers scaffolding learning by reading key segments aloud in class, providing lessons that deliver the content (Greenleaf & Valencia, 2017), telling student the ‘facts’ that they need to know (Tovani & Moje, 2017), and focusing on ‘doing’ practical science (Settlage & Southerland, 2007). When students are exposed to such transmission models and a monolith of facts, they can become passive learners and dependent on the teacher for knowledge (Dillon, O'Brien, & Volkmann, 2001; Münchow et al., 2019). Transmissive models can be more common because developing evaluative reading skills can be daunting for teachers (Lombardi, Bickel, Brandt, & Burg, 2017; Münchow et al., 2019; Tovani & Moje, 2017), particularly when faced with students who struggle with literacy in science classrooms (Davison & Ollerhead, 2018; Greenleaf et al., 2013; Tovani & Moje, 2017).

The Australian Context

Due to concerns about science curriculum and pedagogy in countries such as Australia, there has been ongoing developments and reforms. A significant shift is the recognition of the importance of the NOS, which includes inquiry student learning (National Science Council, 2013). Definitions of inquiry-based teaching and learning span a wide range of meanings and strategies; however it is often viewed as student-centered interactions, student investigations and hands-on activities (Areepattamannil, 2012; Oliver et al., 2019; Rennie, 2010). This approach suggests a move away from the performance-driven agenda (National Science Council, 2013). The new Australian National Science Curriculum’s two major learning strands, Science Inquiry Skills and Science as Human Endeavour (alongside the Science Understanding strand), reflect a focus on the NOS. However, many teachers in Australia continue to grapple with the pedagogic concerns regarding approaches grounded in inquiry-based learning including limited professional development (Fitzgerald, Danaia, & McKinnon, 2019).

Schools in South Australia, where our study was conducted, use the National Curriculum facilitated through the Australian Curriculum Assessment and Reporting

Authority (ACARA) as the basis of science teaching. Science is structured around three interrelated strands related to i) content knowledge; ii) the nature and influence of science, and; iii) science inquiry skills — with an emphasis on building inquiry skills rather than undertaking the inquiry process (Fitzgerald et al., 2019). The National Curriculum also has a particularly strong focus on literacy as a general capability (Davison & Ollerhead, 2018), which is discussed in the science curriculum in terms of the development of critical thinking to both pose and answer questions based on scientific methods (ACARA, 2019). Australian specialist science teachers however do not always see literacy as an important element of the curriculum viewing teaching of literacy skills as the work of English teachers (Davison & Ollerhead, 2018).

With this in mind, our study sought to examine students' perceptions of reading pedagogies in science and how these were related to what was valued in the classroom – contributing to the development of their science identities (a 'good' science learner identity). To date little research has examined student accounts of their experiences as readers in Australian middle school science classrooms.

The Project

The article draws on a broader program of research exploring the nexus of literacy and science, in particular seeking to understand students' gendered science participation (see also Authors, under review). While the wider study is concerned about gender difference, here we were interested in middle school students' perspectives about their early high school experience of learning science.

The rationale for the study is to understand middle school student (12-14 year-olds) beliefs about science and literacy (Author et al., 2019), at a time when many young people begin to struggle with discipline specific literacies (Hopwood et al., 2017). Forty-five Year 8 students (24 boys and 21 girls) volunteered to participate from two school sites in South Australia (metropolitan and rural), representing a range of racial and ethnic groups. [1] In this cohort, 36 students identified as white; others identified as Russian (n=2), Sri Lankan (n=2), Italian (n=1), Pakistani (n=1), Indian (n=1), Vietnamese (n=1), and Malaysian (n=1). Both schools had similar demographics with an average ICSEA (Index of Community Socio-Educational Advantage)[i] value designated by the governing Department of Education. Ethical protocols were followed with principals, teachers, and students and their parents giving informed consent.

The interviews were semi-structured and allowed for participants to narrate their stories, highlighting their personal experiences as readers in science classrooms. By definition, semi structured interviews are 'guided by a list of questions or issues to be explored, and neither the exact wording nor the order of the questions is determined ahead of time' (Merriam, 2009, p. 90). Over the course of the interviews, the team of five researchers adhered to these semi-structured interview protocols, and, maintained 'reliable questions and … an atmosphere conducive to open communication between interviewer and respondent' (Gubrium & Holstein, 2012, p. 32). In our study, members of the research team talked individually with participants for approximately 30 minutes, in quiet locations around the school such as the library or resource room. Interviews were audio-recorded and later fully transcribed.

The research questions were used to guide analysis. This began with continuous reading and re-reading of the data followed by coding of the data according to repeated ideas and topics. We used template analysis (King, 2004) to identify dominant categories drawing on existing literature and prior research (deductive coding) and then adapted these categories during a reflective process of analysis (inductive coding). Sub-categories then emerged — for example, the first main category 'We don't read in science' was further coded as

‘Transmission of knowledge through fact sheets, worksheets and PowerPoint’ and ‘We just do pracs in science’. The second category, ‘A good science student listens to the teacher’, was nuanced by the sub categories of ‘Listening to information’ and ‘Listening to instructions’. Through this process, a coding template was established that the research team could use to initially code transcripts and check for consistency. For instance, two team members first coded five interviews each with iterative peer-checking of assumptions and interpretations. Following this process, the rest of the interviews were coded by the researchers, with any discrepancies discussed during team meetings to reach a consensus (Åkerlind, 2012). This systematic analysis informed our theoretical interpretation.

Discussion of findings

We turn now to a discussion of the findings. Two broad themes emerged from the data. First, most students perceived they did not engage in reading in science classrooms. Second, they felt a good science student listens to the teacher. These perceptions reflect students’ perceptions of the degree to which reading is part of science teaching and learning in middle school.

‘We don’t read in science…’

The first dominant category across the interviews related to the way the Year 8 students informed us that, in their view, they did not read in science. The following sections show the two sub-categories related to this perception of a lack of reading that emerged, namely; i) transmission of knowledge though reading fact sheets, worksheets and PowerPoint, and ii) we just do ‘pracs’ in science.   We had not anticipated this response, hence students’ repeatedly responding to our prompts, that they did not actually read in science was interesting.

Transmission of knowledge though reading worksheets, PowerPoints, and fact sheets.

The majority of young people primarily described a lack of independent reading in science with transmission of knowledge through fact sheets, worksheets, and PowerPoint. They explained how, in the science classroom, teachers largely read texts out loud, provided information they needed to know, and helped them to answer worksheet related questions. Kirra, for instance, was adamant that she did not read in science and told us 'I don't think I've really ever read a book about science'. When Kirra was prompted to think about whether she read in her science class, her response was a resounding 'no'. Tasha asserted she did not read in her middle school science classroom and explained her perception about the decrease in reading since her transition from primary school. According to Tasha, the year earlier, when she was in Year 7 in primary school, there had been some experiences reading 'big books' about science. However, now she was in middle school, the teacher appeared to play a pivotal role in scaffolding reading, particularly when there were instructions to follow. In the following excerpt of Tasha's transcript, she explained her views about the lack of reading in science.

> I don't really read about [science]. We don't really read about it. She [teacher] kind of reads to us what we have to do, and then we do it, but last year we had to read these big books, and there were questions and answer about all that science stuff, but there's not very much reading in science now.

Tasha's comments suggest her teacher had adopted a pedagogic approach which foregrounds scaffolding reading and learning by telling students what they need to know (Münchow et al., 2019; Pearson et al., 2010; Tovani & Moje, 2017). Bella talked about the changes in science reading since she transitioned to middle school.

> Interviewer: What's reading like at this school, because you've just started at high school, haven't you? So, can you tell me about that?

> Bella: I just come from Saint John's [de-identified] so we don't do as much reading as we used to do at my old school, but I still do it at home. It's [reading] probably not as challenging as it used to be.

The perceptions of Bella and Tasha about the lack of challenging reading in science illustrate a theme evident in interviews conducted at both school sites, that was common among both boys and girls. According to Dan the reading in science class is 'not really reading', where he further explained:

> In Science class our teacher might put a PowerPoint up or something and it's not really reading, but we can watch a video and get a lot out of a video, like we get the same amount of learning in the video from what we could in a book.

In Dan's classroom the integration of multimodal resources reflects the increasing use of such approaches in educational contexts whereby reading and learning from a video —was equated with learning from a book. This type of digital learning may be helpful for stimulating student interest around a topic and exemplifying multiliteracies for expression of ideas. However, there are limitations of such experiences, particularly in terms developing the higher level thinking skills around accessing information, validating conclusions, and stimulating further questions (Fang & Schleppegrell, 2010; Mason et al., 2014; Münchow et al., 2019; Pearson et al., 2010) — all critical to becoming fully literate in science.

When students did recount experiences of reading in science, they often mentioned the prevalence of reading fact sheets. Through this process, students perceived that the teacher facilitated learning by providing facts to be read (hard copy printed fact sheets, summary of facts on the whiteboard, PowerPoint presentations) rather than providing a variety of different text types. This pedagogic approach can be limiting, particularly when students need literacy opportunities to build knowledge by expanding their vocabulary (Brown & Concannon, 2016), as well as opportunities to develop thinking processes that facilitate intertextual linking strategies (Münchow et al., 2019). Providing readings that challenge given ‘truths’ about conflicting socio-scientific issues is one way to advance students’ evaluative reading skills (Bråten et al., 2014). The students in our study, however recounted identifying and highlighting key points rather than critically thinking about issues. As Jessie explained:

> We have sheets that we have to read through. So, let’s say we read through a sheet this week and then we would have to rewrite that maybe in our own words, in a hundred words, to make it easier or we might have a sheet that long and then we have to write the key facts or highlight the key words.

Skills required, according to Jessie, involved reading and summarising important information rather than critically thinking about concepts conveyed in the texts. This approach is in contrast to other pedagogic practices that engage students in vocabulary preparation and reading a variety of texts types (Abbey et al., 2016; Ritchie et al., 2011). In looking across the data, the monologic approach perceived by the students influenced what they believed was valued in the classroom, contributing to student learner identities, with several students making references to their abilities to recall the facts to do well on tests.

When engaging with worksheets, according to the students, they did not have to read them independently as they could rely on other key members of the class to read the fact sheets to their group. Many of the students we spoke with also relayed how they did not use textbooks in their science classrooms, as Clancy recalled:

> We’ve got textbooks, but we haven’t used them yet, so we haven’t done much reading unless it’s on the whiteboard, and we have to read that and copy it down. Not much reading in science.

As Clancy referred to his science textbooks that had not yet been read, several other students told us they did not have science text books. Textbooks, which can contain their own inherent weaknesses (e.g., problematic gender and ethnicity representations; complexity that deters student motivation), are not used frequently in Australia (Horsely & Martin, 2015). The emergence of collaborative digital text books is believed to offer affordances for multimodal representation of knowledge, communication and collaboration, however the use of digital textbooks and related multimodal reading has not been widespread in the Australian context to date (Horsley & Martin, 2015)

'We just do pracs in science…'

In their personal recounts around the lack of reading in science, students often refer to the practical side of science to justify this omission. Following instructions related to practicals was highly valued and largely how students understood learning in the science classroom. These routines developed over time, reinforce expectations and what is valued in the classroom, and ultimately influence students' emerging identities (Grootenboer & Edwards-Groves, 2019; Johnston, 2004; Kim & Sinatra, 2018). As Conrad explained, reading is 'not a very big thing that we do' as we 'mostly do hands-on stuff' in science – reflecting common based assumptions about the inquiry-based learning components of science education (Rennie, 2010; Oliver et. al., 2019). This justification for not reading, due to the prioritizing of 'doing the practicals and stuff' in the classroom, was something highlighted by all the students interviewed. There was general enthusiasm about the teacher-directed hands-on activities with a 'love' for 'doing all the pracs', along with a belief that this aspect was essential and, notably, more important than reading in science. In the excerpt below, Callum explained that he would like to peruse post-compulsory studies based on his experiences with the practical side of science.

Callum: Yeah, I think I would like to continue with science.

Interviewer: Why's that?

Callum: Well if it involves all these pracs that are fun and that I'd want to do, I'd like to do more pracs and just learn how ... we did a prac on burning foods to see how much sugar and energy they had in 'em and I found that pretty interesting.

While the practical side of science engaged Callum, as he progresses through the senior years of his schooling, the increasing reading demands of discipline literacy in science may become a barrier (Duke et al., 2011). Mitch explained, 'Well, sometimes I don't quite enjoy [science], like there's a lot of theory stuff. I like doing practicals', which highlights an interesting tension where science teachers must negotiate both content and pedagogic approach; they must balance covering the curriculum content, practicing the necessary skills as well as student engagement all while preparing students for more challenging literacy demands.

The practical side of science contributed to the student perception that science is process oriented and achievable, integral to their science learner identity. As Tyler explained, he was 'pretty good at it [science] because it's not really a hard to thing to do, I guess. It's just pracs and some projects.' This criterion was also associated with success in science according to Kade who also thought he was good at science because he liked the 'hands-on work, and I think I'm alright at it.' For these students, the opportunity for practicals positively engaged them and directly informed how they saw themselves as science learners. Furthermore, some of the students were able to make connections to a pedagogical shift in entering middle school, as Dan pointed out: 'I think in primary school I didn't enjoy it [science] as much because we didn't get to do pracs. But going into high school it's a bit different.' Again, the excitement around the practical side of science at the expense of adopting effective pedagogies which foster complex reading skills may have consequences for students who wish to progress to post-compulsory sciences.

Until recently, students' first experiences of purpose-built science laboratories were restricted to high schools in Australia. Not surprisingly, opportunities to engage with the practical aspects of science was clearly a highlight for most of the students we talked with and they identified this shift to practical opportunities in middle school. Kelsey's personal account highlights how practicals and reading worksheets structured the learning of science at the middle school level:

> Yeah, a little bit [different] because last year we usually did worksheets, and then rarely, not rarely, but sometimes we would do hands-on experiments. But in high school[ii], we do experiments and worksheets, but it's more detailed and more like, it's more detailed, I think.

This absence of complex reading related to science literacy reported by students resonates with international studies. These studies highlight the shift towards doing science and the value attributed to the practical hands on focus (Settlage & Southerland, 2007; Oliver et al., 2019). While there were references to reading websites at home to complete their science projects, these students did not recount expectations related to reading a variety of texts (Lupo et al., 2018) at school.

A good science student listens to the teacher

The second main theme that emerged was that students perceived a good science student as compliant and rule-abiding, which has possible identity implications. As learning and identity formation are mutually accomplished social practices (Hand & Gresalfi, 2015), the narratives illustrated the way monologic interactions — translation of information from teacher to student — were perceived as important norms in the classrooms that were enacted through students listening to their teachers. Understanding student perceptions in this area is important because school norms, practices, and expectations provide key symbolic information that students draw on to make sense of their experiences, to define themselves, and construct their identities (Kim & Sinatra, 2018; Reay, 2010; Wortham, 2005). The following sections highlight two sub-categories related to the importance of listening to the teacher, namely; i) listening to information; and ii) listening to instructions.

Listening to information

For the majority of students, an important part of being a ‘good science student’ related to listening to information. This view of a good science student may be associated with student beliefs that science involves the teacher relaying facts — identified in the first category.

A good science student, according to Zane, is ‘Someone who’s able to listen, comprehend what the teacher is saying’. In this way ‘listening to the teacher and paying attention’ is pivotal to the didactic relationship between knowledge as facts in science and transmission of this knowledge through listening. For instance, Tasha, who previously described the way reading was less prominent and challenging now she was in middle school, thought that a good science student needed to listen to the teacher to take in the information that was being conveyed.

> Well I think a good science student is someone who listens and takes in like all the information that the teacher's telling you.

In the excerpt above, Tasha illustrates a picture of a student as an empty vessel that ‘takes in’ knowledge about science. Rather than portray the good ‘science student’ as active and inquisitive, asking probing questions, and understanding how scientific processes work, there is a trend towards the construction of the good student embedded in a system of transmissive pedagogy (Thornberg, 2009). Listening was also important for learning, according to Bella. She appeared to equate listening with learning.

> Well, probably because I'm still young and still going to school and, yeah, because you really have to listen and see what you can learn if, yeah, because you learn something new every day in science I reckon. Yep.

Another student, Trent, also thought that listening was key to becoming a good science student. Trent describes how it is far more important than intelligence.

> Interviewer: It sounds like what you're saying they have to have a high degree of intelligence around it [science at school]?
>
> Trent: No, they don't really have to have a high degree of intelligence, they just need to know what they're doing and listen.

The absence of the need for intelligence to be a 'good science student' in the above comments is an interesting observation at this stage of the students' journey as science learners, particularly as success in science relies heavily on developing complex scientific reasoning (Bråten et al., 2014). Along with listening to the teacher for information, students also talked to us about listening to follow instructions.

Listening to instructions

Listening to the teacher was also particularly important for following directions as students engaged with the health and safety aspects of 'doing the pracs'. The focus on the practical aspects of science appeared inter-related with the need for associated instructions. For instance, Dan, who previously told us what he did in science was 'not really reading', explained to us that a 'good science student' needed to be 'listening to the teacher and doing what the teacher wants, just listening and doing the safe thing if you're doing like a prac'. Dan was dismissive of reading in science and his student identity related to engagement in the correct procedures with practical activities. What appeared most important, according to another student, Trinity, was ‘Listening to the teacher, making sure you get the instructions right, double checking.’ As Kelly explained:

> A good science student is always listening to the teacher, and making sure, say if we are doing prac knowing what to do, and listening...

According to another student, Tex, listening and paying attention were pivotal in his science classroom.

> You don’t have to be the best at a subject to be a good student of it if you’re paying attention, and the teacher is explaining what to do, and you’re doing what you’re meant to be doing. That makes you a good student in that [science] subject.

In the above example, following instructions is valued and essential for success. In contrast, not listening to the teacher for instructions and doing the right thing could be problematic. As Riley explained, his lack of listening led to his less favourable evaluation of his success as a science student.

> Riley: Well, I listen and stuff but sometimes I do something wrong or I add too much stuff and then something else happens. Kind of like that.
>
> Interviewer: What do you mean add too much stuff?
>
> Riley: If we’re doing a project or something like an experiment, and I add too much stuff into ... like liquid into something or burn something ‘cause I add that.
>
> Interviewer: Okay. So, would you say you’re good at science?
>
> Riley: No, not the best.

For the students in our study, listening to the teacher and successful engagement with practicals appears salient in terms of meeting the expectations and norms around a good student (Thornberg, 2009), ultimately contributing to one's emerging science identity (Johnston, 2004; Kim & Sinatra, 2018). There appears to be echoes here of 'safe conduct' within laboratory spaces. Given the current performative educational context — we had expected that students might associate a good science student solely with grades. A couple of students made references to their grades when they were evaluating if they personally were a good science student. For instance, Joel told us he was good a science because he 'got an A in science last year, so, I'm pretty good,' constructing his learner identity in relation to standardized measures of success (Reay, 2010); however, when students were asked to describe a typical 'good science student' their default response nearly always included 'listen to the teacher'.

Recommendations and conclusion

Our findings contribute to the field by illustrating middle school students' perceptions of reading in science classrooms and their conceptions of what is valued to become a good science student. According to the students in our study reading was not an important aspect of learning in science classrooms with the conception of a good science student primarily related to listening to the teacher for information or instructions. We argue the learning experiences reported by the students in our study influence their emerging science identities (Hand & Gresalfi, 2015; Kim & Sinatra, 2018; Wortham, 2005) and could have lifelong implications as schools are 'crucial sites of identity work and identity making' (Reay 2010, p. 278). That is, there appears to be a cyclical relationship or bi-directional influence between these findings whereby student perceptions of the norms and values associated with a good student are inter-related with their didactic experiences of reading literacy in the science classroom which has implications for how they become scientifically literate.

While our findings are based on students' perceptions of learning, their accounts resonate with many of the issues identified in our introduction – the tendency for teachers to present science as a monolith of facts (Moje Munchow, 2019; Tovani & Moje, 2017) and a focus on 'doing' practical science (Settlage & Southerland, 2007; Oliver et al., 2019). However, we are cautious of portraying teachers and their pedagogical approaches in a negative light as there are significant common challenges for science teachers who are increasingly expected to develop new inquiry-based approaches related to changing standards (ACARA, 2019; Fitzgerald et al., 2019; Oliver et al., 2019) and facilitate complex literacies in science for which they are not necessarily prepared, nor see as part of their role (Davison & Ollerhead, 2018).

According to Fensham (2016), two things are urgently needed to overcome teacher difficulties as they facilitate the science curriculum. The first is to provide explicit examples of good pedagogy: teaching these new NOS components in classrooms so that the teachers can observe what is intended and how it can be done in practice. This example would also include overcoming the 'traditional' view of science as objective and value-free. The second is to provide a means of assessing the staged acquisition of these procedures by students in valid and reliable ways. This would require moving beyond traditional conceptions of science as a body of subject matter (Fitzgerald et al., 2019). Providing teachers with access to knowledge (Bråten et al., 2017), however, is key to advancing student learning and needs to begin with dismantling the structure of pre-service teacher education programs that isolate literacy and science preparation (Pearson et al., 2010). Progress can also be made by drawing pre-service teachers' attention to the relationship between pedagogical practices and the identity development of students.

To conclude, more research is needed in regard to evaluative reading as embedded within inquiry-based approaches, particularly at the middle school level where disengagement from science occurs (Fang, 2006; Hopwood et al., 2017) and the literacy demands intensify (Mason et al., 2014; Münchow et al., 2019). As Pearson et al. (2010, p. 459) argue, when science literacy is ‘conceptualized as a form of inquiry, reading and writing activities can be used to advance scientific inquiry, rather than substitute for it.’ Positioning students as constructors of knowledge, rather than listeners and receivers of knowledge requires giving them the tools and information resources to employing science literacy practices (Greenleaf et al., 2013). Reading and evaluating knowledge is critical for students given the increasing need to engage with and respond to socio-scientific issues such as climate change, eco justice, genetic testing and pandemics. Therefore, we would argue that literate practices — particularly reading — need to be foregrounded in middle school science classrooms as evaluative processes to enculturate students into the skills to construct knowledge, beliefs, and worldviews required to read and think like a scientist.

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[i] The ICSEA (ACARA, 2015) provides contextual school data related to students' family backgrounds (parents' occupation, their school education and non-school education) and school demographics (geographical location and the proportion of Indigenous students).
[ii] In the South Australian education system, schools tend to be divided into Primary School (Foundation – Year 7) and High School (Year 8 -12). In 8 – 12 High Schools, 'middle school' is seen as Years 8 and 9. Some schools cater to Foundation – Year 12, which will then include a middle school cohort usually from Year 7 – 9.