Engagement and outdoor learning in mathematics

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The study reported here was conceptualised using a theoretical framework that included three dimensions of engagement; emotional, behavioural, and cognitive, and these were used to structure the data collection and analysis vis-à-vis learning mathematics outdoors. This comparative case study involved 34 students from two Year 6 classes at a Queensland state primary school. The findings indicate that the students were engaged in their mathematics learning in the outdoor context. However, there was no compelling evidence that suggested the outdoor environment was any more emotionally, behaviourally, or cognitively engaging than the indoor context.

The concept of engagement has been a growing concern for researchers, particularly in mathematics education (Attard, 2012; Chan et al., 2015), where it has been seen as a key factor in ameliorating low levels of achievement and student boredom (Fredricks et al., 2004). For this reason, it is important that the concept of engagement be explored in mathematics education, as low levels of engagement can result in low participation and achievement (Attard, 2011). Consequently, this has the potential to affect Australia's perennial shortage of mathematically literate citizens (Attard, 2011). Engagement is a multifaceted concept that has been defined along three dimensions: emotional, behavioural, and cognitive (Fredricks et al., 2004). Researchers have suggested that utilising the outdoors in mathematics education helps to increase students' engagement (Fägerstam & Samuelson, 2014; Haji et al., 2017; Young & Marroquin, 2008). It seems there is a growing interest by researchers to evaluate and compare the efficacy of indoor and outdoor learning environments. However, it is seldom seen that the effectiveness of outdoor learning is holistically evaluated through the lens of the engagement dimensions. This study seeks to determine the effects that outdoor learning has on students' engagement in mathematics. To this end, this study will explore outdoor learning vis-à-vis the three dimensions of engagement: emotional (with aspects of affective engagement), cognitive, and behavioural, and investigate the engagement of students in relation to indoor and outdoor environments. In addition, this study will clarify distinctions among the three constructs of engagement and how they are both individually and holistically identified within the learning context.

Given the apparent gaps in the literature, this study sought to determine the effects that outdoor learning had on students' engagement in mathematics. The research question guiding this study were:

- *What sort of engagement (emotional, behavioural, and cognitive) in mathematics does an outdoor learning environment facilitate?*
- *In what ways, if any, does student engagement in mathematics differ according to the learning environment?*

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Theoretical Framework

Emotional engagement is defined as the positive and negative reactions that students have to their peers, teachers, academics, and school (Fredricks et al., 2004). Skilling (2014) suggests that when students are emotionally engaged, they demonstrate interest and enjoyment. Emotional engagement is also commonly labelled as affective engagement by mathematics education researchers (e.g., Attard, 2011; 2012; Grootenboer & Marshman, 2016), and these researchers frequently come from an educational background and explore the deeper internal state of engagement. Others, who label it as emotional engagement, typically come from a psychological background and look at student's reactions to school experiences and environments. *Behavioural engagement* is defined as an individual's active participation and involvement in academic and social activities (Attard, 2012). The concept of participation is inherent to the construct of behavioural engagement (Finn et al., 1995) with Skilling (2014) and Fredricks et al., (2004), suggesting that students who are behaviourally engaged actively participate, persist and concentrate, ask questions, and contribute to class discussions.

Cognitive engagement is defined as an individual's investment in, and acknowledgement of, the value of learning and their willingness to go above and beyond the minimum requirements of a task (Attard, 2012). It also refers to the ability to suppress distractions and to maintain and regulate efforts in sustaining cognitive engagement (Fredricks et al., 2004; Skilling, 2014). It is critical to acknowledge that these engagement constructs are not isolated processes occurring within the individual, but rather they are dynamically interrelated and a shift in one can dramatically influence the others. Therefore, in this article, the dimensions of engagement are considered holistically as a multifaceted phenomenon.

Attard (2012) suggests that effective mathematical engagement occurs when a student is enjoying the subject, can easily see the relevance that their work has to their own lives and future, and can make meaningful mathematical connections between their learning in the classroom and their learning beyond school environment. Also highlighted in her work is the significance of choice and creativity in the mathematical learning context, and the suggestion that, if students are engaged in activities that encourage creativity and that provide opportunities to make decisions about their learning, their engagement in mathematics will increase. Motivation concepts are suggested to have significant relevance and are often synonymous with engagement. Student motivation increases when they are able to make links between what they are learning, their knowledge, and their inside and outside classroom experiences (Opitz & Ford, 2014).

The literature frequently suggests that outdoor learning is an effective pedagogical approach to increase student engagement (Attard, 2012; Fägerstam & Samuelson, 2014; Haji et al., 2017) and consequently student learning. Outdoor learning can include activities that take place on the playground, the oval, or the garden, and it has been suggested that students perform significantly better in outdoor activities than in similar indoor classroom activities in mathematics (Fägerstam & Samuelson, 2014; Haji et al., 2017). Similarly, it is considered that exclusively learning mathematics inside the classroom hinders students from fully understanding mathematical concepts (Haji et al., 2017). There is a diversity of desirable learning features associated with outdoor learning that can be seen as prompting, and resulting from, increased levels of student engagement. Taking mathematical lessons outside adds a new dimension to the learning experience where opportunities for multi-sensory perceptions are increased (Fägerstam & Blom, 2013).

Linking conceptualisation of engagement to the effectiveness of outdoor learning

When reviewing the literature on engagement and outdoor learning, clear links can be made between the two. Table 1 outlines the links between emotional engagement and outdoor learning theories. Table 2 outlines the links between behavioural engagement and outdoor learning theories.

Table 1
Linking emotional engagement theories to outdoor learning theories

Emotional Engagement Theories	Outdoor Learning Theories
"The element of fun was identified as an element of "good" mathematics lesson" (p. 371) (Attard, 2011)	"The pupils in this study all described positive experiences regarding the outdoor lesson… all of them spontaneously uttered remarks such as 'it was fun'". (p. 68) (Fägerstam & Blom, 2013)
"When an individual is engaged with mathematics, he or she has been influenced by motivation" (p. 10) (Attard, 2012)	"Outdoor lessons in outdoor environments have positive impact on the pupils' interest and motivation" (p. 69) (Fägerstam & Blom, 2013)

Table 2
Linking behavioural engagement theories to outdoor learning theories

Behavioural Engagement Theories	Outdoor Learning Theories
It is emphasised that inherent to the construct of behavioural engagement is the concept of *participation*, which is a crucial component in achieving positive academic outcomes (Finn et al., 1995)	Students who are generally reluctant to *participate* in mathematics are more likely to engage in tasks when lesson are taken outside (Young & Marroquin, 2008)
Behavioural engagement is concerned with students' actions such as their "efforts, persistence, concentration, attention, asking questions, and *contributing to class* discussions" (Fredricks et al., 2004, p. 62)	Students are generally willing to take greater risks when mathematics is taken outside and are more likely to volunteer to *share their answers and justify their thinking* (Young & Marroquin, 2008)

Also outlined in the literature on engagement is the close connection that behavioural and cognitive engagement share (Fredricks et al., 2004). As many students are willing to take greater risks and persist when learning is outside the classroom, it is also probable that outdoor learning facilitates opportunities for cognitive engagement. A significant component regarding the effectiveness of outdoor learning in mathematics, labelled the 'novelty and variation dimension', is proposed in Fägerstam and Blom's (2013) study. It is suggested that since outdoor learning is often a new educational experience for students, this might have a high impact on students' positive engagement. In their study, students often regard indoor learning as boring and monotonous (Fägerstam & Blom, 2013). It can then be proposed that outdoor learning offers a valued variation to this type of learning.

Methodology

The methodology for this study was previously presented (see Laird & Grootenboer, 2018), so only a brief outline will be provided here. To establish what effect the mathematical learning site (outdoors and indoors) has on students' engagement, a comparative, collective, case study methodology was used. The study involves the comparison of two sets of two cases. Both cases were Year 6 classes undertaking mathematics lessons on the same topic and concept.

The first set of two cases involved the students initially participating in a mathematics lesson inside the classroom. Following this, they participated in a similar mathematical lesson outside the classroom (e.g., the playground, oval, or elsewhere on school grounds). The second set of cases involved the students participating in the same mathematical lesson, but in the reverse order where they participated in the outside lesson first and then the inside lesson second. The focus of the lesson, which was introducing students to the 'order of operations ("BODMAS"), was determined by the teachers to accord with their mathematics *scope and sequence* planning.

For this study, three methods of data collection were used: a simple survey, structured observations, and document analysis. They relate specifically to the three dimensions of the theoretical framework as is outlined in Table 3 below.

Table 3
Data collection

Dimensions of Engagement	Data Collection Method
Emotional engagement	A survey that the students completed at the conclusion of each lesson.
Behavioural engagement	Observations of students participating in the lessons using an observation framework.
Cognitive engagement	Student work samples* collected in each lesson

* The nature of these depended on the lesson focus that the classroom teachers chose

As there were no existing suitable instruments found in the literature, new instruments were developed using relevant theoretical literature on the nature and features of engagement in educational settings (see Laird & Grootenboer, 2018).

Findings

Emotional Engagement

The emotional engagement of the students in the study was measured through a post-lesson survey given to all the participants immediately following both their indoor and outdoor lessons. It is acknowledged that this instrument is limited in its capacity to measure emotional engagement; nevertheless, it provides some insights that are useful in considering engagement in mathematics learning. The first analysis was conducted to see if there were any statistically significant differences for the whole sample at the item level, and total score, between the indoor and outdoor lessons. The descriptive statistics are shown in Table 4 below.

Table 4
Descriptive statistics for emotional engagement indoor and outdoor

		N	Mean	Std. Deviation
1. I enjoyed the lesson	Inside	33	3.88	.927
	Outside	34	3.94	.814
2. I thought the lesson was interesting	Inside	33	3.61	.827
	Outside	34	3.59	.957
3. I had a lot of fun during the lesson.	Inside	33	3.42	1.146
	Outside	34	3.56	.894
4. I would like to do that lesson again.	Inside	33	4.06	1.059
	Outside	34	3.56	1.019
Total	Inside	33	14.97	3.359
	Outside	34	14.68	3.082

These results of the t-tests indicated that there were no statistically significant differences in the students' emotional engagement between the indoor and outdoor lessons as measured by the emotional engagement survey. Specifically, the students' post-lesson responses to individual items indicated that the outdoor lessons were not perceived as being more enjoyable, fun or interesting, and there was no distinction in their perception of whether they would like to do a similar lesson again.

An open question at the end of the survey provided the participants with an opportunity to express any other thoughts. 23 responded, and in their responses, they were generally positive about both the inside and outside lessons. Positive responses associated with emotional engagement (e.g., fun, liked, enjoy) for the indoor lesson were limited (n=7), whereas there were many more for the outdoor lesson, and several students (n=23) gave more than one positive response. The words used were often about particular features of the lesson including "being outside" and also being able to "move around", with, for example, one student stating, "I would like to do the lesson again because it was outside and I think we should do more outside tasks". Also, students often used positive emotional engagement terms in regard to being able to work in pairs/groups, the way their teacher taught in this context, and the lesson generally as a whole. By way of examples, one student responded, "It was much funner [sic] than the lessons in class and we got to work in pairs or in groups most of the time. We never get to do that in class", and another said, "I would like to do the lesson again because it was outside and I think we should do more outside tasks".

Behavioural Engagement

The behavioural engagement of students in the study was measured through a behavioural engagement checklist, which was completed by the lead author during both the indoor and outdoor lessons. Although it is acknowledged that this instrument is limited in its capacity to measure behavioural engagement, it does provide some insights that are useful in considering behavioural engagement in mathematics learning. The resulting data was multifaceted, nuanced, and intricate, but here only aggregated findings will be presented, and these will focus on the different phases (see below) of the lesson, and the two learning sites (i.e., indoor, and outdoor).

During the lesson observations, three distinctive lesson phases were identified and these were present in all observed lessons - both inside and outside. The three phases were listening to the teacher (LT), working as whole class (WC), and individual work (IW). The purpose of identifying these lesson phases is so that behavioural engagement can be compared vis-a-vis specific learning phases rather than just time phases. Student engagement was observed and recorded at 5 minutes intervals. The number recorded represented different levels of engagement from the students in the class: 1 = None, 2 = Some, 3 = Half, 4 = Most, 5 = All. The summarised data for behavioural engagement for both classes in both lesson sites is outlined in Table 5 below (note that LT was barely evident in the data so it is not included)

Table 5
Mean behavioural engagement ratings across lesson phases and lesson sites (n=34)

Lesson Phase	Site	Active participation	Ask questions	Contribute to class discussion	Persist with tasks	Display strong levels of concentration	Average
WC	Outside	4.5	2.3	2.5	4.5	4.3	3.62
	Inside	4.4	2.3	2.5	4.4	4.4	3.6
IW	Outside	4.15	2.75	2	4.2	3.65	3.35
	Inside	4.15	3	3	4.2	3.75	3.62
Average	Outside	4.325	2.525	2.25	4.35	3.975	*3.485*
	Inside	4.275	2.65	2.75	4.3	4.075	*3.61*

These results indicate that there were minor differences between the behavioural engagement levels of students in the outdoor and indoor setting. Overall, it seems that students were ‘actively participating’, ‘persisting with tasks’, and ‘displaying strong levels of concentration’ with similar or the same levels of engagement during outdoor and indoor lessons. The data for ‘asking questions’ and ‘contributing to class discussion’ showed some differences indicating that students were engaging with the teacher and the class more in the indoor setting. When looking at the ‘asking questions’ section of the checklist, there seemed to be minor differences between the two indicating that students were asking more questions in the indoor setting. These results indicate that there were minor differences between the behavioural engagement levels of students in the outdoor and indoor setting while they were working as a whole class and doing individual work.

Cognitive Engagement

Definitions of cognitive engagement relate it to an individual’s ability to persist when problem solving, endure in the face of failure, demonstrate highly strategic learning qualities, and adopt metacognitive strategies to arrange and assess cognition (Zimmerman, 1990). In this study these were ‘measured’ based on an interpretation of these features that could be identified in students work samples. The work samples collected provided some evidence of the students’ levels of cognitive engagement, albeit that it was difficult to clearly identify certain features and to attribute them with any certainty to the particular site of the lesson. With this limitation in mind, in general the students demonstrated evidence of cognitive engagement when they were given the opportunity to immerse themselves in mathematics that required a high level of problem solving. This did not seem to occur in any particular environment - indoor or outdoor, but rather evidence of learning features that indicated high levels of cognitive engagement were observed only after some form of basic conceptual understanding was sound. For example, evidence of higher order thinking was found more in the students' second lesson work samples on order of operations because by this time they were able to participate in the more complex tasks. It is acknowledged that the data in this section is perhaps the least compelling, and in part, this is due to the 'internal' nature of cognitive engagement, meaning evidence often has to be inferred from behaviours and objects that can be observed. Also, there were some difficulties in even capturing the student work samples due to the activities of the lesson. Nevertheless, for the purpose of this small-scale study, cognitive engagement was examined using these qualities in an attempt to grasp some understanding of students' cognitive engagement levels.

Concluding Comments

This study focussed on student engagement in learning mathematics and, as is clear from this study and the relevant literature, this is a complex phenomenon. However, rather than being sidelined by the apparent difficulty in grasping the multifaceted and intricate nature of mathematical engagement, in this study the decision was made to accept the complexified quality of the phenomenon and then attempt to further investigate the topic. Unsurprisingly the findings are not conclusive; nevertheless, they are interesting and insightful. Put simply, rather than the indoor or the outdoor environment being more conducive to mathematical engagement per se, there is a need to appreciate all the pertinent factors (including the learning environment) when seeking to engage students in mathematical practices.

In general, the findings suggested that the students were engaged emotionally, behaviourally and cognitively in the outdoor learning environment. Although most of the data suggested that the outdoor learning environment was conducive to engendering all the dimensions of engagement, it was evident the dimension of emotional engagement was enhanced the most. However, although the outdoor environment was generally engaging for the students, it was not evident that they were any more or less engaged in their mathematics learning than in the indoor environment. This finding is noteworthy as it is somewhat at odds with the literature that indicated, albeit not conclusively, that an outdoor environment is likely to be more engaging.

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