Can an outdoor learning environment improve children's academic attainment? A quasi-experimental mixed methods study in Bangladesh

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The present study adopted a quasi-experimental mixed method approach to investigate the influence of an improved school ground on children's academic performance. In total, 123 children from two (intervention and control) primary schools in Bangladesh participated. In the intervention school, a barren school ground was redesigned with several behavior settings (e.g., gardens and amphitheater) for teaching and learning. Treatment group children (n=29) received math and science classes outdoors, while a comparison group (n=32) received usual indoor classes. A control school with no changes to the outdoor environment was included (n=62). The redesigned school ground was associated with higher levels of academic attainment. Furthermore, all intervention schoolchildren perceived more opportunities to explore in the redesigned school ground. Qualitative insights suggest the diverse settings provided more opportunities to explore, experiment and work collaboratively. These results highlight the potential for school ground design to contribute to improvement of children's academic attainment in developing countries.

Keywords: outdoor learning, primary school ground, quasi-experiment, behavior settings, academic attainment

Introduction

Outdoor learning is becoming increasingly prevalent in developed countries, as research highlights benefits of learning outdoors on academic attainment, engagement and behavior (e.g., Lieberman & Hoody, 1998; Lieberman, Hoody, & Lieberman, 2000, 2005). Indeed, definitions of outdoor learning often cite benefits to academic attainment. For example, Palavan, Cicek, and Atabay, (2016) state that “outdoor education focuses on experimental, hands-on learning in real-life environments through senses, e.g., through visual, auditory, and tactile means, improving students’ learning and retention of knowledge as a result” (p.1885). In developing countries, poor academic attainment, engagement and drop-out are common, therefore, it seems appropriate to examine whether outdoor learning could be used to promote children’s learning in this context. At present, one in five Bangladeshi children who enroll in primary schools do not complete their primary education (Ministry of Primary and Mass Education, 2016). Poverty, lack of quality education and the poor physical environment of schools are often cited as causes for this (Chowdhury, Chowdhury, Hoque, Ahmad, & Sultana, 2009; Zaman, 2014). The present study examined whether and how school ground design and outdoor learning could facilitate and improve children’s academic attainment in Bangladesh. While there is a considerable body of research highlighting benefits of outdoor education on learning in developed countries, research in the context of developing countries is scarce, with only one study published to date (Khan, McGeown, & Islam, 2018). This study therefore makes a considerable contribution to our evolving understanding of whether and how school ground redesign and outdoor education can influence attainment in developing countries.

Outdoor Learning and Academic Attainment

Numerous studies have found a positive impact of outdoor learning on children’s academic performance (measured via self-reports or assessments) (Khan, McGeown, & Islam, 2018; Lieberman & Hoody, 1998; Lieberman et al., 2000, 2005). For example, in the US, students attending schools where the surrounding environment was used as a context for teaching (Environment used as an Integrated Context, in short EIC) reported better reading, writing, math, science and social studies achievement compared to students in more traditional schools (Lieberman & Hoody, 1998). In later studies using standardized test results, EIC students were found to achieve higher mathematics and science scores than students in traditional classrooms (Lieberman et al., 2000, 2005). Furthermore, teachers reported reduced discipline and classroom management problems, increased engagement and learning enthusiasm, and greater pride and ownership of accomplishments in the EIC schools compared to the traditional schools (Lieberman & Hoody, 1998). More recently, in a randomized control trial in the US, after receiving a gardening intervention (raised beds and lessons in gardens) children from low income schools showed modest gains in their science knowledge from baseline to follow up compared to the control group (Wells et al., 2015). While in a pre-post quasi-experiment in Bangladesh, Khan et al. (2018) found higher science attainment scores and more positive reports of learning engagement when primary school children had been taught science outdoors (in an amphitheater) than indoors in their classroom.

In developing countries, primary school indoor classrooms often feature poor physical environments for learning, for example, poor lighting, seating and visibility are common (Khan et al., 2018). These indoor classrooms offer few, if any, opportunities for independent exploration and collaboration as children are typically seated in rows facing a blackboard, with insufficient space for group work or exploration to occur naturally or easily. It is in these contexts that a well-designed outdoor school ground could provide an alternative place for children to learn more effectively, and offer greater opportunities for independent exploration and cooperation (Khan, 2012; Wu, Anderson, Nguyen-Jahiel, & Miller, 2013).

Indeed, the opportunity to explore and investigate the world from outside the classroom is typically inherent within most definitions of outdoor learning. From psychology, theories of constructivism (Piaget, 1964) and social constructivism (Vygotsky, Cole, John-Steiner, Scribner, & Souberman, 1978) offer suggestions as to how outdoor education can facilitate learning. Piaget's theory of constructivism proposes that children learn best through independent discovery (Inhelder & Piaget, 1969); that by exploring their environment and making their own discoveries, children construct new knowledge (Wood, 1998). On the other hand, Vygotsky's theory of social constructivism suggests that learning occurs through interpersonal connections in a social environment, where adults and peers support and promote children's learning.

School Ground Design and Academic Attainment

Most research exploring the relationship between school ground design and academic attainment has focused on the impact of 'greenness'[1]. Indeed, several studies in the US have revealed a positive association between school and neighborhood greenness and children's academic attainment, although previous studies exploring this relationship did not differentiate between different types of greenery (i.e., tree, shrub and grass) (Browning, Kuo, Sachdeva, Lee, & Westphal, 2018). More recent studies by Sivarajah, Smith, & Thomas (2018) and Kuo, Browning, Sachdeva, Lee and Westphal (2018) positively link school tree cover density with academic achievement. Furthermore, Kweon et al (2017) reported a positive association between number of trees and achievement in mathematics and reading standardized tests; landscapes devoid of features (e.g., grass), on the other hand, have been found to have the opposite effect. Interestingly, even classroom window views of trees and shrubs have been found to be correlated with high school students' graduation rates and academic merit awards (Matsuoka, 2010).

The relationship between school ground design/greening and academic performance is complex, with research often focusing on mediating variables; for example, reduced stress and improved well-being, attention and cognitive functioning (Chawla et al., 2014; Dadvand et al., 2015; Kelz, Evans, & Roderer, 2013; Li & Sullivan, 2016). However, an alternative approach is to examine academic attainment by the affordances that school ground design offers. Gibson's (1979) theory of affordances refers to those properties of an environment that support and complement people's development. The opportunities for learning offered by different physical features of the school ground have been termed 'cognitive affordances' by Khan, Bell, McGeown, and Silveirinha de Oliveira (in press). Indeed, rich and diverse outdoor environments provide more affordances for play and learning (Cosco, 2006; Moore & Wong, 1997) whereas barren school grounds can discourage children from diverse play, social interaction, ecological experience and learning (Samborski, 2010).

In summary, these research studies highlight possible benefits of a carefully designed school ground on children's learning and attainment. However, despite a growing body of knowledge on this topic, significant research gaps remain. For example, most experimental research studies have investigated the influence of school ground redesign on physical activity, cognitive functioning or stress reduction; rarely have studies focused on pedagogy and attainment, and there an absence of mixed methods research studies that also take into account children's views. Furthermore, a significant gap exists in our knowledge of school ground design and its relationship with academic attainment in developing countries. To our knowledge, Khan et al (2018) was the first to report a quasi-experimental study investigating the impact of learning in an outdoor classroom in the context of a developing country.

The Present Study

In the present study, an intervention was carried out in a primary school in Bangladesh, where the school ground was designed and developed as a place for teaching and learning. Using a pre-post design the present study evaluated the impact of learning in a renovated schoolground on children's academic attainment. Using questionnaires and focus group discussions, the study further explored how the school ground may have supported children's learning. It is a study of children's behavior from an environmental designer's perspective, the aim of which is to investigate whether the use of the outdoors as a learning environment can help with issues particularly pronounced in developing countries like Bangladesh i.e. low academic attainment.

An intervention school (IS) and control school (CS) were selected in Bangladesh; the former received changes to the school ground and outdoor education was introduced to a randomly selected group of students at this school (TIS), while a second group at this school did not receive outdoor education (CIS). The following hypotheses were examined quantitatively. It was predicted that:

a) The treatment group (TIS) would have significantly better academic attainment in subjects taught outdoors (i.e. math and science), compared to the comparison group from the same school (CIS) and control school (CS) children.
b) The TIS group would report significantly more positive reports of opportunities for exploration outdoors compared to the CS group. No differences were predicted between TIS and CIS groups.
c) The TIS group would report significantly more positive reports of opportunities for collaboration outdoors compared to the CS group. No differences were predicted between the TIS and CIS groups.

Qualitative methods were also used to understand TIS children's perceptions of how the school ground design and outdoor teaching supported, or hindered, their learning.

Method

Study Design

This mixed methods intervention study included pre and post-test measures. The independent variable was school ground (redesigned in intervention, no changes in control) and the dependent variables were academic attainment and children's perceptions of opportunities for exploration and collaboration. Qualitative insights were also sought using focus groups.

Selection of Study Settings

Two public primary schools: an intervention school (IS) and a control school (CS) in the sub-district of Raipura, about 180 kilometres from Dhaka, the capital city of Bangladesh, were selected (see Figure 1). The majority of children in Bangladesh attend public schools for primary education and these schools share a standard design, which is prototyped across the country following some site adjustments (e.g., orientation of the building and number of classrooms depending on the length and width of the site). Over 60,000 public primary schools meet these criteria. Among the 213 public primary schools in the sub-district of Raipura, 10 schools were shortlisted based on several criteria:

a) Whether the schools comply with the physical environment requirement (0.33 acres of mandatory land area)
b) Demographics of the school and children (i.e., average school size, n = 300-400 students)
c) No development or pilot project taking place on site
d) Interest and availability from the school for intervention and field research

Following a rigorous analysis of schools in Raipura based on these criteria, the intervention school (IS) was selected. Using the IS's exam scores, child demographics (e.g., gender), school size and quality of the physical environment, a control school was selected (CS) (see Table 1). For ease of data collection and to ensure comparability in curriculum and assessment, the search for a control school was restricted to the same township; this also ensured children were of similar socio-economic backgrounds.

Table 1: Profiles of intervention and control school

	Intervention School	**Control School**
Number of students	358	325
Students' gender	52% boys, 48% girls	49% boys, 51% girls
Student teacher ratio	40:1	36:1
School parcel size (square meter)	1180	1000
Building area (square meter)	294	180
Number of students participating	TIS: 29 , CIS:32	62
Mean age of participating students	9.18 (1.223) TIS: 9.11(1.19) , CIS: 9.24(1.27)	9.57 (1.06)
Gender of participating students	TIS: 45% boys 55% girls CIS: 59% boys 41% girls	48% boys 52% girls
Exam score of participating students	**Math** 43.71 (20.16) TIS: 47.71 (19.53) , CIS: 39.71 (20.32)	53.02 (22.74)
	Science 45.34 (20.74) TIS: 48.86 (21.14) , CIS: 41.82 (20.10)	51.42 (14.90)

(a) (b)

Figure 1: Pre-intervention view of (a) the intervention school from the road and (b) the control school from the northwest corner

Participants

In total, 123 children (aged 8-11) participated in the study (61 from IS and 62 from CS). Within the intervention school, there were two predefined ‘sections’[2], Section B comprised the treatment group (TIS) (*n*=29) and section A comprised the comparison group (CIS) (*n*=32). There were no baseline differences in test performance between the sections and both sections received the same number of daily classes, with specific curriculum content (e.g., science, mathematics) taught by the same teacher in both sections.

Children aged 8-11 (Grade IV) were selected as it is possible to obtain reliable measures of their academic performance as they participate in mathematics and science exams, whereas younger students do not. In addition, the drop-out rate for primary children is highest at this Grade (BANBEIS, 2014), therefore evaluating interventions to encourage greater engagement and retention among this age group is crucial.

Measures

Academic attainment: Math and Science

Public primary schools in Bangladesh administer three exams taken at four-month intervals in April, August and December. Children’s attainment scores were collected in December 2014 and May 2015 as pre (T1) and post (T2) results from both the intervention and control school. Only mathematics and science exam scores were used as only these subjects were taught outdoors. The exams taken by students in the intervention and control school were the same and clear marking criteria were given, therefore scoring was objective.

Perceived exploration and collaboration.

A self-report questionnaire was designed (following Artino, La Rochelle, Dezee, & Gehlbach's 2014 survey scale design process) to gain insight into children's perceived opportunities for exploration and collaboration outdoors. Following a literature review and early input from children and teachers (n = 7), questionnaire items were developed originally in English. Following pilot testing (5 children, 2 teachers) in Scotland, minor language modifications were made before the questionnaire was translated double-blind following the recommendations by Griffee (2001). Expert validation was conducted by an expert in child development in Bangladesh. Further pilot testing (6 children/6 teachers) in Bangladesh resulted in one further modification. All children completed the questionnaires at T1 (November 2014) and T2 (May 2015).

The questionnaire examined perceived opportunities for exploration (using 4 items focusing on independent exploration, exploration, playfulness and discovery, T1 $\alpha = .40$, T2 $\alpha = .68$) and collaboration (using 4 items focusing on support, co-operation, sharing of ideas and group work, T1 $\alpha = .42$, T2 $\alpha = .62$) outdoors. Cronbach's alpha values were higher at T2. Factor analyses (principal component analysis with Varimax (orthogonal) rotation) using T2 data indicated that the four exploration items were distinct from the four collaboration items, see Table 2. Furthermore, to assess the scales' test-retest reliability, T1 and T2 data were used from the control school and were $r = .582$, $p<.05$ and $r = .470$, $p=.05$ for exploration and collaboration respectively. Children responded using a 4-point scale, ranging from "never true" to "always true."

Please see Appendix for questionnaire items and response scale. At both times, the questionnaire was completed in the children's indoor classrooms. Children were given instructions on how to complete the questionnaire, including practice questions. The researcher ensured all children completing the questionnaire understood the questions asked.

Table 2: Factor loadings for questionnaire items

Question	Exploration	Collaboration
Support	.002	**.724**
Playfulness	**.693**	-.118
Independent exploration	**.483**	.397
Co-operation	-.084	**.732**
Exploration	**.743**	.261
Sharing of ideas	.153	**.642**
Discovery	**.835**	-.119
Group work	.495	**.566**

Note: Highest loading for each item is in bold. All items loaded most highly onto proposed construct.

Children's qualitative insights.

Qualitative insights were gained via six focus groups (4-6 children in each) at T2. Only all TIS children (13 boys and 15 girls) participated in the focus groups. The researcher created small groups and a friendly environment to encourage full participation from all children (Krueger & Casey, 2009). The focus group discussions were semi-structured, each lasting approximately 30 minutes. Discussions focused on how the school ground supported or deterred learning in science and math, children's views about learning other subjects outdoors and the potential influence of the school ground on teachers' quality of teaching. The conversations were recorded and translated into English during transcription.

Procedure

Pre-intervention data collection (T1, November 2014) was held prior to school ground construction (November 2014 – January 2015). TIS children were then taught mathematics and science outdoors from January 2015 – May 2015, with post-intervention data collected in May 2015 (T2).

Design and development of the school ground.

The school ground was designed as a combination of seven behavior settings: a natural learning area, a water learning area, an area with loose materials, an amphitheater, a play area, gardens and huts (see Figures 2 & 3). All settings were designed around an open yard and a pathway was formed using a series of stepping stones, providing access to all settings. Some parts of the school were painted bright colors and the children painted a mural on the boundary wall. As part of the natural learning area and gardens, new plants were planted, which resulted in 27 types of vegetation in the school ground after redesign compared to only two types before intervention. A detailed description of the design and development of the school ground is published elsewhere (Khan et al, in press). After the school ground was ready for use, the use of the school ground for teaching of the curricula (science and math) was limited to only the TIS group (see Figure 4), however the school ground was used for play and other informal learning activities by all the children in the school.

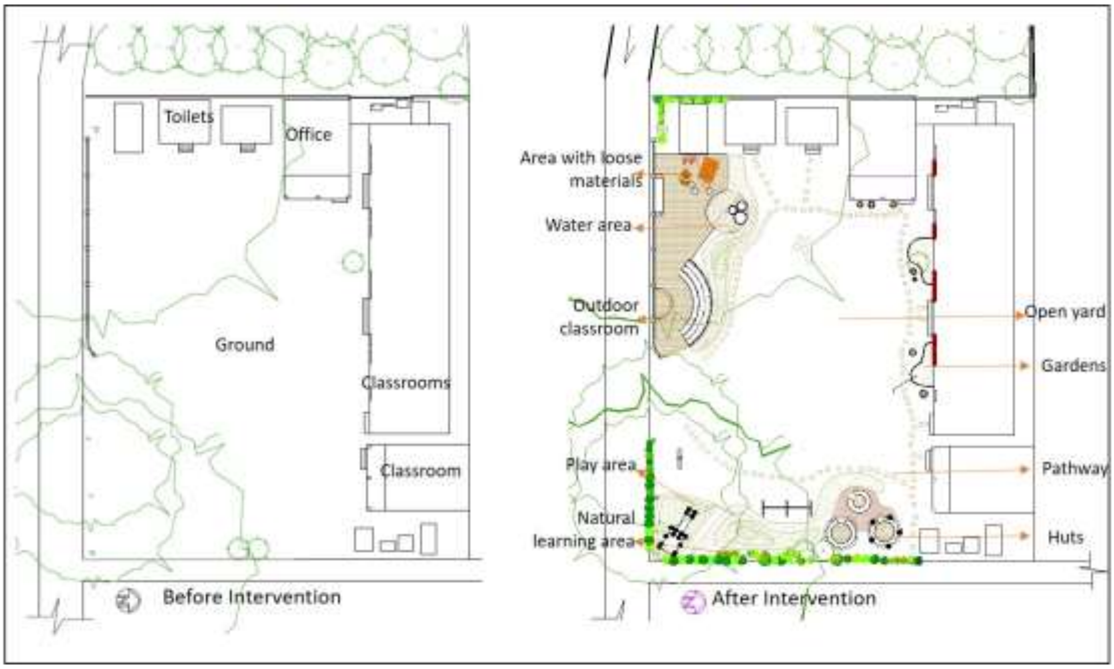

Figure 2: Plan of the school ground before and after the intervention

Figure 3: Image of the school ground after the intervention

Intervention details.

In both the intervention school (treatment and comparison group) and control school, children received 40 minutes of mathematics and 40 minutes of science teaching daily (children attend school 6 days a week in Bangladesh). The time allocated to mathematics and science teaching was not changed from the ordinary provision in either school. In addition, children in the treatment group did not receive any supplemental teaching – their standard curriculum was always taught outdoors instead of indoors (with some exceptions due to weather). In the intervention school, the same teacher taught math to the treatment group outdoors and comparison group indoors. Similarly, the same teacher taught science to the treatment group outdoors and comparison group indoors; therefore ‘teacher’ remained constant across both conditions. The teachers were given no guidance as to how to teach math and science outdoors and were encouraged to develop their own pedagogy to teach the same curriculum as was taught indoors. This curriculum was the same as that in the control school. For the comparison group in the intervention school, students sitting beside windows could view the redesigned school ground from their classes, but through small windows which are characteristic of the building’s design.

Groups	**Pre-test T_1** **Oct – Nov 2013**	**Experiment X** **Design and construction Nov-Jan 2014** **Outdoor learning/ play Jan-May 2015**	**Post-test T_2** **May 2015**
Treatment Group **Intervention School**	Attainment Scores Questionnaire Focus groups	Exp (Intervention + Outdoor learning + Outdoor Play)	Attainment Scores Questionnaire Focus groups
	T_1	-	T_2
Comparison Group **Intervention School**	Attainment Scores Questionnaire	No Exp (Intervention + Outdoor Play No Outdoor Learning)	Attainment Scores Questionnaire
	T_1	-	T_2
Control School	Attainment Scores Questionnaire	No Exp (No Intervention)	Attainment Scores Questionnaire

Figure 4: Design of the treatment and the comparison groups

Ethical considerations.

Ethical approval for the project was granted by the University of Edinburgh and permission was also obtained from the school headmaster and the parents to record, photograph and videotape the children during the research process (i.e., renovations to the school ground, focus group discussions). In addition, verbal assent from the children themselves was gained prior to the study and prior to each focus group discussion.

Data analysis

Quantitative data was analyzed using SPSS. The Kolmogorov-Smirnov test of normality generated a significant result in most of the variables, which suggests the violation of normality. However, this was conservative for many of the cases (Hopkins & Weeks, 1990; Pallant, 2013). As an alternative approach the skewness and kurtosis data were examined to identify whether the data fell into the acceptable range of normality (George & Mallery, 2013; Lewis-Beck, Bryman, & Liao, 2003), which they did. Therefore, parametric tests (one-way ANCOVA) were selected to compare the groups, however a non-parametric alternative for ANOVA (Kruskal-Wallis ANOVA) was also conducted.

The influence of the outdoor environment on exam scores was measured by comparing the groups - i) TIS and CS and ii) TIS and CIS at T2, using a one-way ANCOVA, which accounted for T1 scores. The influence of outdoors on perceived exploration and collaboration was also analyzed following the same procedure. The data generated from the focus groups were analyzed using thematic analysis in order to capture the complexity of meanings from the children’s responses (Guest, MacQueen, & Namey, 2012). The data were analyzed combining the matrix and template process within thematic analysis outlined by King and colleagues (2010). From this, several themes emerged: children's activities, place preferences and learning math and learning science in the school ground. These themes were used to form the headings of the preliminary matrix structure; each question under a general theme formed a sub-theme (e.g., opportunities for exploration and opportunities for collaboration under learning science and math in the school ground) which formed a sub-heading in the matrix structure. Focus group extracts/quotations were then assessed and organized under the headings of that matrix structure. A template was developed based on the themes from the matrix; the themes and subthemes in the matrix and template were not rigid and subthemes or overarching themes were redefined throughout the analysis process, allowing new themes to emerge, e.g., physical comfort. The analysis was an iterative process that required going back and forth between the template and matrix.

Results

Pre-test scores

At T1, there were no significant differences in math or science scores between TIS and CS or TIS and CIS ($p > .05$). Similarly, there were no statistically significant differences found for perceived exploration and collaboration between the groups ($p > .05$). Therefore, the T1 measures indicate the comparability of the groups and schools in terms of their academic attainment and perceptions of opportunities for exploration and collaboration outdoors.

Academic attainment

In a one-way ANCOVA (co-varying for T1) to explore differences between the groups after four months of teaching and learning in the outdoor environment (T2), there was a significant difference in math attainment between the groups: $F(2, 99) = 8.53$, $p < .001$, $\eta_p^2 = .15$ (see Figure 5 and Table 3). After correcting the significance level for multiple comparisons, (Bonferroni), TIS scores were significantly higher than

CIS and CS scores ($p < .0125$). There was no significant difference between CIS and CS. With regard to science, there was a significant difference between the groups: $F(2, 99) = 7.00$, $p < .001$, $\eta_p^2 = .13$. After controlling for multiple comparisons (Bonferroni), TIS scores were significantly higher than CIS and CS scores ($p < .0125$). There was no significant difference between CIS and CS. These results support the hypothesis that learning in a redesigned school ground can improve children's academic attainment.

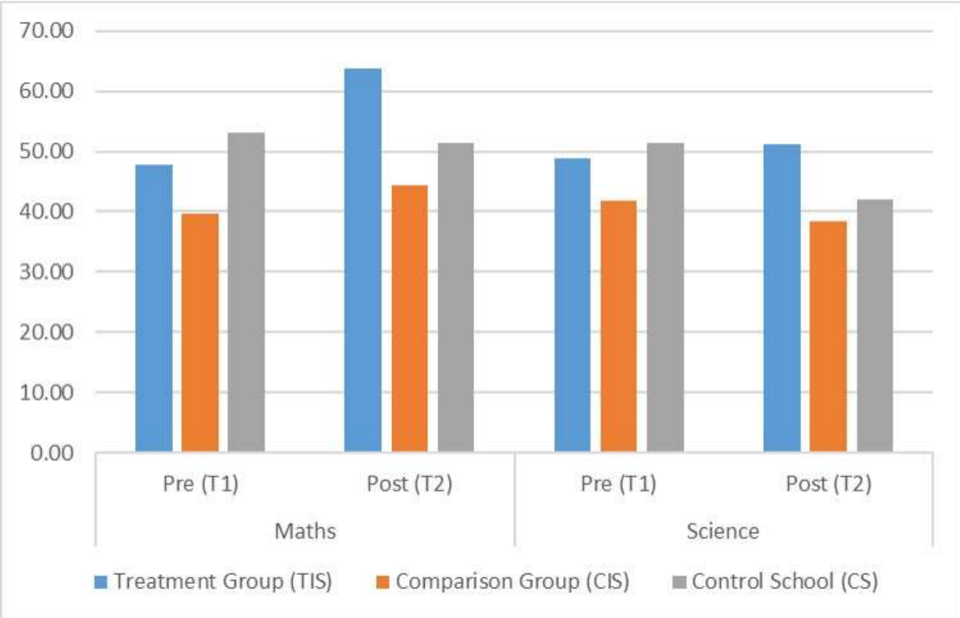

Figure 5: Difference in mathematics and science attainment between TIS, CS and CIS at T1 and T2

Table 3: Mean scores (M) and standard deviations (SD) in academic attainment, perceived exploration and collaboration

Subject	Treatment Group (TIS)		Comparison Group (CIS)		Control school (CS)	
	Pre (T1) *M(SD)*	Post (T2) *M(SD)*	Pre (T1) *M(SD)*	Post (T2) *M(SD)*	Pre (T1) *M(SD)*	Post (T2) *M(SD)*
Academic attainment						
Mathematics	*47.71 (19.53)*	*63.75 (22.72)*	*39.71 (20.32)*	*44.43 (21.16)*	*53.02 (22.74)*	*51.49 (20.48)*
Science	*48.86 (21.14)*	*51.14 (15.10)*	*41.82 (20.10)*	*38.36 (14.49)*	*51.42 (14.90)*	*42.07 (16.15)*
Perceived Exploration	*13.12 (1.98)*	*13.16 (1.99)*	*11.60 (2.69)*	*12.27 (2.67)*	*12.23 (2.00)*	*9.18 (2.07)*
Perceived Collaboration	*12.52 (2.34)*	*13.07 (2.14)*	*12.08 (1.64)*	*12.52 (2.60)*	*12.58 (2.29)*	*12.56 (2.62)*

Note: Mathematics and science exam scores can range from 0-100; a pass mark of 33 or above is required for both exams. Exploration and collaboration questionnaire items can range from 4-16.

Opportunities for exploration

In a one-way ANCOVA (co-varying for T1) to explore differences between the groups in perceived opportunities to explore outdoors, after only TIS students had received four months of outdoor teaching and learning (T2), there was a significant difference between the groups: $F(2,70) = 20.76$, $p < .001$, $\eta_p^2 = .38$ (see Figure 6). After controlling for multiple comparisons (Bonferroni), TIS scores were significantly higher than CS scores ($p < .0125$), but not CIS scores. CIS scores were also significantly higher than CS scores ($p < .0125$). This suggests that the children in the intervention school perceived greater opportunities for exploration, regardless of whether they were engaged in formal learning in this context.

Opportunities for collaboration

In a one-way ANCOVA (co-varying for T1) to explore differences between the groups in perceived opportunities for collaboration outdoors, after only TIS students had received four months of outdoor teaching and learning (T2), there was no significant difference: $F(2,70) = 1.35$, $p > .0125$ after controlling for multiple comparisons (Bonferroni). (see Figure 7).

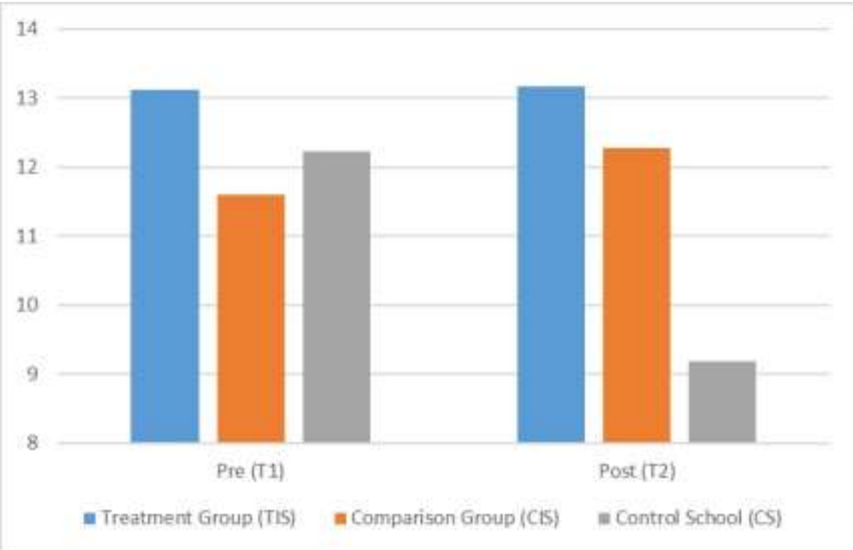

Figure 6: Difference in perceived opportunities for exploration between TIS, CS and CIS at T1 and T2

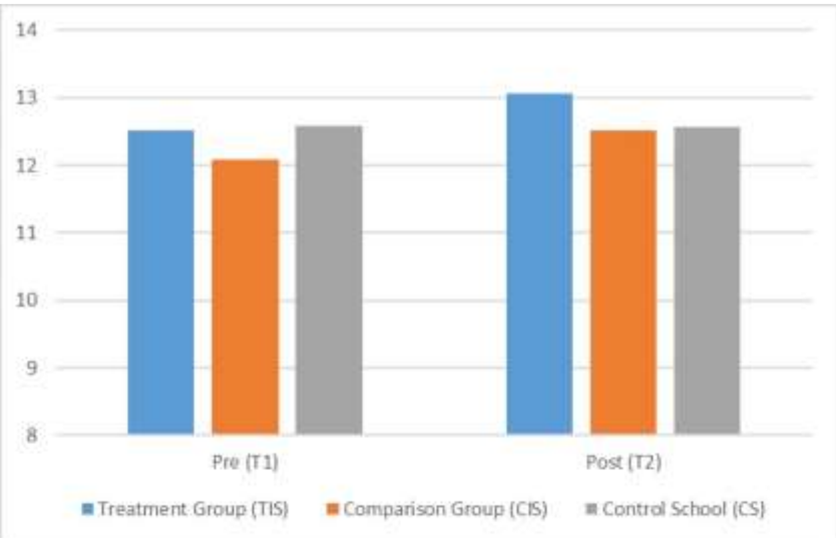

Figure 7: Difference in perceived opportunities for collaboration between TIS, CS and CIS at T1 and T2

Children's qualitative insights

Following T2 data collection, but prior to data analysis, focus groups were conducted to gain insight into children's perceptions of how the school ground design supported or discouraged their learning. The findings are discussed around the two main themes of exploration and collaboration, but a further important theme emerged - physical comfort.

Opportunities for exploration.

Opportunities for exploration were perceived to be very limited inside the classroom and children felt the school ground offered far more opportunities to explore. Indeed, the opportunity to explore and experiment was one of the main features discussed with regard to learning science and mathematics outdoors: *'In science class we can experiment with what happens to a plant with or without water in gardens, and learn about the importance of water.'* (Girl 1). The children explained how they used different settings for that purpose: *'We made the water habitat in the tubs, we put fish there...'* (Boy 2). The natural and manufactured materials in the loose materials area offered children the affordance for constructing activities: *'Madam lets us play and build different things.'* (Boy 1)*; 'We build houses in the open yard fetching materials from the area with loose materials.'* (Girl 6).

Many children also said that the teacher could explain their science and mathematics curriculum much more clearly, using the different settings in the renovated schoolground, which better supported their understanding and was more likely to lead to sustained knowledge: *'Madam explains showing trees...she explains interdependence of plants and animals...I can understand easily.'* (Boy 5). *'We can understand better when the teacher uses different elements. Even if we forget, we can remember when we look outside at these settings'* (Girl 3). The teacher used different loose materials to teach the children different concepts and theories related to science and mathematics: *'Madam uses seeds to teach us counting, division, subtraction...'* (Boy 3). The teacher also tried using seeds inside the classroom, but: *'We can't see in the classroom standing if madam works with seeds...but in the amphitheater we can all see and understand...'* (Girl 4).

Opportunities for collaboration.

One important aspect repeatedly mentioned by children was the opportunity to work in groups in the outdoor environment; children had far greater opportunities to do this than in the classroom environment. *'Madam tells us to work in groups, we work in groups in the huts…we work wherever we like…'* (Girl 3). According to most of the children, working in groups in different settings during the outdoor classes helped them understand easily; the children explained how they used different settings for group work: *'We work in groups in the huts, playhouse and the amphitheater, we count the bamboo pieces in mathematics class.'* (Boy 3); *'One of us tells and another one writes...'* (Girl 1). Working in groups keeps children engaged in their tasks, the children also said that they co-operated with each other and helped their friends: *'We sometimes poke each other in the classroom, but in the outdoor class we work together*... (Boy 5).

Physical comfort.

The children enjoyed their outdoor classes as they felt more physically comfortable there. The poor physical environment of the classrooms most likely explains this. In Public Primary Schools in Bangladesh, the classrooms are generally dark and there are no fans in most of them, which makes children uncomfortable on hot summer days: *'There is light and air outside...shade…'* (Boy 6). *'It feels hot in the classroom...'* (Girl 8).

Discussion

The present study examined both the outcome (educational attainment) and the process (opportunities for exploration and collaboration) of learning in an outdoor environment compared to an indoor classroom. With regard to educational attainment, children taught outdoors (TIS) had significantly higher exam scores (science and math) than children taught indoors (CIS and CS). This was an exciting finding and demonstrates the potential for outdoor teaching to have a significant positive impact on children's learning in developing countries. Indeed, these findings echo those of past researchers in developed countries (Lieberman and colleagues 1998, 2000, 2005) and align with a smaller scale project conducted in a developing country (Khan et al., 2018). Focus group discussions provided some insight into why these differences may have occurred. For example, TIS children reported that they could understand the concepts of math and science better when taught outside. Indeed, they had much less to say about learning in the classroom, whereas learning in the outdoor environment was perceived as more 'active, collaborative and challenging' (Singal & Swann, 2011, p. 469). Our results demonstrate that an outdoor space designed with purpose and bearing educational opportunities can enhance the academic achievement in developing countries. Interestingly however, the findings are inconsistent with the general perception of open space researchers, who propose that even playing in a renovated school ground can have an impact on children's academic performance (Lopez, Campbell, & Jennings, 2008).

With regard to exploration, children enrolled in the intervention school (TIS and CIS) reported significantly higher levels of perceived outdoor exploration opportunities, compared to children in the control school (CS). Therefore, children in the intervention school, regardless of whether or not they received outdoor teaching, experienced a greater awareness of the potential for the outdoors to be a site to learn independently; indeed, barren school grounds provide few affordances for exploration (Samborski, 2010). These increased opportunities for exploration were also shared during the focus groups with TIS children, as they spoke of how the different elements in the various settings of the school ground could be used to experiment and investigate (e.g., gardens, water habitat and loose materials). These findings echo Moore and Wong's (1997) work on school ground redesign in the US and Singal and Swann's (2011) work on outdoor learning.

With regard perceived opportunities for collaboration, there was no statistically significant difference between the IS and CS groups. This is, to some extent, inconsistent with the focus group findings, where children from the TIS spoke enthusiastically about opportunities for collaboration outdoors based on physical features of the outdoor environment (e.g., huts). Indeed, it would be expected that children in the IS would have a greater awareness of the opportunities to collaborate outdoors. There are a number of possible explanations for these findings. Firstly, definitions of outdoor learning typically stress increased opportunities to explore and investigate, not collaborate; it may be that outdoor learning only benefits the former, not the latter. However, the absence of a difference could also be explained by the way in which teachers encouraged children to use the new outdoor environment; teachers perhaps focused more predominantly on the opportunities for active and independent exploration, rather than increased opportunities for collaboration. Therefore, it is not only changes to a school ground that are important, but also sufficient training with teachers to ensure the newly developed outdoor environment is used optimally to promote learning, engagement and retention. As noted earlier, indoor classroom size and layout in developing countries do not easily invite opportunities for collaboration

(Khan et al., 2018); therefore, there is arguably unexploited potential to develop this outdoors.

Limitations and future research directions

Firstly, it is not possible to disentangle the influence of being outdoors with instructional approach, as TIS students received a change in both. Indeed, the assessment of factors affecting internal validity is incomplete; therefore, it is not possible to conclude which factors led to the increases in attainment found in the TIS group. While this study focused on the pedagogical possibilities inherent within the school ground design (i.e., exploration and collaboration), it is very possible that other mechanisms associated with being outdoors and exposed to increased ‘greenness’ (e.g., attention restoration, increased wellbeing) can explain, in part, the findings. An additional control school, where children received outdoor education in the absence of a renovated school ground is necessary to understand the influence of the design. To conclude, it is unclear which of the multiple changes (e.g., pedagogical approach, outdoor environment, novelty of the new setting) can explain the findings. Future research on a larger scale is necessary to understand this.

Furthermore, the approaches used to teach mathematics and science outdoors were not prescribed by the research team. This was an intentional decision as the teachers had autonomy over their pedagogical approaches indoors. However, teachers will vary in the approaches they use to teach these subjects (both indoors and outdoors) and this will influence students’ outcomes. The seven outdoor behavior settings (e.g., natural learning area, huts) offered considerable flexibility for use and therefore students’ attainment and activities (exploration and collaboration) will be a reflection of how the teacher guided learning in these settings. Further research is necessary to understand how different behavior settings can be used most effectively to optimize students' learning.   Despite this, a strength of this study is that the same teachers taught the different groups either indoors or outdoors and students' interest and attainment were a priority for teachers regardless of the setting where they taught (i.e., teachers had no desire to improve one of their groups' performance over the other).

In addition, the post-test was conducted after only four months of outdoor teaching; therefore, it was not possible to understand the longer-term implications of the outdoor design on the variables of interest. While post-tests after three months are found in landscape architecture research (Silveirinha de Oliveira et al., 2013), longer-term follow-ups are necessary to explore sustained impact. In addition, as this was a new design, it is unclear what impact this had on the findings. For example, the novel experience of teaching and learning outdoors may have created a shared enthusiasm among the teachers and children, which could explain the increased academic achievement among the TIS group. Alternatively, and equally possible however, is that the novel experience of teaching and learning outdoors was a new and uncertain approach for teachers and students; teachers had no opportunity to use tried and tested approaches to support children's learning. Therefore, it is possible that gains in academic attainment could be even greater when teachers have more experience and training in outdoor education. Further research is necessary to look at the impact of this project as teaching and learning outdoors becomes more routine and teachers gather greater experience and confidence in teaching outdoors.

Among the limitations of this study are weaknesses in the reliability of the measures. Both the 4-item measure of exploration and the 4-item measure of collaboration had relatively low internal consistency, as indicated by Cronbach alpha (ranging from .40-.68). It is unclear why Cronbach alpha values for exploration and for collaboration were higher at T2 than at T1; we speculate that use of the outdoor environment may have led the students to consolidation their perceptions of opportunities for exploration and collaboration. Furthermore, factor analysis revealed that the items loaded onto the constructs they were intended for. To measure the stability of the instrument, test-retest reliability was calculated; T1 scores correlated significantly with T2 scores, although only a moderate relationship was found. This perhaps reflects the length of time between T1 and T2 (six months); test-retest reliability is typically calculated over shorter periods of time. In future research, the development of a longer instrument (i.e., more than four items to measure each construct), greater input from the population under study, more extensive piloting (including assessing test-re-test reliability over a shorter period) would improve construct validity. In addition, research cites numerous benefits of outdoor learning (e.g., improved behavior and attention, increased interest, enjoyment etc.). A questionnaire and focus groups designed to measure a wider range of constructs from the research literature would be useful.

Due to funding restrictions, the intervention was conducted in a single school with a relatively small sample size, posing threats to external and statistical validity. However, the school is representative of more than 60,000 public primary schools in Bangladesh. The standard design of primary schools is followed in many developing countries in South Asia and Sub-Saharan Africa, which arguably means the study has some generalizability to not only primary schools in Bangladesh, but also to other developing and less developed countries. Nevertheless, it cannot be assumed that an approach successful in one setting will be successful in another; as with all education-based interventions, it requires considerable interest and commitment from schools and teachers to be successful.

Implications

The present study has considerable implications for Governments and donors when they are prompted to consider policies regarding children's learning and academic attainment. Building more classrooms is the dominant approach for infrastructure development in the primary education sector of Bangladesh; however, these classrooms often do not function properly and need technical adjustments (Kalra, Khan, & Rehman, 2014). In a previous mixed methods study by Khan et al. (2018), children reported that outdoor school ground redesign significantly improved their physical learning environment, with significantly better lighting, acoustics and seating reported outdoors. Furthermore, qualitative insights revealed that aspects of the indoor classroom led to poor learning opportunities (i.e., an inability to view the blackboard in crowded classrooms, noise from neighboring classrooms, poor lighting and airflow). The cost to build one classroom for 50 children is approximately £27,000,[3] whereas a school ground can be developed at a cost of approximately £10,000[4] and can be used by children throughout the whole school for both pedagogy and play. Providing children with more diverse spaces to learn and play and providing teachers with the insights necessary to maximize the use of these spaces should be on the agenda of policy makers in developing countries, where poor attainment and retention are key issues. Furthermore, while not a focus of the present study, health and wellbeing are also key concerns in developing countries and there is a rich research literature demonstrating the positive influence of being outdoors on both health and wellbeing outcomes. This study demonstrates that developing an outdoor learning environment adjacent to a school offers an innovative yet cost effective approach to enhance learning.

In terms of guiding further school ground renovation in developing countries, Khan and colleagues (in preparation) are currently creating a blueprint based on this study, with details of the different behavior settings and the affordances they offer.

While not proposing a prescriptive approach to the development of school grounds, this blueprint will provide extensive details of the design of this school ground that can be used as an example for other schools in developing countries interested in introducing outdoor learning.

Conclusion

This mixed methods research study provides some of the first evidence to demonstrate the benefits of designing and developing an outdoor learning environment to support children's attainment in developing countries. To ensure teaching and learning is optimal, guidance regarding the potential uses of the outdoor settings is important. Such insights are likely to come from future engagement with the research users (i.e., teachers and children) and through larger scale mixed methods studies.

Acknowledgment

We thank the children, teachers and parents of the schools, the members of the managing committee and the community of the intervention school for their participation and support. We also thank the Charles Wallace Bangladesh Trust for support with the continuation of analysis and write up of the study.

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[1] Exposure to trees and vegetation

[2] In this school there were two 'sections' (i.e., classes) in Grade IV; students are split to ensure the sections are matched on average academic attainment. That is, students' academic performance in the final exam of their previous school year is used to create these sections (i.e., student with the highest mark is assigned to Section A, second highest mark to Section B, etc).

[3] The cost for building one classroom was calculated based on the study by Kalra et al. (2014)

[4] The cost for developing a school ground was calculated based on the development work in the intervention school, which excludes the fees for a landscape architect.