Students' Use of Knowledge Resources in Environmental Interaction on an Outdoor Learning Trail

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Abstract: This study examined how students leveraged different types of knowledge resources on an outdoor learning trail. We positioned the learning trail as an integral part of the curriculum with a pre- and post-trail phase to scaffold and to support students' meaning-making process. The study was conducted with two classes of secondary two students. We coded two groups' discourse to examine the use of knowledge resource types in the meaning-making process in an outdoor learning setting: contextual resource, new conceptual resource, prior knowledge resource, as well as the relationship among these knowledge resource types. Next, we also examined environmental interaction and integration in the students' use of these knowledge resource types. Analysis showed that contextual resources are chiefly instrumental in fostering students' capacity to harness new conceptual resource and to activate prior knowledge resource in interacting with and integrating the outdoor learning environment in the meaning-making process.

Introduction

Rapid technological advances have revolutionized the way people learn, as well as redefined learning spaces to embrace learning beyond the four walls of the classroom. Research studies on outdoor learning and mobile learning (e.g., Kerawalla et al., 2012; Maulucci & Brotman, 2010; Maynards & Waters, 2007; Orion & Hofstein, 1994; Sharples, Taylor & Vavoula, 2007) accentuated some similar theoretical convictions: a) the criticality of understanding learners' interaction with the environment endowed with rich physical affordances; b) learners' interpretation of the physical environment; and c) the integration of outdoor learning with indoor classroom learning in the meaning-making process. Orion et al.'s (1997) study found that *active interaction with the environment* is instrumental in meaning-making on an outdoor field trip. Likewise, Frohberg et al.'s (2009) review of mobile learning accentuates the importance of *physical interaction* with multiple resources available in the environments; giving emphasis to the design of learning activities to empower learners to capitalise on the immediate physical space and the *resources* available to enhance the learning context.

Notwithstanding the multitude of studies on outdoor learning, research remains unclear on the meaning-making process: a) how learners use the different types of knowledge resources, in an outdoor learning setting to co-construct knowledge; b) how learners interact with the outdoor learning environment to enhance and/ or advance the different types of knowledge resource; and c) how learners integrate outdoor and indoor learning experience harnessing these knowledge resource types. Building on our previous research on small group collaborative learning, this study explores the knowledge resource types students use on an inter-disciplinary mobile learning trial. We also investigate students' interaction with and integration of the physical environment, where the outdoor learning trail forms an integral part of the curriculum from pre-to-post learning trail.

Theoretical Framework

Outdoor Learning as Environmental Interaction

In outdoor learning, students assume an active role in constructing information from the environment where the "d*irect experience with concrete phenomena and materials*" (Orion, 1993, p.325) becomes key in the meaning-making process; a process which Kerawalla (2012) coined it the "sense-making process" in her study on students' interaction with the physical environment. The interaction with the physical environment concretizes the otherwise, inert or abstract concept, knowledge and skills acquired within the confines of the classic classroom. Thus, *environmental interactions* form a significant signpost in an outdoor learning context to help students make sense of the world around them. Here, learners are given the authentic platform to attach values and meaning to the objects and the surrounds. Maynards and Waters' (2007) work on outdoor learning for children also underscores the potential of the outdoor learning environment where it fosters the construction of knowledge on a larger scale: exploring the world at first hand and experiencing natural phenomena. On a similar note, Kerawalla et al.'s (2012) work on *doing geography* showed that students develop and acquire new

skills not taught in the traditional classroom setting, but through their *situated interactions* with the environment and *improvisational interpretations* of the environment. These new skills emerged as students responded to the challenges in the data collection process. Apart from skills, the appropriation of knowledge with the real world environment becomes contextualized and assumes meaning through use.

Environmental interaction essentially draws upon two intricately interwoven elements: *learning* and *context*. Sharples et al. (2005) contend that the essence of mobile learning lies in understanding how people "create impromptu sites of learning" as they cross from one context to another. In a nutshell, the context for learning does not reside in the surrounds, but rather it is the learners who give meaning to the context. Here, *knowing* and *contexts* are mutually constitutive; and *learning* is "(re)conceived as fundamentally constitutive of the contextual particulars in which it is nested" (Barab & Krishner, 2001, p.5). This also mirrors Pachler's (2009) notion of mobile learning where learning is conceived "as semiotic work and meaning making in which users develop, with the aid of devices, new cultural practices with and through which they learn and strengthen their resources for meaning-making whilst interacting with the world ... (p.5)". Learners become active agents in the meaning-making process in an outdoor learning setting where they undertake activities to interact with the environment to concretize or create knowledge which culminates in the development of "new cultural practices", and thereby, strengthen their "resources for meaning-making".

Knowledge Resources for Environmental Interaction

As aforementioned, the interaction with the outdoor learning environment implies that learners are engaged in reinterpreting and re-contextualizing during the meaning-making process: attaching new values and meanings to the environmental features (Pachler, 2009). However, this process is not without its inherent challenges. Kerawalla et al.'s (2012) study on students' sense-making process in a geography field trip found that students had to leverage a range of multimodal resources from gesture to prior classroom learning to support their engagement in the interaction with and interpretation of the learning environment. Here, students learn flexibility in their use of knowledge resource types to respond to varying contextualized situations, as well as construct or create new knowledge. Orion and Hoffstein's (1994) works on field trips surface the concept of *novelty space,* which comprises of three essential pre-field variables, namely, the *cognitive*, the *geographica*l and the *psychological* novelty. Cognitive novelty refers to the concepts and skills learners would be confronted with during the field trip; geographical novelty is related to learners' familiarity with the location of the field trip; and psychological novelty refers to the psychological readiness, and inherently, learners' prior experiences with outdoor learning experiences. They observed that students showed better learning performance on a field trip when this *novelty space* is reduced. In other words, the body of knowledge resources made available and accessible for learners' appropriation of these various knowledge resource types during their interaction with the outdoor environment can significantly reduce all three novelty spaces.

From the perspectives of knowledge resources in collaborative learning settings, it is important to examine how learners leverage different types of knowledge resources available to them for knowledge convergence. The body of knowledge resources could be conceived of as a tool that allows groups to have flexibility and manipulation during the interaction with and interpretation of the environment where knowledge resource types can be restructured and approximated to respond and to react to new situations. Fischer and Mandl (2005) examined how students in different collaboration conditions used a range of knowledge resources for process and outcome convergence. Their study identified three core knowledge resource types in the collaborative meaning-making process to construct knowledge: *contextual resource*, *new conceptual resource* and *prior knowledge resource*. Contextual resource refers to the 'case information in the given case'; new conceptual resource refers to new 'theoretical concepts' that students learn within a theory text and prior knowledge resource means theoretical concepts not taught in a theory text, but are likely to have emerged from students' prior learning experiences. Of equal significance would be two other categories of resource use: the relationship between contextual resource and new conceptual resource, as well as the relationship between contextual resource and prior knowledge resource.

Against this theoretical backdrop on environmental interaction and use of knowledge resource types in outdoor learning, our research questions are:

- RQ 1: What type of knowledge resources do students use in an unstructured activity on an inquiry-based outdoor learning trail?
- RQ 2: What is the relationship between the type of knowledge resources and students' interaction with the environment on an inquiry-based outdoor learning trail?

Research Methodology

Participants and research setting

The research study was implemented with two classes of secondary two students (N=40) at one of the future schools in Singapore; a forerunner in the use of emerging interactive digital media-based tools and mobile technologies for teaching and learning both in-and-out of the classroom learning settings, as well as across all subject areas and levels. The mobile learning trail took place at the Singapore River where students could learn about the history of the Singapore civilization, the importance of the river location and the measurement of water quality and conditions. We chose the Singapore River as an ideal location for interdisciplinary learning as students could explore various topics of inquiry by synthesizing history, geography and science knowledge. The outdoor learning trail was conducted in small groups of four to five members, resulting in eight groups from the two classes.

Design of the outdoor learning trail

We position the outdoor learning trail not as a stand-alone, one-day event, but as an integral part of the formal curriculum with a pre- and post-trail phase. All learning activities were co-designed by the research team and the collaborating teachers. The recce trips of the river trail site formed a very critical phase in our design and development process of the overall trail structure: structured activities and the phasing in of an unstructured activity where students could pursue their own inquiry generated during the pre-trail phase. The recce trips enabled collaborating teachers (also the content experts) from the geography, history and biology department, to see how the three subjects could lend content to each other in the design of the trail activities.

Table 1 presents the overview of the learning outcomes and lesson activities for each phase. To facilitate the integration of conceptual understanding of the three different subjects on river, civilization and change, students were given an overarching BIG (Beyond Information Given) question on "why does civilization begin at the mouth of a river?". Next, the various activities in the pre-trail, as well as during the trail were designed to scaffold and to support the students' inquiry-based learning process and their responses to this BIG question. First, pre-trail lesson on famous rivers in the world was a tune-in activity to provide a baseline theoretical understanding about the given BIG question. The tune-in activity also enabled students in small groups to develop own line of inquiries relating to the BIG question that they want to pursue during the unstructured learning activity (see Table 1) at the Singapore River Trail.

Second, the outdoor learning trail includes both structured and unstructured learning activities. Structured learning activities refer to the series of tasks designed a priori by the teachers and researchers whereas the unstructured learning activities refer to the inquiry tasks that students had developed in their respective small groups during the pre-trail lesson. To scaffold students' meaning-making process in the structured learning activities, trail activities were designed with a gradual progression from well-structured task-types (performative and applicational) to less-structured task-types (knowledge generative and synthesis) at the three learning stations along the river (see Table 1 for a brief overview of the trail and task design). After completing all trail activities, students in a small group of fours or fives were given thirty to forty minutes to pursue their own line of inquiry (generated in the pre-trail phase) during the unstructured activity along the river vicinity.

Third, post-trail activities back in class were a measure for summary of learning, follow-up and debrief, allowing groups to share their findings, and attempt a 'rise-above' phase of the progressive inquiry cycle of knowledge building.

Table 1: Overview of Desired Learning Outcomes & Lesson Design from Pre-to-Post Trail

BIG Question: Why does Civilization begin at the mouth of a river?		
Phase	Desired Learning Outcomes	Lesson Activities
Pre-trail (in class)	Students should be able to: 1. Develop group pre-trail inquiry and/ or hypothesis relating to the big question. 2. Draw connections to similar inquiries and hypotheses at the class level. 3. Provide constructive feedback on inquiries and hypotheses presented by other groups.	1. List three famous rivers in the world, their common features and functionalities. 2. Develop one group pre-trail inquiry/ hypothesis relating to the big Q on river and civilization in the web-based platform.
Trail (Singapore River) (Showing	Structured Learning Activities in the Learning Trail 1. Transfer skills and concepts acquired in the classroom to the outdoor learning	Performative tasks 1. Measure the river water conditions. 2. Determine the location for ideal water conditions.

only the learning station Clarke Quay)	environment in the undertaking of performative task types. 2. Apply the integrated conceptual understanding of the three different subject areas in the knowledge generative and synthesis task types.	Knowledge generative & synthesis tasks 3. Explain why location has ideal water conditions. 4. Discuss the importance of water quality.
	Unstructured Learning Activities in the Learning Trail Students pursue their own pre-trail inquiry leveraging on the physical affordances of the technological tools and the learning environment. They are free to move around in the vicinity of the river site	Students in small groups pursue their own line of inquiry in this unstructured learning activity (30 min.), to investigate the pre-trail inquiry (i.e. the research questions they developed) and the hypothesis (each pair in the small group of four to five shares an iPad and data-logger).
Post-trail (in class)	1. Identify new ideas/ concepts developed (during the unstructured learning activity) relating to the big question 2. Synthesize and evaluate findings (pre-trail inquiry and trail tasks) in response to the big question	1. Class session where students share their collated findings and new concepts developed in response to the big question. 2. Students attempt a rise above to the big question in the knowledge forum, identify new knowledge and concepts and advance their ideas at the class level.

Technology mediation

As an initial study to investigate students' use of knowledge resource types and environmental interaction, the deployment of mobile technologies is intended to empower students to pursue their own line of inquiries, creating their own content with peers on an outdoor learning trail. Each small groups of four to five, was equipped with two iPads and two data-loggers and probes (to measure the water condition). And to reduce the physical presence of the teacher and frontal loading of information, all trail activities were hosted on the web-based platform (see Figure 1). Students were also able to host all their findings and collated artifacts (pictures, data, etc.) on the web-based platform. The provision of the broadcast alerts and feedback features seek to enable immediacy of teacher facilitation and inter-group communication during the learning trail.

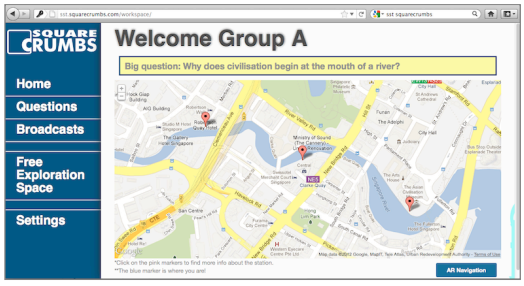

Figure 1. Web-based platform hosting all trail activities and customized Google map of trail site

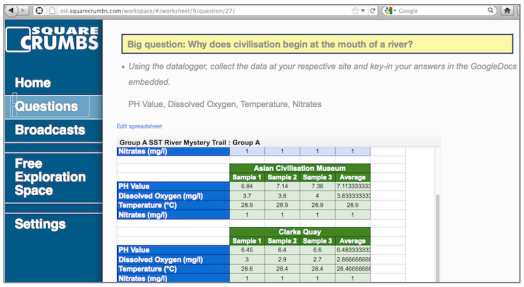

Figure 2. Well-structured task on measuring water conditions at three different sections of the river

Data collection and analytic approach

To examine more closely the use of knowledge resource types and the interaction with the physical environment, we observed two groups of students from each of the two classes. Group A had four students and Group B had five students. Group discourse and interaction was video- and audio-recorded and transcribed (approx. 38 pages in total) for analysis. Excluding non-task talk and the sporadic private conversations, we analyzed a total of 113 segments of content- and task-related statements (questions statements inclusive) in the group's discourse. Chi (1997) proposes the use of semantic boundaries to determine the unit of analysis as an idea may require a few sentences to put across. Moreover, similar ideas could be surfaced several times by team members who are more vocal. Hence, each of the 113 segments forms an unit of analysis and may contain one or more than one statements/ question statements depending on the discussion threads, ideas and turn of talks.

In this paper, we focus mainly on how small groups used a range of different knowledge resource types in the unstructured activity to pursue their inquiries. For discourse analysis, we adapted the coding scheme from Fischer and Mandl's (2005) study where they investigated the knowledge resource types learners use in the group discourse. Table 2 shows the various categories of knowledge

resources defined in this study: considering the outdoor learning context and the curriculum design. First, we define *Contextual Resources* (CR) as a type of knowledge resource made available at the pre-trail activities, the overarching Big Question, as well as the trail activities that provide students with the contextual information. Second, *New Conceptual Resources* (NCR) is defined as a type of knowledge resource that integrates the conceptual understanding of the three subjects, geography, history and biology on river, civilization and change, explicitly covered in the textbook. Lastly, *Prior Knowledge Resources* (PKR) refers to a theoretical concept not covered in the textbook. We also examined (a) the relations between contextual resources and new conceptual resources (CR & NCR), and (b) the relations between contextual resources and prior knowledge resources (CR & PKR). The relation between new conceptual resources and prior knowledge resources was not examined, as these two types of resources are mutually exclusive.

Table 2: Coding Categories of Content Dimension (adapted from Fischer & Mandl, 2005)

	Content Dimension
Categories of Knowledge Resources	**Descriptor and Sample Statements from Group Discourse**
Contextual Resources (CR)	Statement and question statement that explicitly refer to the contextual information; arising from undertaking the pre-trail activities, the BIG Question, as well as the trail activities at the trail site. e.g., "...move the port because it was very polluted"
New Conceptual Resources (NCR)	Statement and question statement that refer to the integrated conceptual understanding of the three subjects; arising from interaction with the physical affordances of the trail site. e.g., "...so he (The prime minister) decided to make it into a commercial, residential and entertainment precinct."
Prior Knowledge Resources (PKR)	Statement and question statement that make explicit reference to a theoretical concept(s), not included in the theory text (also could be activated owing to the interaction with the physical affordances of the trail site). e.g., "Our country saw that trading would not boost the economy".
Relations between Contextual Resources & New Conceptual Resources (CR & NCR)	Statement and question statement that link a theoretical concept(s) within the theory text to the contextual information. e.g., "no the trading port wasn't removed. It was replaced, it was replaced to make way for tourist attractions and others."
Relations between Contextual Resources & Prior Knowledge Resources (CR & PKR)	Statement and question statement that link a theoretical concept(s) not in the theory text to the contextual information. e.g., "It is because that time when they needed foreign talents..."

Findings

This section addresses the aforementioned research questions. We shall begin with RQ1 - presenting the findings of the knowledge resource types both groups used in the unstructured activity on an outdoor learning trail, before proceeding to RQ 2 - discussing the findings on students' interaction with the environment and use of the knowledge resources.

A comparison of the frequency of knowledge resource types used

Figure 3 shows the frequency of the range of knowledge resources for group A and group B. Both groups showed higher use of contextual resources as compared to other knowledge resource types. Another noteworthy finding is that students were able to develop new conceptual resources by harnessing contextual resources. They were also able to draw connections between contextual resources and new conceptual resources in their interaction with the physical environment.

One distinguished difference between both groups lies in both the activation and application of prior knowledge resources. Group B generated higher number of statements (question statements inclusive), showing use of prior conceptual knowledge resource than Group A did (see Figure 3). We also attribute this phenomenon to the nature of pre-trail inquiry generated by each group. Group B's pre-trail inquiry focused on the "*timing* of the clean river campaign in the 1980s" and they hypothesized that some significant events could possibly explain the occurrence of the clean river campaign. Contextual resources (from undertaking the structured activities) were insufficient for their line of inquiry. Likewise, student's capacity to develop and affirm new conceptual resources and/ or see relations between these resource types became unwittingly contained within the availability and accessibility of the resources available at the learning trail. Analysis of the discourse moves in Group B's discussion thread and field notes showed them making reference to significant events and developments in Singapore during the researched period. They had to affirm these inferences with

authoritative sources on the Internet, before they could eventually construct new meanings and advanced existing prior knowledge. Conversely, Group A's pre-trail inquiry on "what happened to the Singapore River as a trading point, and why it was removed and what is it now?" afforded them greater leverage on contextual resources and the physical affordances of the river site to affirm their new conceptual resources, and to draw valid inferences between contextual and new conceptual resources.

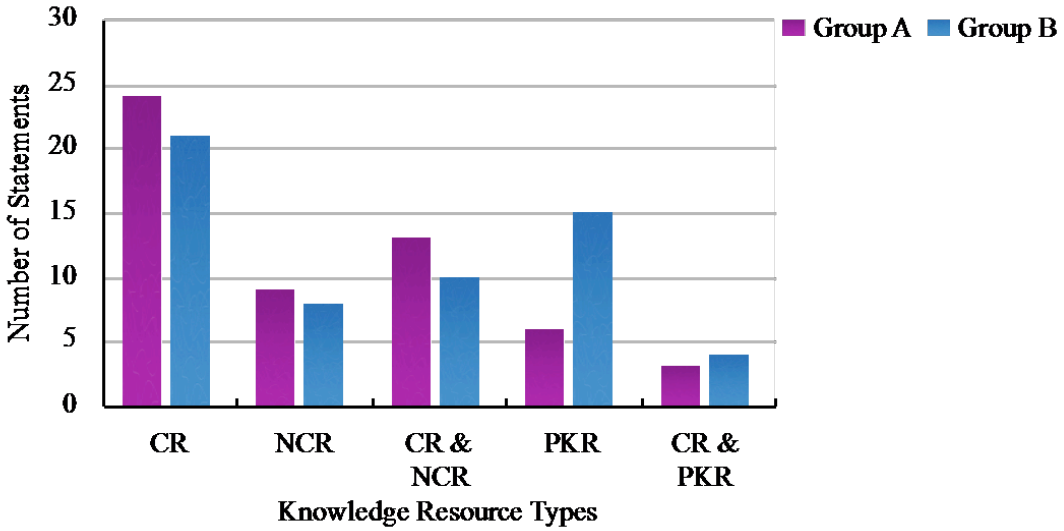

Figure 3. Frequency of Knowledge Resource Types Used in Group Discourse

Note: CR= Contextual Resources, NCR= New Conceptual Resources, CR & NCR = Relations between Contextual Resources and New Conceptual Resources, PKR = Prior Knowledge Resources, CR & PKR = Relations between Contextual Resources & Prior Knowledge Resources.

Environmental interaction and use of knowledge resources

Relationship between contextual resources and new conceptual resources

By positioning the outdoor learning trail as an integral part of the formal curriculum, the pre-trail activities in the classroom and the structured activities form a significant repository of contextual resources. The provision of pre-trail tune-in activities on famous rivers and the introduction of the BIG question on "Why civilization start at the mouth of a river" are both critical platforms for students to generate their line of inquiry and hypothesis that they intended to pursue during the unstructured learning activity. Albeit that the eight groups from the two classes formulated varied inquiries and hypothesis, yet their intended research inquiries fall within the parameters of the BIG question and the integrated conceptual understanding of the three different subject areas on river, civilization and change. Contextual resources were instrumental for the development of new conceptual resources.

Structured trail activities ranging from well-structured tasks on measuring water conditions to ill-structured tasks on the importance of water quality also form a critical component of the contextual knowledge resources students could use during the unstructured activity where they pursued their own line of inquiry. Figure 3 shows a high usage of contextual resources in contrast to other knowledge resource types. Another reason is the immediacy of contextual resources (trail activities took place prior to the unstructured activity) and the currentness of the interaction with the learning environment where learners are empowered to develop new conceptual resources and draw sound relations between contextual resources and their new conceptual understanding (see Excerpt 1).

The structured trail activities significantly reduced the cognitive novelty as exemplified in the works of Orion and Hofstein (1994). As evident in Group A's discourse, contextual resources on water quality led to the development of new conceptual resources on sedimentation and pollution. Apart from leveraging contextual resources on water quality, environmental interaction was key to the use of contextual resources and the development of new conceptual resources. Students were able to attach new meanings to the context and construct new knowledge and concepts arising from tourism, boats and pollution. The provision of pre-trail activities and the structured activities in the outdoor learning trail enhances the environmental interaction.

Excerpt 1: Group A's discussion on transforming Singapore River from a trading port to touristic site

Student	Statement	Coding Category
Student C	No, no, the trading port wasn't removed. It was replaced..it was replaced to make way for tourist attractions and others.	CR & NCR
Student G	There's more pollution around the sedimentation...this area because of the...	NCR
Student K	I thought there's more pollution on the other side.	CR & NCR
Student G Student C	There should be more here because there's a lot of ... boats There are more tourists around here, so //the boat has to ferry more.	CR & NCR

Relationship between contextual resources and prior knowledge resources

Students' capacity to draw valid inferences is largely contingent on the environmental interaction to make sense of the contextual resources and prior knowledge resources. Interaction with the physical features of the environment enabled them to activate and concretize prior knowledge during the meaning-making process. This is evident in the discourse (see excerpt 2) between students E and G, as well as students T and E where the group re-contextualised and reinterpreted the surrounds of the Singapore River: they were able to attach new values and meanings to the objects and the features (Pachler, 2009). Next, the activation of prior knowledge resources and the application of contextual resources enabled the students to see the relations between the two types of knowledge resources, as shown in the discourse moves: student E surfaced the vanishing trade of the street hawkers and the plan for more expensive tenants; student Y further advanced this knowledge with his prior knowledge on location, the use of land and the price of land (see excerpt 2).

Excerpt 2: Group B surfacing possible reasons for relocating the port in the clean river campaign

Student	Statement	Coding Category
Student E Student G	Oh because Pasir Panjang had new modern facilities. So they decided to relocate the cargo services. Near my house, near the west.	PKR
Student T Student E Student T	Then what happened to the port here? And also, they renovate the place. So that ... so that there will be a better tenant 'cos it's a very modern thing.	PKR
Student E	Because at that time, there were a lot of street hawkers, so then, they decided to have people who are good at art ... more expensive tenants. So they decided to conserve it and organize the place. Get it?	CR & PKR
Student Y	The basic is that they are trying to raise the price of the land?	CR & PKR

However, the scope and subject matter of the various groups' inquiries do determine to a considerable measure the knowledge resource types they were inclined to use in their group discourse. Group B activated more prior knowledge resources to make valid inferences to their inquiries, as illustrated in Figure 3. Further, in the absence of the physical presence of teachers, Group B made use of the authoritative sources via the Internet to affirm their prior knowledge resources relating to the contextual resources and to draw new inferences. Environmental interaction such as the location mapping and navigational possibilities (e.g., bearings, distance and scale etc.) has given them greater agency to test their hypothesis about the clean river campaign and possible significant events. They were able to locate environmental artifacts as evidences to support their hypotheses and affirm findings.

Discussion and Conclusion

This research study reports our initial efforts to explore students' use of different knowledge resources and the relationship of the knowledge resources on an outdoor learning trail. We positioned the outdoor learning trail as part of the formal curriculum (pre-to-post trail) and provided an unstructured activity during the outdoor learning trail to investigate students' use of knowledge resources.

Overall findings showed that students leverage heavily on contextual knowledge resources to negotiate meanings, to create new knowledge and affirm findings to their pre-trail inquiries. Also, students were able to develop new conceptual resources and apply prior knowledge resources due to their physical interaction with the trail site. This is evident from a number of their utterances where a particular place(s) and/or significant national event(s) form their frames of reference in making inferences and drawing connections between different resource types. Students were able to concretize knowledge and concepts owing to the immediacy and currentness of interaction with the rich physical affordances to re-contextualize and to re-interpret contextual and prior knowledge resource.

Our findings carry two important implications on the value of outdoor learning in facilitating the acquisition of knowledge and skills. First, the cognitive, psychological and geographical novelty can be significantly reduced by means of "sufficient" provision of contextual resources. The staging of the learning continuum from pre-to-post trail was a pivotal measure to facilitate the execution of the unstructured learning activity and to provide learners with the contextual knowledge resources. The rich integration of the three subject areas in the design of the trail activities and the framing of the BIG question on civilization and river, serve as crucial cognitive support for the learners. Second, "sufficient" contextual resources are necessary for students to interact with the environment meaningfully to develop new knowledge and concepts.

Although we witnessed some promising results in this initial research study on learners' use of knowledge resources in unstructured learning activities, we acknowledge that there could be limitations such as the integration of other disciplines whose cultural and social practices differ with changing learning contexts. Future research needs to examine how the availability and accessibility of these knowledge resource types works for other disciplines and pedagogical innovations in different learning setting. However, we are persuaded we can equip our students with the necessary knowledge base for harnessing the affordances of outdoor learning.

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Acknowledgement

This research is supported by the FutureSchools@Singapore project under the Singapore National Research Foundation's (NRF) Interactive and Digital Media (IDM) in Education Research and Development (R&D) Programme. The research work was conducted when the authors were with the National Institute of Education, Nanyang Technological University, Singapore. The authors wish to thank SST teachers and students for their contribution in this research.