How Learners Employ Semiotic Resources for Collaborative Meaning-Making in Outdoor Mobile Learning

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Abstract: This paper attempts to investigate how learners employ semiotic resources present in the material and physical world to construct and to negotiate shared meanings in an outdoor mobile learning context. We investigate the collaborative meaning-making and interaction process of two groups of 13-year-old students (Grade 7) during an outdoor mobile learning trail exploring the history and geographical features of World War II battle site. Methodologically, we employ video-based interaction analysis, which facilitates a micro-level analysis of human interaction, to understand how learners deploy and assemble the material and social resources available in the outdoor learning context. We surface two noteworthy patterns about a) how learners in small groups leverage semiotic resources to negotiate, repair and converge at shared meaning in changing contextual configurations and b) how prior learning experiences affect the way learners employ semiotic resources. The findings provide helpful insights into the design and implementation of mobile learning activities in outdoor settings.

Introduction

In recent years, researchers, key stakeholders, school leaders and practitioners alike, recognize the growing significance of the borderless classroom and the emergence of mobile learning as legitimate learning platforms. Hitherto, the rich repertoire of research and literature on mobile learning revolves chiefly around exploring emerging mobile devices and Web/cloud technologies to enhance learning experience across physical locations. On the other end of the spectrum of research on mobile learning, research studies caution against an obsessive focus on the technological system and the naive assumption of learning anytime and anywhere (e.g., Eliasson, Nouri, Cerratto Pargman & Ramberg, 2010; Frohberg, Göth, & Schwabe, 2009). They accentuate the importance of positioning mobile learning as socio-cultural activities and the criticality of designing learning activities that indeed foster both *physical interaction* with multiple resources available in physical environments, and *social interaction* supported through the mediation of mobile technologies (Kerawalla et al., 2012; Pachler, Bachmair, & Cook, 2010). Also, there appears to be a dearth of previous research work, which explores the intricate and the interwoven nature of the *collaborative meaning-making process*, not only between and amongst learners, but also with the *physical and the material world* in an outdoor mobile learning context. However, there remains a dire need for researchers and educators to investigate the dynamics at play in an outdoor mobile learning context, which have significant bearings on mobile learning design and implementation.

To unpack the complex meaning-making processes in an outdoor mobile learning context, this study addresses the question of how learners employ different kinds of semiotic resources present in the material world to construct and negotiate meanings within the context of collaborative mobile learning. While scholars accept the importance of unpacking the interplay of multiple resources during mobile learning, performing in-depth analysis of meaning-making process is methodologically challenging. Thus, we employ video-based interaction analysis (Jordan & Henderson, 1995) to explore this rich-textured experience and interaction at both verbal and nonverbal levels in an outdoor mobile learning environment. Essentially, through the use of video-based analysis, we want to answer the research questions regarding (a) how learners employ the multiple semiotic resources (e.g. artefacts, social resources) in the physical, social and material realm to negotiate, repair and converge at shared meanings, and (b) how prior learning experiences affect the way learners employ semiotic resources in an outdoor mobile learning context.

Theoretical framework

Mobile learning as situated activity in a physical and social context

The notion of mobile learning has been fraught with diverse views and definitions of what 'Mobile Learning' connotes and how it ought to take shape. Some conceptual frameworks of mobile learning underscore the works of Lave and Wenger (1991) on the *situated nature* of learning, where they conceive of "knowing as activity by specific people in specific circumstances" (p. 52). Vavoula and Sharples (2008) accentuate that mobile learning

is essentially about learning in context and pervasive learning across different contexts. Similarly, Pachler et al. (2010) emphasize the situated interpretative nature of mobile learning that mobile learning experiences enable learners to "reinterpret their everyday life contexts as potential resources for learning. Learning is viewed 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, emphasis added). In this light, the focal point of mobile learning would be to maximize the presence of a real world platform, engaging learners in semiotic work with relevant resources for meaningful knowledge creation and production where "the process of learning is informed by sense of place" (Lim & Barton, 2006).

In this research, we contend that there is a critical need to shift from technology-driven mobile learning design to one that supports semiotic work and situated learning experiences leveraging on physical affordances of environment, and importantly, giving focus to the dynamics and synergy of collective cognition in mobile learning. In Frohberg, Göth and Schwabe's (2009) critical review of mobile learning projects, they caution against embracing the general perception of mobile learning as learning anytime, anywhere with compact mobile devices. Mobile devices should be seen as mediating tools that allow people to capitalise on the situation in terms of the immediate physical space, while promoting social interaction that enhances the learning context.

Collaborative meaning-making and semiotic resources

The process of collaborative meaning-making is poignantly illustrated by Stahl's (2005) notion of a "shared meaning and common ground" constructed through group discourse in the context of a joint activity, where he contends that the "status of this shared meaning must be continually achieved in the group interaction"; frequently the shared status of 'breaks down' and repair is necessary" (p. 345). In mobile learning scenarios, the 'context' of a shared activity cannot be fully pre-specified, since the repair and re-conceptualisation of meaning-making is created through the situated activity of learning (Sharples, Taylor, & Vavoula, 2005). On the same note, Kerawalla et al.'s (2012) research on learners' interpretation of and interaction with the environment on a geography field trip showed that apart from the use of mobile technologies, learners had to leverage multimodal semiotic resources such as gesture, gaze, and bodily location in the meaning-making process. By semiotic resources, we are inclined to adopt van Leeuwen's (2005) definition of semiotic resources as actions, materials and artifacts for communicative purposes, which encompass both the physiological, as well as the technological realm. A semiotic resource is thus, a material, social, and cultural resource.

As aforementioned, the collaborative meaning-making process, therefore, inevitably involves trouble and repair among participants, making it necessary to realign with semiotic resources such as artefacts and social resources in the physical and material world to arrive at shared meanings. From the perspective of interaction analysis, when premeditated trajectory of activity is interrupted, it calls for more than repairs at the verbal level: it necessitates an analysis of how learners exploit *bodily*, *artifactual*, *spatial*, and *social* resources in the physical, social and material environment, to restore normalcy and resolve issues (Jordan & Henderson, 1995). For instance, in the video-analysis on how two students resolve technical difficulties in operating a machine, Roschelle and Clancey (1991) surface the notion of a "shared visual and manipulative space" where identifying the trouble and the solutions requires mutual alignment in this 'shared space'. Here, the two students engage a combination of 'talk', 'gesture' and 'screen objects' in this 'shared space' to arrive at a solution.

However, in a mobile learning context, the concept of a shared visual and manipulative space and the likelihood of stable situations may vary significantly. Here, it is helpful to visit Goodwin's (2009) postulation of *changing contextual configurations*. Goodwin (2009) contends that contextual configuration does not and cannot remain constant for "as action unfolds, new semiotic fields can be added, while others are treated as no longer relevant" (p. 21). This implies that the actions and thought processes experience a course of continual change as new semiotic resources enter and exit the context. Thus to this end, participation framework, interaction patterns and the building of action are subjected to the fluidity of contextual configuration specific to the moment and to that particular context. As such, participants alter their course of actions accordingly, to accommodate, to adapt to new configurations, and to realign with the emerging artifactual, spatial and social resources. Thus, our research questions aims to investigate the following:

1) How do learners employ the multiple semiotic resources (e.g., artefacts, social resources or spatial resources) in the physical, social and material realm to negotiate, repair and converge at shared meanings?
2) How do prior learning experiences affect the way learners employ semiotic resources in an outdoor mobile learning context?

Methodology

Research background and context

This research was carried out in one of the future schools in Singapore, which leverages on its 1:1 computing initiative to create a technology-rich learning environment. The research team worked closely with the collaborating teachers in the Integrated Humanity subject (i.e., history and geography) to design mobile learning activities that integrate knowledge, skills, and attitude to solve complex problems in authentic places. One particular platform of such mobile learning activities is what we called a *mobile learning trail*, conceptualized as a series of learning activities in and out of school mediated by mobile devices and applications.

In this paper, we discuss the implementation of a mobile learning trail titled *the British Defence Strategy Trail* that was designed for students to understand the fall of Singapore in World War II. The British Defence Strategy Trail took place at Fort Siloso, situated at the Western tip of Sentosa Island, Singapore, which is the site used by the British to defend Singapore during WWII. Fort Siloso was selected as a suitable location for this mobile learning trail for its historic significance during WWII, and for the availability of physical artefacts such as numerous tunnels, artillery guns and other resources left behind from the war.

Participants of the British Defence Strategy Trail were Secondary One (Grade 7, aged 13) students, who were acquainted with the use of interactive digital tools and mobile technologies both in and out of the classroom. We adopted a small-group collaboration structure where groups of 3-4 members were formed and remained in the same group throughout the trail. Regarding more specific design of learning activities, we first identified a BIG (Beyond Information Given) question that serves as an overarching inquiry goal that students pursue through various learning activities. Under a BIG question, we adopted a three-stage learning model that includes the integrated design of pre-trail lessons in the classroom, outdoor mobile learning trail and post-trail discussions in the classroom. Prior to the mobile learning trail, the students participated in History and Geography lessons to learn about the history of WWII and mapping/ navigation skills.

As shown in Figure 1, we identified four areas at Fort Siloso; what we called "learning stations" for the mobile learning trail. A series of trail tasks at the four learning stations (A to D) was designed to enable learners to answer the overarching BIG question on "What is the role of Fort Siloso at Sentosa Island in the British's big plan of defence to protect Singapore during WWII?" Various learning tasks at each of the four stations were designed for students to co-construct and to advance knowledge toward answering this BIG question. Table 1 presents an overview of the type of tasks designed for the British Defence Strategy Trail at learning stations A and C (for the focus of this paper). Trail tasks range from performative to knowledge generative. A *performative task* refers to a simple direct application task that is procedural, close-ended and linear leading to fixed answers. In a performative task, students are expected to apply knowledge and skills learned in pre-trail lessons in school to real-world contexts. On the other hand, a *knowledge generative task* is ill-structured, open-ended and non-linear leading to multiple potential answers. For instance, at learning station A, learners were first tasked to determine the direction of the gun using the iPad compass (Task 1: Performative), and thereafter, to locate the tunnel B and explain the purpose of the tunnel (Task 2: Knowledge Generative).

Table 1: Overview of mobile learning trail tasks at Sentosa Island

BIG Question: What is the role of Sentosa in the British's big plan of defence to project Singapore during WWII?		
Station	**Task Type**	**Task Description**
A	Performative	T1. Determine the direction of the guns using the iPad compass.
	Knowledge Generative	T2. Describe the dimension of the tunnel and state its purpose
	Knowledge Generative	T4. Explain why the previous artillery gun (Area A) and this one are pointed in the same direction.
		T5. Give reasons for the British's plan to locate the tower at Area B. Describe the role and purpose of the tower and the guns.
C	Performative	T6. Calculate the distance between the cliff to Pulau Palawan (house food & ammunition supplies).
	Knowledge Generative	T7. Identify whether the vessel is "friendly" or "hostile" using the chart at the watchtower.
	Knowledge Generative	T8. Give reasons for the erecting of another tower in this area. Describe the role and purpose of the tower and the guns.

On the use of mobile devices, students in small group (3-4 members) shared an iPad as a main mobile device to access the web-based platform called SquareCrumb that hosted all learning activities and associated mobile applications (see Fig 2). In this platform, the students could retrieve the learning tasks at each learning station, save their findings, data, and notes. They were able to interact with other group members and teachers through the synchronous broadcasting and feedback features.

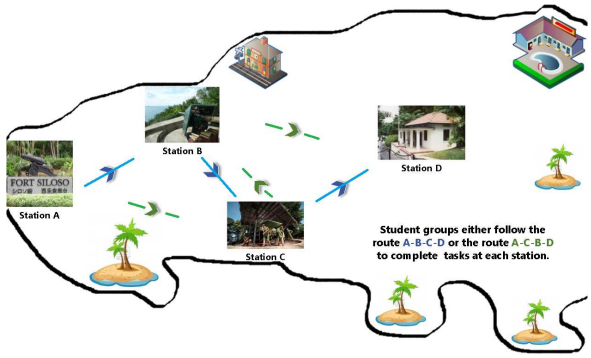

Figure 1. Activity sequence and structure in the British Defence Strategy Trail

Figure 2. Learners leverage use of technological resources to find their bearing.

Data collection and analysis

We closely observed and monitored two small groups of four members each (Group 1 and Group 2 hereinafter) throughout the mobile learning trail. These two groups of students were audio- and video-recorded during the trail. Each student wore a small-sized audio-recorder, which recorded the dialogue of each group. One research assistant was assigned to each group to video record group interaction throughout the trail. Two researchers followed each group and took field notes. All video and audio recordings of participants' interaction discourse at the two learning stations (A & C) were formatted and transcribed respectively for analysis using the TransAna software. Stations A and C were selected for analysis owing to the range of task types and the physical and material context of the learning stations which aligns with the objective of this research study. In total, there was approximately an hour and 35 minutes of video footage for the two groups. The two researchers who followed and observed the two groups, taking field notes were also the same researchers who conducted the video-based interaction analysis. Apart from individual analysis work, the two researchers engaged in "collaborative viewing" (Jordan & Henderson, 1995) to overcome the inclination towards partiality arising from predetermined conceptions and analyst bias. Further, in the collaborative viewing and discussion phase, field notes taken on day of event were also resurfaced to lend support and affirmation of analysis and findings.

The corpus of video data at the two learning stations was first segmentised according to larger, clearly defined events. These larger events were first, marked by the learning stations and next, by the different task types. Each of these larger events was then further segmentised into smaller units for analysis based on discursive moves, participation movements, interaction with the resources in the physical and the material space. Our data analysis was guided by a set of analytic foci in interaction analysis (e.g., turn-taking interaction, participation structure, artefacts and documents, trouble and repair) from Jordan and Henderson (1995).

Findings and discussion

In this section, we attempt to surface two noteworthy patterns from interaction analysis about how students in small groups leverage the use of semiotic resources in the material and physical world to construct and negotiate shared understanding:

1) How do learners employ the multiple semiotic resources (e.g., artefacts, social resources or spatial resources) in the physical, social and material realm to negotiate, repair and converge at shared meanings?
2) How do prior learning experiences affect the way learners employ semiotic resources in an outdoor mobile learning context?

Trouble and repair in changing contextual configuration

We investigated how learners leverage the use of semiotic resources to manage "trouble and repair" in an outdoor mobile learning setting, where the contextual configuration of semiotic resources in the physical and material world is unlikely to remain constant. The following interaction discourse (see Episode 1) illustrates how changing contextual configurations shape and structure the collaborative meaning-making process and how learners reassemble resources inherent in each contextual change, to negotiate conflicting perceptions and achieve collective goals.

Table 2: Episode 1 – Group 2 in the process of locating tunnel C

Line	Student	Verbal	Nonverbal
1	E	Eh the map is correct or not?	The team is walking towards what they believe is tunnel C. However, E appears uncertain about the digital map and G decides to move off to check if the tunnel ahead is indeed tunnel C.
2	Y	No, Gavin checking!	
3	E	Huh? That one is tunnel A, we	E is still trying to locate tunnel C with the digital map. G calls out to them that it is tunnel A, not C.
4	G	Tunnel A	
5	Y	Tunnel B is there, then tunnel C is all the way there! See all the people there. Why you want to go there?	Y spots other teams heading in that direction and confirms that tunnel C should be on the other side.
6	E	Tunnel C is that way, cos erm, north is this way right, then north south, north east, north	E hands over the iPad to Y. She makes use of spatial orientation to affirm the team's current position and the probable location of tunnel C.
7	G	Check that map (referring to the Google map). Tunnel A, where's tunnel A?	G suggests to the team to check the map again.
8	E	Isn't it showing south? Go!	The three of them review the map.
9	G	No not that direction. 24… So that means we suppose to go there. Opposite. That means go there la. Do we need to climb the stairs?	G studies the map and re-directs the team. On the way to the tunnel, E also makes use of the physical map & signage to affirm the location.

The team was confronted with conflicting viewpoints owing to the different resources the members tapped on, coupled with some technical problems with the digital map. Here, the technological resource (i.e., digital map), the physical location map and the rich physical affordances of an outdoor setting (their spatial orientation with reference to their present physical location) offer differing information on the exact location of tunnel C (see Lines 1 to 7). On top of that, there was the availability of social resources (e.g., other groups) as point of reference (see Line 5). Learners were engaged in a process of what Roschelle (1992) construed of as an "iterative cycle of displaying, confirming and repairing meanings" where former conjectures give way to new meanings/ ideas based on new contextual configurations that enter the collaborative learning space. In this situation, learners move from one contextual configuration to another in 'trouble and repair' (Goodwin, 2009, p. 34), by reassembling resources to restore interaction and resolve difficulties. It also reiterates that establishing common grounds in shared meaning-making (Stahl, 2005) could only be achieved through mutual alignment in a 'shared space' (Roschelle & Clancey, 1991).

Another interesting phenomenon observed in this episode is how semiotic resources, in particular, the rich physical affordances of the outdoor learning context could impact seemingly straightforward task types. While application and procedural tasks are presumably easier as compared to tasks that require critical thinking and inferential skills, our analysis showed otherwise. Apparently, both groups at the learning station C spent considerable amount of time in completing the performative task (T6: Calculate the distance between the cliff to Pulau Palawan). Further, we observed more occurrences of "trouble and repair" as compared to knowledge generative task type. We attribute this to the presence of the real world platform - the rich physical affordances that somewhat "complicates" seemingly easy procedural and applicational tasks. The interaction with the real environment presented some *unforeseen variables*. Application skills such as mapping, measuring of gradient, determining directions and bearings become complex to the participants in an outdoor context endowed with rich physical affordances. Concepts and skills they have learnt and "practised" within the four walls of the classroom, were no longer as clear-cut for transfer into the current context. The problem-solving process necessitated collective review of ideas, negotiation and finding consensus. The rich semiotic resources present in an outdoor learning context created new challenges and opportunities of looking at familiar tasks and formulas. The situated interpretative nature of the mobile learning context (Pachler et al., 2010) cannot be

underestimated for learners leverage on emerging resources specific to the learning context, to interpret and to interact with the environment in the meaning-making process.

Contingency action versus conditioning in interacting with artifactual resources

In the following episode, we address how prior learning experiences affect the way learners employ the semiotic resources in an outdoor mobile learning context. Here, we foreground Knoblauch's (2009) notion of "habitualised, routinized and institutionalized" (p.13) meanings on action where he sees *conditioning* as possessing considerable impact on current action and meaning-making.

Episode 2 is about Group 1's interaction and discourse at learning station A where they were tasked to describe the dimension of the tunnel. Learners were unanimously certain that the dimension of the tunnel resided in the artifactual resources such as exhibits and displays delivering information about the history and structure of the tunnels. Group 1 participants approached exhibits and displays (see Lines 7 - 12) chiefly to look for answers. In a bid to save time and human resources, group eventually spilt up to look for answers on the displays and exhibits (Lines 5, 9 & 13).

Table 3: Episode 2 – Group 1 enters tunnel B and their immediate preoccupation is to look for answers to the first task question, which is to describe the dimension of the tunnel

Line	Student	Verbal	Nonverbal
1	A	Describe the dimension of the tunnel.	Team gathers for a very short while at the end of the stairways and takes a quick glance around the tunnel. A reminds team of the task question.
2	D	What dimension? 3D dimension or the…	
3	B	4 dimension	
4	C	Dimension ... dimension. Why do you want us to find dimension? What dimension?	
5	B	Eh... It might be written on the wall.	Team appears certain that the dimension can be found on the exhibits as they hurry from display to display and move briskly from one exhibit to another in the tunnel (perhaps too accustomed to conventional field trips tasks where answers are derived from displays or artifacts).
6	D	Look at the question first.	A, B & C forge ahead and scan through the exhibits very quickly for clues on dimension. D lags behind and calls out to the rest to review the question. She finally gestures A to the bench. They re-read the question. C & D join them.
7	B	Calvin, you search here. I go and search there	B proposes a spilt to look for answers. He suggests that the team be spilt into two as they have two task questions to complete at the tunnel – one was the dimension and the other; the purpose of the tunnel.
8	C	Search what? Search what? [louder]	C is confused by the division of labour.
9	B	Search, search for the dimension	B replies C as he is walking off (B & C are supposed to look for dimension).
10	A	Yea what...what...what dimension	A gets a little agitated and seeks affirmation on task and role assignments.
11	D	Ok. You find what is the dimension and the purpose	
12	A	No. No. Bob find dimension, Calvin finds the necessary and we go and find purpose.	A looks impatient and corrects D.
13	B	But, purpose is over there!	B notices A & D are heading the "wrong" direction and reminds them that they are supposed to look for purpose.
14	A	Ok ...sorry. Ok. So what is the purpose?	
15	D	No, we are finding dimension	
16	A	We all go this side…	Team spilt up.

Group 1 was unable to allow the environment to speak to them amid the rich affordances of the physical environment in mobile learning. Neither were they able to comprehend the requirements of the task question correctly. The engagement and interaction with the artifactual resources (exhibits and displays) became

brief, superficial and conservative. Here, artifactual resources in the tunnel became a restraint rather than a resource because learners had approached task questions with past experiences of outdoor learning trips where they were accustomed to looking for answers in the artifacts. Prior experiences conditioned and reproduced recurring learning behaviour. Their strongly entrenched pre-conceived notion of conventional field trips not only impacts the way they interact with the real world environment to construct knowledge and meaning, but also inadvertently shapes their participation framework. We attribute such a phenomenon to what Knobluach (as mentioned in Kissman 2009, p. 13) conceives of as "fixed patterns that also shape action" when meanings become "habitualised, routinized and institutionalized socially".

Likewise, Group 2 showed initial confusion and uncertainty about describing the dimension of the tunnel. This was especially so when they saw many students reading the exhibits for answers. However, they restored their discussion track after briefly browsing the exhibits (see Episode 3, Lines 1 to 3, verbal utterances and nonverbal observations). They moved away from the exhibits, and came together to discuss, making reference to spatial resource in their description of the tunnel. Here, the participants were not entirely constrained by known protocols on field trips; rather, they were able to interact with the current environment and ride on the affordances of the semiotic resources resided in the specific situation to re-negotiate shared meanings. Akin to what Lim and Barton (2005) advocate that, 'the process of learning is informed by the sense of place', Group 2 developed a sense of situational intent and was able to engage with the artifactual resources to make valid interpretation and inferences.

Table 4: Episode 3 – Group 2 enters tunnel B to review the task question and to visit the tunnel

Line	Student	Verbal	Nonverbal
1	E	What is, what do you mean by dimension?	Student E & Y descend the stairways leading to the tunnel. Student G is just right behind them, reading the task question aloud. Student E voices her query on "dimension", she is not sure what is required of them.
2	G	That means the tunnel, how big is this, is it cramp or what?	The three students are now at the entrance to the tunnel. They look around. Student E & Y, upon seeing many students reading the exhibits, approaches one of the displays briefly. Student Y moves to look around the tunnel, trying to do some the spatial reasoning.
3	E	Is it cramped?	Student E moves away from the exhibits to look around the tunnel.
4	Y	What's the dimension of the tunnel…	Student G moves to the bench; looks into the iPad. Student Y & E stand beside him but continues to look around the tunnel.
5	G	Dimensions? Erm...dimensions. Eh...why why where	
6	E	There's quite narrow.	The three students come together to discuss their viewpoints, making references to the spatial resources to make some conclusions about the dimensions of the tunnel. They conclude that it is about 6 feet wide, using student G's size as a gauge.
7	G	6.	
8	E	10.	
9	Y	6. Gavin can only fit like that.	

Conclusions and implications

This research study reports our initial efforts to investigate how learners leverage the use of semiotic resources in the physical, social and material world to construct and converge at shared meanings. It enables us to make sense of how and why learners leverage the available resources, and how they repair and restore a projected sequence to accomplish collective goals.

Our two key findings reported here afford us some insights into the challenges and implications in designing and implementing mobile learning activities. First, in an outdoor learning context where contextual configurations cannot remain constant, learners assemble and reassemble the physical, social and material resources in 'trouble and repair' to negotiate and to re-converge at new meanings and shared understanding. Designing mobile learning could consider how we can help learners response to changing contextual resources in an outdoor learning environment to advance their learning collectively. Instructional scaffolds and technological supports could empower learners in their interaction with and the interpretation of the learning environment in the meaning-making process. Technological support could facilitate rather than dictate the learning process. Embedded tools could serve as a means of support, while provisions could be made for

learners to deploy other technological tools where they deem more relevant at the point of contextual reference. Second, the richness of the semiotic resources present in an outdoor environment has a bearing on task-types (aim and structuredness of the task), and consequentially, shapes how learners leverage use of available resources in the physical and material world in the meaning-making process. Task design in mobile learning could see a combination of structure and unstructured learning space, where the latter might make provisions for the environment to speak to the learners; i.e. learners be given that platform to see relationships. Further, prior experiences and past conditioning could affect learners' use of semiotic resources. This is evident in our second finding that conditioning has a profound impact on current action and meaning making. Learning activities could possibly create space for learners to develop a sense of situational intent and the capacity to ride on emerging semiotic resources.

We acknowledge that there could be limitations to our findings and conclusions as mobile learning design and practices vary from context to context and across different subject disciplines. Further, the communities of practice and the socio-cultural conditions of learning can neither be predetermined nor prescribed, as it is nurtured and refined overtime. Nevertheless, our initial efforts to understand how learners leverage use of multiple semiotic resources for collaborative meaning making, will provide some insights into the richness of an outdoor learning context, in particular, the opportunities and challenges in exploring the material conditions for learning.

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