

## Analysis of Small Group Interactions in a Seamless Language Learning Environment: An Artifact-Oriented Approach

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**Abstract:** We present a study in “Move, Idioms!”, a mobile Chinese Language learning approach that emphasizes learner created content and contextualized meaning making with their daily encounters. Students used smart-phones on a 1:1, 24x7 basis to capture photos of the real-life contexts pertaining to Chinese idioms or conjunctions, made sentences with idioms/conjunctions, and posted them onto a wiki space for peer review. This paper focuses on students’ on-campus face-to-face collaborative learning process. We derive a novel visualization approach for descriptive analysis of the small group activities inspired by the notions of mediation by artifacts and distributed cognition to provide a synoptic view of the process of student artifact co-creation in such collaborative activities. The artifact-oriented analysis and visualization approach is our preliminary attempt in making sense of how the seamless learning process may look like in the perspective of learners’ individual and collaborative learning experiences.

### Introduction

From e-learning to m-learning, the most publicly known phrase to describe these new advancements is perhaps “learning anytime, anywhere.” The mobile technology enhances student learning whenever and wherever they are motivated to learn (Chan, et al., 2006). Whereas the rise of e-learning a decade ago had resulted in educators’ concern of aggravating the digital natives’ indulgence in the cyberspace, we argue that through proper m-learning design that emphasizes learners’ interactions and meaning making with the peers (f2f) and the material reality (e.g., Rogers & Price, 2008; Wong, Boticki, Sun, & Looi, in press; Wong & Looi, 2010; Zhang, et al., 2010), the technology would instead bring them “back” to the physical world (Wong, 2010b).

Chan et al. (2006) define seamless learning as an approach where a student can learn whenever they are curious in a variety of scenarios and in which they can easily switch from one scenario or context to another (formal and informal learning, personal and social learning, physical world and cyberspace, etc.) using the personal device as a mediator. Nevertheless, after several years of relevant studies, the potential of mobile-assisted seamless learning has yet to be fully explored. One major challenge is that seamless learning has been blended into learners’ day-to-day lives where every-“thing” within and beyond the four walls of the classroom has the potential of supporting or distracting/constraining their learning. This salient characteristic of seamless learning makes it difficult for any existing analytic tool to capture the full picture of seamless learning journey. Furthermore, the rich learning resources and contexts that could be distilled from learners’ non-academic daily lives to complement formal learning are often neglected by both learners and teachers (e.g., Coffield, 2000).

How can learners’ habit of mind and skills in making meaning with their daily encounters, and associating those with their formal learning gains be nurtured through their participations in (teacher-) *facilitated seamless learning (FSL)* (Wong, 2010a) experiences? This is one of the major research issues of our recent study in exploring a FSL design for Mobile-assisted Language learning (MALL), “Move, Idioms!”. In the study, we facilitated a Primary 5 (11-year-old) class in Singapore to study 48 Chinese idioms (with 8 additional conjunctions in the later part of the study to experiment on the versatility of the learning design) over 10 months. Apart from in-campus idiom/conjunction lessons with contextualized and small-group learning activities (collaborative), the students were each assigned a smart-phone which they were allowed to access 24x7. With their smart-phones, they took photos in daily lives (personal), made sentences with the idioms/conjunctions, and then posted them onto a wiki space for peer review (collaborative). In analyzing the students’ learning process in “Move, Idioms!”, we are keen to uncover how the interplay of personal and collaborative meaning making (in both formal and informal settings, through non-ICT and ICT means), and the different forms of student artifacts constructed in different contexts, could create a “chaining” effect in mediating the students’ learning journey (i.e., one piece of student work becomes a mediating artifact of the next stage of learning activity).

We have published (Wong, Chin, Tan, & Liu, 2010) our in-depth analysis on one particular form of student artifacts – the photo/sentence sets that they shared on the wiki, in the aspect of personal meaning making. In this paper, we shift our focus to the students’ on-campus face-to-face (f2f) collaborative learning processes, not only with the aim of revealing how the social meaning making took place during their discussions

with the mediation of various forms of student artifacts, but also establishing a construct for our future attempt to link the outcomes of such social learning experiences to their out-of-class, personal artifact creation and peer reviews.

Our rationale behind the design of the small-group f2f activities is to motivate and prepare the students for their out-of-school personal learning experiences. The small-group activities can be viewed as a group “exercise” of what and how the students can individually do in performing their out-of-class learning activities – closely observing and reflecting upon their living environments, associating environmental contexts (or creating contexts with the aid of physical objects or people) with their learned idioms/conjunctions, and generating artifacts for sharing. With this, we derive a novel visualization approach for descriptive analysis of the small-group activities of “Move, Idioms!” that is inspired by the notions of mediation by artifacts and distributed cognition. It is not (yet) our intention in this paper to formalize this approach for more general use, but more to provide a helicopter view of the process of student artifact co-creations in such collaborative FSL activities.

## Mediation by Artifacts

Research findings show that classroom learning mediators include tasks, teacher and peer resources, subject content, and semiotic artifacts (e.g., languages, textbooks, PowerPoint and worksheets) (Liang, 2009). Artifacts (broadly defined to include instruments, signs, languages, and machines) mediate activity and are created by people to control their own behavior (Nardi, 1996). As (Stahl, 2002) posits, if we adopt a Vygotskian view of mediation by artifacts, then the knowledge construction process can be conceptualized as the construction of knowledge artifacts, involving physical and symbolic artifacts as starting point, as medium and as product.

The notion of mediation by artifacts, as formulated by Leont’ev (1981), accounts for material activity and its outcome in the form of transformed material objects. More recently, spoken and written discourse began to figure in the lists of mediating artifacts (Wells, 2002). Leont’ev (1974) argues, “A tool mediates activity that connects a person not only with the world of objects, but also with other people..” Distributed cognition offers a similar notion; e.g., Hutchins (1987) discusses “collaborative manipulation,” the process by which we take advantage of artifacts designed by others (and ourselves), sharing ideas across time and space.

Combining both social and cognitive aspects, a distributed cognition perspective (Hollan, Hutchins, & Kirsh, 2002) suggests that cognitive activities such as knowledge construction are distributed across individuals and information artifacts through and with which they interact. The perspective implies the unit of analysis at the cognitive system as a whole, and emphasizes understanding of the coordination among the individuals and the artifacts in a system. Under the perspective, we would look for transformations of representations across individuals where those transformations can be interpreted as an intersubjective cognitive process. Examples include merging, revising, and connecting representations of ideas (Suthers, 2006).

We found the commonality between the small-group learning activities of “Move, Idioms!” and both notions of mediation by artifacts and distributed cognition. Our work is also related to an interpretative study (Alcock, 2005) on young children’s co-construction of playful narrative events, motivated and mediated by artifacts – where Alcock put forward the concept of “distributed imagination” and claimed it an analogy of distributed cognition. One notable aspect in Alcock’s thesis is that she treats people (e.g., the teacher who orchestrated the learning activity; a child who used her own body as an artifact to imitate a television character for her peers) as a potential form of artifacts. That echoes Cole’s (1996) wider overarching concept of artifacts that people may be used as mediating objects. In addition, the meaning and use of artifacts are structured and transformed through activities. Hence, the term “mediating artifacts” is not necessarily in the traditional sense of (persistent) man-made objects, but could refer to any element (object or human) involved in the cognitive system of a learning activity, which can be appropriated into a mediating artifact that serves students’ learning needs. Such a view is congruent with (Latour, 1996) argument that “to act is to mediate another’s action” (p.237) – both humans and objects mediate, and one can only proceed to action by mediating another’s action.

## “Move, Idioms!” –Theoretical Framework and Learning Experience Design

As a fundamental component of language learning, vocabulary learning is often delivered in conventional ways, such as providing abstract definitions and sentences taken out of the context of normal use (Miller & Gildea, 1987). Such pedagogical strategies may pose a greater problem for learning of context-dependent vocabularies, such as conjunctions, idioms and proverbs. The complex nature of such vocabularies may result in highly context-dependent appropriateness of their usage. There are many possible real-life contexts where such vocabularies could suitably (or unsuitably but often mistakenly) be used, which are almost impossible to be prescribed in a simple definition.

Recognizing both the importance and the limitation of formal, in-class language learning, language learning theorists have been advocating the integrations of formal and informal (Titone, 1969), and personal and social (Noel, 2001) language learning, which mesh well with the notion of seamless learning. Informed by the theories, we developed a cyclic, customizable learning experience design of “Move, Idioms!” (see Figure 1).

The processes of the four activities are described below:

**Activity 1 – In-class/campus contextual idiom learning:** The activities are conducted to motivate and prepare students to engage in subsequent out-of-school activities. During each lesson, new idioms are introduced to the students in the means of multimedia presentations. The teacher then conducts contextualized learning activities such as facilitating the students to take photos in the campus to illustrate the idioms.

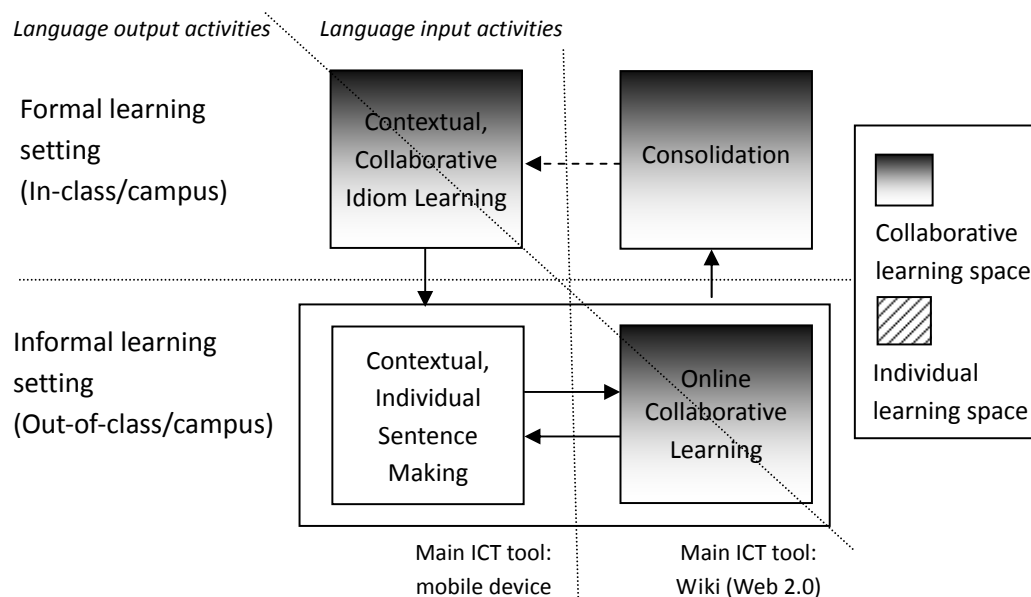


Figure 1. The “Move, Idioms!” Learning Experience Design.

**Activity 2 – Out-of-class, contextual, independent sentence making:** Students carry the mobile phones assigned to them 24x7 in order to identify or create contexts in their daily lives which could be associated with the idioms. They then take photos, make sentences by using the idioms to describe the photos, and post them onto a class wiki space. We create one wiki page for each idiom for students to post their artifacts. This offers convenience for comparing student-identified/created contexts pertaining to the same idioms.

**Activity 3 – Online collaborative learning:** Students perform peer reviews on the wiki by commenting on (with the built-in comment tool of wiki), correcting or improving their peers' sentences (by modifying the sentences posted on the wiki pages).

**Activity 4 – In-class consolidation:** Each student group is assigned a few existing student artifacts (photo/sentence sets) on the same wiki page with a mixture of correct, ambiguous and erroneous usages of an idiom. The groups compare the artifacts and revise the sentences if necessary. Subsequently, teacher-led classroom discussion makes contradictory views among the groups surfaced, facilitating class-wide debates.

## The Enactment of “Move, Idioms!”

Our design research study of “Move, Idioms!” took place in January-October 2010. A class of 34 Primary 5 students, with mixed abilities in Chinese Language (as L2), participated in the study. Each of them was assigned a Samsung Omnia II smart-phone running MS Windows Mobile 6.5, with built-in camera, Wi-Fi access, Internet browser and English/Chinese text input. We (the researchers and a group of Chinese teachers) co-designed 8 “Activity 1” and 2 “Activity 4” lessons (see Table 1) which were then enacted by the Chinese teacher with 2-4 week intervals. With a graphic designer background, the teacher had had eight years of teaching experience and had been one of the ICT-mediated Chinese curriculum leaders in her school. Meanwhile, we featured off-the-shelf mobile-optimized comic animations that depict the meanings of the taught idioms during each lesson, which could also be accessed by the students anytime, anywhere.

## An Artifact-oriented Approach to Analyze the Small-Group Artifact Co-creation Activities of “Move, Idioms!”

In our attempt to unpack the learning processes of the small-group activities during the in-class lessons of “Move, Idioms!”, one particular aspect that comes to our attention is the role of artifact mediation throughout their rich, situated learning experience, which can be characterised as an experience situated in ‘continually moving and re-constructed contexts’ (Looi, Wong, & Song, in-press). In turn, we carried out descriptive analysis on the verbatim transcriptions of audio and video recordings as well as the field notes of student group interactions during all the in-class lessons. The 8 student groups were comprised of 4-5 members each, which were randomly assigned by the teacher prior to the study and were heterogeneous in Chinese Language

competencies. We adopt the above-stated perspective of mediating artifacts as the analytical means. The intention of the analysis is to identify various forms of learning support tools and intermediate products, both physical and non-physical, map them into the artifact-oriented perspective, and unveil their relationships as well as various paths that different student groups had taken to accomplish their learning tasks in different lessons. We engaged student groups to member-check our analysis – though we did not use the academic term “artifacts” and instead asked them to confirm and further elaborate “things that contributed to or distracted their photo/sentence co-creation activities” that we discovered. Due to the space constraint, we will not go into the detailed analysis but to present the synoptic view of our findings.

**Table 1: Summary of 10 “Move, Idioms!” in-class lessons (all were “Activity 1” lessons unless otherwise stated).**

Lesson ID: #1	Worked in groups of 4, students brainstormed and made sentences that utilized the idioms (one idiom per sentence) learned in this lesson and sketched the scenario on paper worksheet. Students were not assigned the smart-phones yet.
#2	Students were assigned the smart-phones after receiving technical training. Worked in groups, they repeated the activity of Lesson #1 except that they were asked to enact the scenarios and took photos within the classroom. They then signed out the phones for 24x7 access.
#3	Each student group was assigned a particular area within the campus (e.g., canteen, basketball court, ecological garden). They went to the designated area, brainstormed to associate their encounters with their learned idioms, took photos and made sentences. They were encouraged to make one sentence that utilized two idioms.
#4	Each group brainstormed a paragraph that utilized multiple (both newly learned and previous) idioms. In-class Photo taking was not allowed but they were asked to plan for four pictures to depict the group-generated scenario.
#5	Each group brainstormed a paragraph that utilized multiple idioms, and took photos within the campus.
#6	An “Activity 4” lesson.
#7, #8, #9	Same as #5. For Lesson #8 and #9, they were taught and brainstormed sentences that utilized learned conjunctions instead – although most sentences had incorporated some idioms as well.
#10	An “Activity 4” lesson.

The unit of analysis is the group photo/text co-creation session. By artifact we refer not only to the student products (photo/text sets) but also the mediating artifacts and emergent, intermediate products involved in their learning processes. We classified the artifacts identified in the analysis into four categories. The classification is based on the major role of each artifact in the learning process. To simplify the analysis, we exclude task regulating artifacts such as timers and teacher’s monitoring but focus on identifying artifacts that are directly contributing to the contents of the students’ outcome artifacts. The four types of artifacts are:

- Physical artifacts: Physical or environmental tools that mediate the learning activities, such as the ICT tools, the classroom and the campus (and the physical objects available there), and even people (teachers, students, researchers, guests) who posed for photo shooting;
- Subject matter artifacts: Artifacts that represent the target knowledge to learn – the idioms and conjunctions themselves (which are linguistic/cultural artifacts), and the example sentences, paragraphs, or photo/text sets given by the teachers (digital artifacts – in PowerPoint form), as well as comic animations and YouTube videos, to demonstrate the usage of the vocabularies;
- Socio-cognitive artifacts: Non-physical artifacts generated through socio-cognitive means, such as teacher’s verbal scaffolds and peer discourses (both are semiotic artifacts), students’ *in-situ* improvising or emergent strategies to carry out the learning activities, ideas and stories for photo taking and sentence/paragraph compositions, and their shared (evolving) understandings in the associated meanings and linguistic functionalities of the idioms and conjunctions;
- Outcome artifacts: The target artifacts that the students are explicitly required to generate, including photos and text, peer review comments and peer revised text.

Hatch and Gardner (1993) propose a concentric model of the forces affecting a distributed cognition system. The three forces in the model are personal, local and cultural. Our level of analysis with the four types of artifacts being identified fits to the local level. We generated diagrams which depict all the artifact-mediated processes leading to outcome artifact creations as we have observed in the small group f2f discussions. Due to the space constraint, we present only the diagram pertaining to the combination of Lesson #5, #7, #8, #9 (with a photo set and a coherent plot in a paragraph as the outcome artifact) in this paper (see Figure 2). Although it is possible to generate one diagram per group per lesson, we decided to feature one consolidated diagram per lesson design for the same reason (space). The arrows in the diagrams represent mediation-outcome relationships. Each numbered node in the diagrams denotes a mini-state, which we refer to as *joint mediation*, of multiple artifacts (linked by incoming arrows) to the student group that results in certain output artifacts (linked by outgoing arrows). We refer to such nodes as joint mediation nodes (JM-nodes). Note that for any JM-node with multiple “input” artifacts, it is not necessarily that all (but can be any combination of) the “input” artifacts

will be utilized in every instance of the joint mediation. The same goes for a JM-node with multiple output artifacts (not necessarily all but can be any combination of output artifacts). The numbers in the JM-nodes show the rough sequence of different joint mediations (not definitive, as some groups could have occasionally backtracked to previous states to revise their earlier artifacts) in the co-creation processes. The JM-nodes labeled with the same number plus an alphabet (e.g., 1a) represent supplementary joint mediations that occurred in the same mini-state and were likely to be interweaving (or never happened in some cases). In addition, we identified certain mediating artifacts that occasionally did not play their usual constructive roles and instead became distracting or constraining factors to students' co-creation processes. We refer to them as *constraining mediation*.

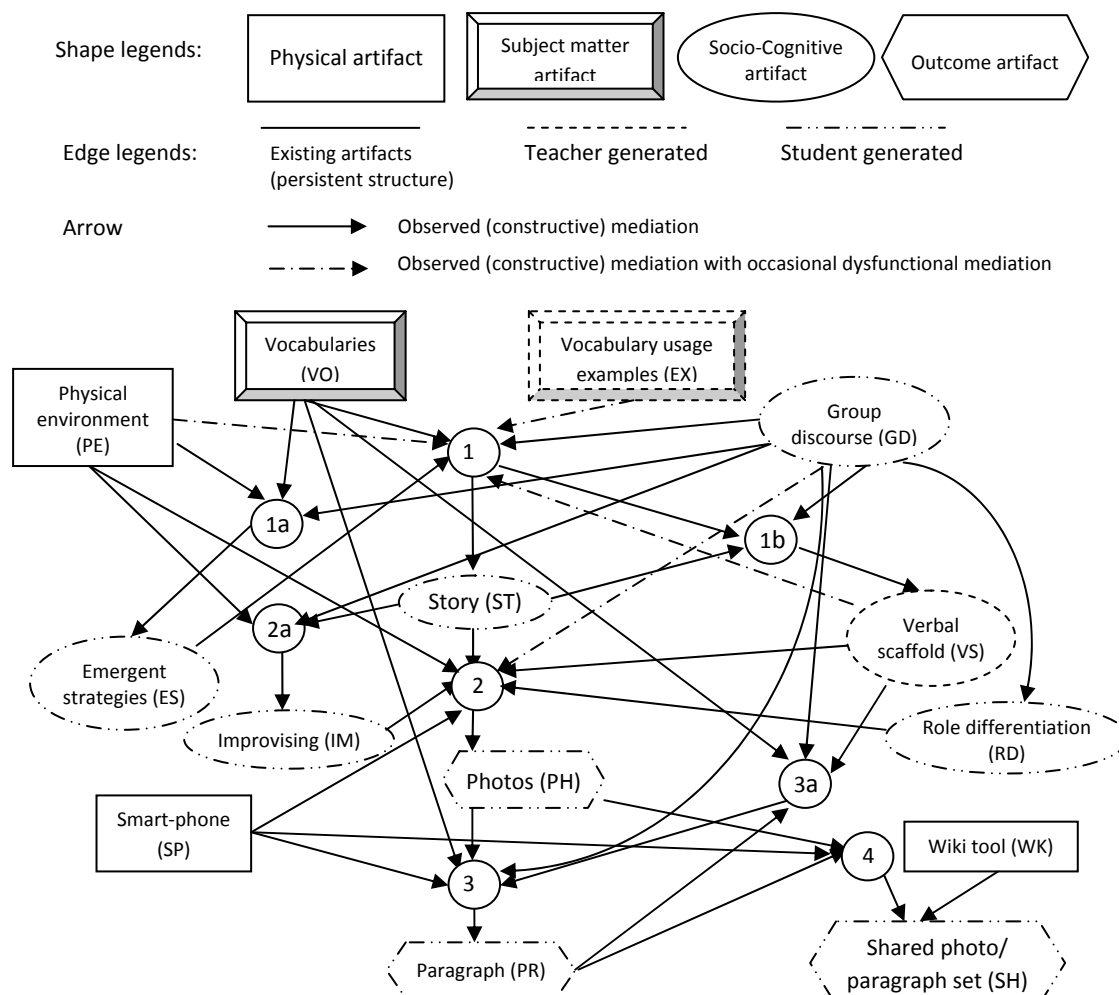


Figure 2. The Artifact-oriented Diagram of Collaborative Learning Activities in Lesson #5, #7, #8, and #9.

### Analysis of Small-Group Artifact Co-creation Processes in Lesson #5, #7, #8 and #9

The small-group activities in Lesson #5, #7, #8 and #9 can be divided into four mini-states – story co-generation (the result of the joint mediation of 1), photo set co-generation (the result of 2), paragraph co-generation (the result of 3), and wiki page appending (the result of 4).

**JM-node 1 & 1a:** Fresh from learning new idioms/conjunctions, student groups brainstormed their stories in the class, with the set of vocabularies new idioms to use (VO), the vocabulary usage examples (EX), the potentially accessible physical environment (PE; see the next paragraph for elaboration), and the (emergent) group discourse (GD) and teacher's verbal scaffolds (VS) as mediating artifacts. In particular, the vocabulary usage examples (EX) were presented by the teacher prior to the small group activities, in the forms of idiomatic/conjunction animations, PowerPoint presentations of photo and sentence/paragraph sets, or videos. Such digital artifacts had inspired or influenced some groups' subsequent storytelling (ST). In many cases, we consider the EX a constraining mediation as the artifacts constrained the students' creativity – some student groups copied the essential story idea and only made minor changes in the characters or the props. That is, they were not able to apply the learned idioms in different contexts, thus limiting their deep learning and internalization of the idioms. However, there were also positive cases where student groups managed to work out stories inspired by the EX but with more enriching contents and utilizations of different sets of idioms.

Even with the “comfort” of brainstorming (GD) stories (ST) in the classroom rather than *in-situ*, students usually took into consideration the accessibility of the physical environment (PE) for their subsequent photo shooting. This might instead become a constraining mediation as they had to revise the story and even drop some of the idioms (VO) in mind to satisfy the PE constraints. For example, a student proposed using the idiom 鸟语花香, literally means “birds twitter and fragrance of flowers” but figuratively characterizes “a fine, beautiful day”, in their story. The group spent minutes to debate about how tedious it would be to take a photo with both twittering bird(s) and flowers in it within the campus. Even though a member aptly pointed out the metaphorical nature of the idiom and could be used to describe fine weather and pleasant sceneries, with or without actual birds and flowers in the context, his group-mates did not concur and eventually gave up the idiom.

Conversely, for another group, the PE constraints triggered them to figure out strategies (ES) to overcome those. For example, another group which was similarly stuck in how to portray 鸟语花香 (a fine, beautiful day) had the teacher granted permission to take photos after school. They then worked out a plan of taking four photos and assigned each group member the task to take one of them, with a student who claimed that she could take a photo with birds and flowers from her home balcony assuming the obvious responsibility.

The common misconception on the usage of 鸟语花香 (a fine, beautiful day) was later clarified by the teacher to the class at another lesson. However, we argue that through such socio-cognitive learning activities, students were able to more effectively internalize the correct functionality of the idiom after the clarification. Therefore, such a mediating artifact which is seemingly constraining the students’ outcome artifact creation in short term may turn out to be conducive in their learning in a long run if the teacher is able to scaffold for “making errors work for the students and not against them” (Rubin & Thompson, 1982).

JM-node 1b: During the small group activities, the teacher was usually “touring” among the groups to check their progress and provide verbal scaffolds (VS) to improve their contextualized stories (ST) where necessary. Therefore, the VS is usually a product of the joint mediation of VO, PE and/or GD. However, there were occasional cases where the teacher advised against certain student groups’ story ideas for no pedagogical reason. One possibility was that the teacher’s designer background had made her subconsciously more ‘interventionist’ in students’ creative processes and products. We consider that another form of constraining mediation that might have distracted the students’ creativity.

JM-node 2 & 2a: The joint mediation of ST, PE, GD and the smart-phone (SP) resulted in the production of the first part of an outcome artifact – the photo set (PH). Improvising (IM) prompted by PE, including the sets (e.g., the library) and props (e.g., putting math and science books, sketch paper, a ruler and a calculator on the desk of an inventor character in the story – these props were contributed by different students) available, took place in some photo shooting occasions that resulted in the adaptation of their original ST. All the group-generated ST required some group members to become actors and enacted the scenario. Therefore, most of the groups were getting self-organized (i.e., role differentiation or RD) with dedicated “directors” and “photographers” being appointed (or self-appointed), and they sometimes switched roles between directors, photographers and actors. There were also cases where co-directing and co-photographing took place and due to the simplicity of the storyline, they still managed to carry out the learning task smoothly.

The smart-phone (SP) did not *only* serve as a productive tool. Occasionally, students checked a photo on the phone display immediately after shooting, and decided whether a retake was needed to make sure their idea was correctly executed and the idiom association was appropriate. In turn, SP became a cognitive tool (albeit still a physical artifact) to mediate their deeper thinking.

JM-node 3: The joint mediation of PH, VO, GP and SP resulted in the production of the second part of an outcome artifact – the paragraph (PR). Unlike during JM-node 1 where student groups only worked out rough story ideas (ST) that “guaranteed” usage of some of the given idioms or conjunctions, this would be the time that they synthesized their ST and photos taken (PH) and threaded the idioms they had in mind together to become a coherent paragraph (PR). In developing their paragraphs, some groups re-looked at the photos taken by different students (although most groups would have appointed an “official” photographer during JM-node 2, some students had taken extra photos when they were not engaged in acting) and replaced or inserted photos to the original photo sets. Additional idioms might incidentally be added to the paragraph. One instance took place in Lesson #5 where a group came back to the classroom from photo shooting on a story about basketball playing. A student recalled that her group-mate who played the role of basketball player (and became a PE artifact) was sweating minutes after the shooting started, which was captured by the photos (PH). She asked if 汗流浹背 (“all of a sweat”) is an idiom (VO) and a group-mate confirmed that. They decided to incorporate the idiom into the paragraph (PR). We checked with the group afterward and found out that the idiom was not taught in the present year but two of the group members recalled that their Chinese teacher in the previous year taught it in the class. The other two members who came from another class with a different teacher had not come across the idiom before; but they now learned it from their group-mates.

JM-node 3a: During JM-node 3, some groups found it difficult to organize their photos, or organize the idioms and their stories into paragraphs. The teacher was again “touring” among the groups and provided the

much needed scaffolding (VS). Typically, she looked at the unfinished paragraphs (PR) and offered ways to organize the relevant artifacts, sometimes with additional or alternative idioms (VO) being proposed.

JM-node 4: These were merely synthesizing-and-posting tasks (synthesizing photo and sentence into a complete instance of outcome artifact, and posting it onto the web) although they did append new contents to the relevant wiki pages, i.e., a new version of a wiki page, which was a collective outcome artifact, was generated.

## Discussion

Seamless learning is probably one of the most complex forms of learning as it involves multi-facets of learners' daily lives and has the potential of integrating most of the ICT-enhanced learning models – digital classroom learning, e-learning, m-learning, context-aware ubiquitous learning, etc. A holistic seamless learning experience design requires that learners not only interact with other people and instructor-provided artifacts within a relatively closed learning environment (e.g., traditional classroom or e-learning portal), but also with the authentic physical environment and perhaps the Internet at large, where learners may draw any element that they incidentally encounter and appropriate it into a useful mediating artifact for learning. We need additional analytic methods to unpack the individual and collaborative learning experiences of seamless learners. The most common existing CSCL analytical tools may offer a microscopic view of the dynamics of student collaborations within the situated learning context, most likely in a socio-cognitive constructivist perspective, but not so much on how individuals or groups interact with the environments. The artifact-oriented analysis and visualization approach reported in this paper is our preliminary attempt in making better sense of how the seamless learning process may look like, in the perspective of seamless learners' individual and collaborative learning experiences.

We are not the first who adopted such an artifact-oriented approach in analyzing learning environments, i.e., to map relevant elements in such environments into mediating artifacts for subsequent analysis. Apart from the above-stated analysis on young learners' narrative co-construction activities (Alcock, 2005) which bears the greatest resemblance with our work, there had been other studies (e.g., Conole, 2008; Lei, 2008; Wang & Ching, 2003) which adopted similar approaches of artifact-oriented analysis.

The uniqueness of our work is twofold. First, we developed a visualization approach to reveal the interdependence among the mediating and outcome artifacts within relatively complex learning processes perhaps with multiple branching – as the flexibility of multiple learning pathways (see: Looi, et al., 2009) is a significant feature for seamless or authentic learning environments. In our diagrams, we observed what Stahl (2002) conceptualizes as "... the construction of knowledge artifacts, involving physical and symbolic artifacts as starting point, as medium and as product." (p.67) Artifacts changed their roles through learners' appropriation for carrying out different learning tasks. Seamless learners ought to assume greater agency in deciding what and how to learn, either personally or collaboratively and across different learning spaces, rather than always being "dictated" by the externally-supplied mediating artifacts with prescribed roles. In turn, their habit of mind and skills of identifying and appropriating artifacts (including their previously learned knowledge and previously created artifacts) to mediate both their planned and incidental learning would become crucial for them.

Second, the above-stated literature almost only portrayed ideal situations where all mediating artifacts worked well in supporting student learning. As artifacts, in nature, both enable and constrain human activities (Paavola & Hakkarainen, 2004), we identified some weak links (constraining mediations) of the learning processes through our analysis on the empirical data – artifacts which may instead constrain or distract the learning tasks under certain circumstances. We believe that such findings (together with the identified positive emergent strategies and teacher's scaffolds) could be used to inform future pedagogical and even technological (re)design to eliminate or reduce such constrains and strengthen the use of emergent positive artifacts.

## Conclusion and Future Work

This paper reports on our effort in analyzing the small-group f2f artifact co-creation processes in the "Move, Idioms!" learning environment. We derived an artifact-oriented visualization approach, inspired by the notions of "mediation by artifacts" and distributed cognition, to meet this end. Due to the strong nature of situated learning in our design, analyzing the discourses among the group members leading to their outcome artifact creations without taking into consideration their interactions with the environment is inadequate. We believe such an approach can also be applied to analyze the students' personal, out-of-school learning experiences, especially that the small-group artifact co-creation activities were designed in the way as a preparation of their personal artifact creation activities in informal settings. Subsequently, the interplay between collaborative and personal learning can be investigated. Still, more work need to be done to formalize the approach, such as a more rigorous categorization of artifacts, the similarities and differences in applying the approach to analyze collaborative and personal learning experiences, and how can it be applied to inform future learning design.

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