Title	Exploratory study on the physical tool-based conceptions of learning of young students in a technology-rich primary school
Authors	Wong Lung-Hsiang, Jan Ming-Fong, Yancy Toh and Chai Ching-Sing
Source	*10th International Conference of the Learning Sciences (ICLS) 2012, Sydney, Australia, 2 -6 July, 2012*
Published by	International Society of the Learning Sciences

Original citation: Wong, L.-H., Jan, M.-F., Toh, Y., & Chai, C.-S. (2012). Exploratory study on the physical tool-based conceptions of learning of young students in a technology-rich primary school. In J. van Aalst, K. Thompson, M. J. Jacobson & P. Reimann (Eds.), *Proceedings of the International Conference of the Learning Sciences (ICLS) 2012* (Part 1, pp. 243-250). Sydney, Australia: International Society of the Learning Sciences.

Exploratory Study on the Physical Tool-based Conceptions of Learning of Young Students in a Technology-Rich Primary School

Lung-Hsiang Wong, Ming-Fong Jan, Yancy Toh, & Ching-Sing Chai, Learning Sciences Laboratory, National Institute of Education, 1, Nanyang Walk, Singapore 637616.
[lunghsiang.wong, mingfong.jan, yancy.toh, chingsing.chai]@nie.edu.sg

Abstract: This paper explores young students' tool-based conceptions of learning in a technology-rich primary school in Singapore. By examining how young children represent the images of learning through their drawings, we have distilled the types of learning tools that are being accentuated from students' emic perspective. We contend that the prevalence, absence or peripheral representation of tools (in particular technology) in students' drawings will help us make sense of the collective cultural roles tools play in their world. Interviews are also conducted with students and teachers to further tease out the underpinnings of children's conception of learning. The content analysis of 183 drawings revealed that technological tools were more prominently featured in mix-achievement classes than high-achievement classes. The reasons for such discrepancy emanate from the distinct learning priorities of and strategies used by these two groups of students. We also extend our discussion to explore the pedagogical implications of our findings with regard to 21st century learning dispositions.

Introduction

The mediating roles of tools in shaping human experience have long been recognized by educators (Bernhard, 2009; Jonassen, 2000; Müller, 1940; Wong, Chen, & Jan, in-press). While the choices of learning tools shape the learners' learning experiences, individual learners' conceptions of learning may also determine the tools that they choose or prefer in mediating their learning. The proliferation of technology-mediated learning in the past two decades may give rise to the evolution of dialectical relationships between learners, their learning experiences and their learning conceptions. However, research on students' conception of learning has not been focusing much attention on the roles of technological tools for learning. Questions like this are important for educators to examine the gaps between theories and practice of technology-based learning.

In this paper, we report on our recent exploratory study on young learners' conceptions of learning in a technology-rich primary school in Singapore. Our aim is to find out how children in an ICT-enriched school represent the images of learning. In relation, what kinds of tools are being accentuated in the children's drawings and how do children project themselves as learners when these tools are depicted? We surveyed 183 Primary 3 (3rd grade; 9-year-old) students in their general conceptions of learning by inviting them to draw a picture or write anything on "What is 'learning' to me?" on a piece of paper respectively. We adopted such a picture questionnaire method due to the target students' limited verbal capability for expressing their conceptions of learning. In addition, 38 students were invited for one-to-one interviews as a means to triangulate our interpretation. Preliminary coding and analysis led us to the focus of one specific element in the pictures – the physical learning tools (i.e., physically existing entities), the most frequently portrayed or mentioned elements in the pictures. Furthermore, the drawings exhibit certain discrepancies when the pictures submitted by high-achievement (HA) and mixed-achievement (MA) students were compared. As such, we see the potential in making use of the referred tools in achieving deeper understanding in the students' conceptions of learning.

In this paper, we will delineate our coding and data analysis process in making sense of the picture data. We will also present preliminary findings arisen from our data analysis and relate them to the specific schooling and social context of the student participants. We hope that our report can serve as a foundation for more sophisticated analysis of the relationships between the tools and other elements portrayed in the pictures, as well as shed light on methods to investigate young children's conceptions of learning.

Literature Review

Learning Tools

The Longman Dictionary refers to "tool" as "something that you hold in your hand and used to do a particular job". This conventional definition implies physical nature of tools, with the purpose of enhancing human physical power, strength and capabilities. Conversely, Vygotsky (1978) argued that learning required two mediational means – tangible tools (technical tools) and intangible tools or signs (semiotic tools). At Vygotsky's time of writing, technical tools were general physical entities, while semiotic tools were (and still are) the means by which cognitive functions are manifested, such as language, numbers and diagrams. With the advent of ICT, the distinction between tools and signs in modern times, has blurred – that is, computers have the ability to mediate cognitive processes (Duffy & Cunningham, 1996).

Conceptions of Learning

"Conceptions of learning" can be broadly defined as "beliefs and understanding held by learners about learning" (Lai & Chan, 2005, p. 3). One of the most prominent taxonomies on conceptions of learning is proposed by Marton, Dall'Alba and Beaty (1993) who built on Saljo's (1979) work to define 6 hierarchically-related levels of learning: 1) Learning as increasing one's knowledge; 2) Learning as memorizing and reproducing; 3) Learning as applying; 4) Learning as understanding and abstraction of the meaning; 5) Learning as an interpretive process of seeing something in a different way and 6) Learning as the concept of "changing as a person". Biggs (1994) re-conceptualized the 6 levels and interpreted the first 3 levels as quantitative outlook, where learners viewed acquisition and accumulation of content as indicators of proficiency; and the remaining 3 levels as qualitative outlook where the focus of learning is coalesced around understanding, associating and meaning-making. Van Rossum & Schenk (1984) visualized the 6 levels in terms of reproduction and construction of knowledge, and expounded that learners who emphasized on reproducing tend to adopt surface learning approaches whereas those with constructive orientation tend to adopt deep learning approaches. Apart from deep and surface learners, there is also another group of "strategic" learners who are motivated to achieve the highest possible grades. These learners regulate their learning to create a learning environment, maximize their use of resources as well as develop understanding of assessment orientation (Entwistle & Ramsden, 1983).

Many studies have explored the inter-relationship between conceptions of learning and various variables such as approaches to learning (Lai & Chan, 2005), self-concepts (Burnett, Pillay, & Dart, 2003), learning outcomes (Martin & Ramsden, 1987), learner autonomy (Chuk, 2004), learners' experience of learning (Prosser & Trigwell, 1997), and learning context (Van Rossum & Schenk, 1984). The literature supports the view that students' conception of learning can influence their learning strategies or processes, and when these mediating variables are viewed together, they can be a good predictor of learning outcomes.

Although there is much fruitful work done in exploring the conceptions of learning and learner-oriented influences, there is tardiness in investigating the relationship between students' conceptions of learning and their learning tools. Clarebout and Elen (2006) conducted a comprehensive literature review on the tools, defined as non-embedded support devices that were used in computer-based learning environment. After combing the vast body of literature that spanned from 1982-2002, they only surfaced 17 studies that addressed factors influencing tools used. They concluded there is some but not compelling evidence that the tools used by learners are shaped by learner, tool and task characteristics. Of relevance to our study is that high achievement students appear to benefit more from having more control over the tools used and that they use tools more frequently than low achievement students. Clarebout and Elen's study is very useful in helping us gain perspectives about the macro trend of tool usage. However, the analysis of the meta-study is not situated within the framework of learners' conceptions of learning, thus eschewing on learners' emic sense-making perspectives. In view of this gap, we hope our study, guided by the theme of students' tools-based conception of learning, will be able to shed light in this under-studied area.

The Research Methodology of Picture Questionnaire

In addition to abstracting the research themes that are related to the conceptions of learning, this section also reviews the methodologies used in prior studies. Most abovementioned studies are conducted using questionnaires or inventories and supplemented by interviews, if any. Our methodology departs from the above in that we adopt children's drawings as our primary source of data and deploy semi-structured interviews as supplementary evidence. MacPhail and Kinchin's (2004) methodological review showed that children's drawings is an established methodology which had been used extensively in clinical studies as indicators of a child's intellectual maturity and psychological development; examination of children's understanding of the classroom environment; family relationships and value-laden issues of what is good and bad. The use of children's drawings is a child-centered procedure and evaluation tool where students have the autonomy to decide what to include without being influenced by researcher's frame of reference. More importantly, the method is potentially powerful in conveying students' salient range of experiences in association to different teaching and learning environments (MacPhail & Kinchin, 2004; Xu, Read, Sim, & McManus, 2009). Borthwick (2011) contended that children's drawing can provide multi-perceptivities and encourage teachers to be more reflective in their teaching practices. Lodge (2007) asserted that children's drawings can be viewed as "visual discourse" (p.147) which can be read in a similar way to textual discourse. Citing the views of Weber and Mitchell (1996), children's learning can "express that which is not easily put into words: the ineffable, the elusive, the not-yet-thought-through, the subconscious" (p.304).

Much like using discourse as a major source for research, there are limitations to using children's drawing as the source of data. Reasons include: 1) children's drawing are not the "royal road of access to internal representations" (Krampen, 1992, p. 41) as influences of conventions may affect the depiction of children's internal model. Too many intervening factors create confounding intricacies, rendering it difficult to equate graphic representations with how internal representation is stored (Jolley, 2010); 2) there may be developmental lag in students' drawing abilities and thus affect students' production of representations (Jolley,

2010); 3) there is a tendency to fall into the trap of 'conceptual fallacy' due to over-interpreting the drawings (Cotterall, 1995). Lange-Kuttner and Thomas (1995) elucidated that there is no consensus amongst experts on how pictures should be interpreted. However, most theorists would not dispute the fact that although children's perceptions are influenced by convention and experience, some form of linkages do exist between picture perception and perception of real world. This argument stems from the premise that "even very young children seem to be able to identify the subject-matter of many pictures without training" (p.3). As a corollary to the potential drawbacks and benefits of using drawings as a data collection method, MacPhail and KinChin (2004) recommended the synthesis of both children's drawings and direct questioning methods to gain insights about students' conception. We agree with the authors and have deployed this methodological plurality in our study.

Study Description

Sample

The sample of this study consisted of 183 Primary 3 students (3rd graders) from 6 classes within a primary school in Singapore. The first two classes admitted the top (HA) students of the level (n = 74), while the rest of the students were randomly assigned to the other four classes, which is known as MA students (n = 109). The school is a neighborhood school that in general admits average students. Nevertheless, it is one of the technology-rich schools in Singapore, with the management's long-term commitment in transforming itself into a 1:1, 24/7 (one-mobile-device-per-student, with '24 hours a day, 7 days a week' access) learning environment (Looi, et al., 2010; Wong, Chai, Chin, Hsieh, & Liu, 2011; Wong, Chin, Tan, & Liu, 2010; Wong & Looi, 2010; Zhang, et al., 2010). We conducted the study during April, 2011. By then, the target students had already been accessing to their school's several e-learning portals through their home computers for close to 1 ½ year. They had been using the portals for submitting their homework in digital formats, studying learning materials and/or attempting curriculum-related quizzes. Special arrangement was made for a small number of students who did not have computers at home to access computers at the computer labs after school hours. However, the target students had only episodic experience of 1:1 learning prior to our study. The only 1:1 experience that most of them had was the use of smartphones during a one-off teacher-facilitated educational fieldtrip at the zoo.

Data Collection

We arranged with the school to utilize one hour of class lesson time at each class to conduct the study. Each student was given a piece of A4-size blank paper. We asked them to draw a picture to describe "What is 'learning' to me?" They were encouraged to write additional text to explain the picture, while writing pure text was also allowed. As such an activity instruction might still be too abstract to most of them, we asked them to close their eyes and imagine that they were learning, and draw or write to describe the picture that came across their mind. We did not give them any concrete example about what they could depict so as not to cause a leading effect in their picture contents. We advised them that this was not an arts assignment and would not be graded for the aesthetic quality. In addition, there was no "standard answer"; instead, they should depict whatever they personally thought relevant to learning. We also walked around the student desks and probed selected students on what they were drawing if we found their work-in-progress pictures having ambiguous contents. A researcher took field notes throughout the sessions, where such conversations were recorded.

Procedure of Data Analysis

We followed a coding procedure similar to that of grounded theory (Strauss & Corbin, 1990) in order to minimize the influence of preconceived theories. This allows us the possibility to see new light from the collected data rather than conforming to existing theories. Besides, we quantify the in-vivo codes (e.g., exam papers pictured by students) not only to bring out the frequency but also to demonstrate the intensity of related concepts and their meanings to participants. In addition to pictorial representations, we also coded textual descriptions, speech balloons between the different actors depicted in the pictures and reflection clouds of children. The field notes taken during the survey sessions and students' interviews were used for triangulation.

In addition, we selected 12 HA students and 26 MA students from various classes whose picture contents were either highly representative of many peers (i.e., depicting many common elements) or vastly unique for one-to-one semi-structured interviews. We probed the interviewees about ambiguous depictions and rationales of incorporating the elements in their pictures. We also interviewed 4 teachers from 4 different classes to find out more about their views on their own teaching methods and their students' ways of learning. That helped us in better interpreting the pictures.

Nevertheless, due to the complexity of the data set, we decided to focus on the category with the highest frequency – the tools – as our preliminary step in our longer term investigation of this topic. This is because as we are looking at the context of a technology-rich school, our primary focus is on how students will depict their learning tools, in particular ICT tools. The prevalence, absence or peripheral representation of ICT in their drawings can help us make sense of the roles which ICT play in their world. We can then infer

pedagogical implications based on the congruency/incongruency between students' depicted ICT usage and the school's espoused usage. In order to ensure that such a decision is statistically justifiable, we ran a chi-square test on the number of pictures that depict at least one tool (n = 129) versus those without (n = 35), and yielded $\chi 2 = 53.88$ ($p < .05$), which indicates that the amount of the former type of pictures is significantly higher.
In particular, we concentrated on coding physical tools but ignored semiotic tools. This is because semiotic tools were scarcely depicted in the data set. The young students could easily relate to the physical tools and articulate how the tools were used for learning; but they in general would not consider semiotic tools as mediating tools, but as part of the contents. Furthermore, we are not looking at the micro analysis of individual students' drawing, but common patterns that emerged from the 164 pictures, i.e., what we are investigating are the 'group data' or 'group's cultural patterns' (MacPhail & Kinchin, 2004, p. 89). Semiotic tools are imbued with subjective and heavily contextualized interpretations, thus rendering the generalization process across the 164 pictures ineffectual. We removed all other codes but focused on re-examining the tool-related codes, and worked out the coding scheme as shown in Table 1. The right-most column of Table 1 lists examples of the roles or functionalities of the corresponding tools as depicted or described in the pictures.

Table 1: The coding scheme for physical tool-based conception of learning.

First-level category	Second-level category	Code	Functions Mentioned by Students (Examples)
No tool	-	-	-
Non-ICT tools	Personal stationery	Pen / pencil / eraser / stationery case	For doing worksheets
		Paper notebook	For note taking at outdoor learning
		Ruler	For drawing straight lines in the worksheets
		Folder	For filing the worksheets
	Classroom-based tools	Whiteboard / blackboard	Teacher use in classroom lessons
		Pointing stick	Teacher use in classroom lessons
	Furniture	Desk / chair	For sitting still and studying with concentration (either in the classroom or at home)
	Assessment-related tools	Homework / worksheets	For drill and practice
		Past year exam papers	To practice for exams
	Books & references	Book shelf	For keeping books
		Any book	For all reading and studying purposes
		Textbook	For studying the formal syllabus
		Storybook	For easy reading or improving language
		Paper dictionary	Assisting language learning or general-purpose writing
	Tools for sport activities / physical education	Basketball & net	Basketball playing / training
		Soccer & net	Soccer playing / training
		Badminton & net	Badminton playing / training
		Running mill	For keeping fit
		Skipping rope	Playing or training rope skipping
	Tools for science learning	Equipment for science experiments	For science experiments in the lab
		Plants / seeds / watering container	For planting activities related to biology classes
		Specimen	Exhibits in the science lab
	Tools for music & arts	Piano	Used in piano lessons
		Violin	Used in violin lessons
		Assorted music instruments	Used in music lessons
		Color pencils / crayons	Used in art lessons or personal drawing
ICT tools	Handheld devices	iPhone / other smart-phone	For supporting outdoor learning, Internet access or creating simple student artifacts
		iPad / other tablet	For accessing to Internet or school e-learning portal
		Calculator	To support math learning
		e-dictionary	Assisting language learning or general-purpose writing
	Non-handheld devices	MacBook / Notebook computer	For accessing to Internet or school e-learning portal; doing assignments
		Desktop computer	For accessing to Internet or school e-learning portal; doing assignments; downloading past-year exam papers
		Television	Learning by watching TV shows
	Classroom-based tools	Overhead projector / visualizer	Teacher use in classroom lesson

After re-coding the pictures with the above physical tool-based coding scheme (which were very minor revisions), we split the valid data set into two groups – the HA group (72 pictures) and the MA group (92 pictures), based on which classes individual students came from. We ported the coding Excel sheet to the SPSS software and performed chi-square tests to compare the code frequencies of both groups in various categories

and sub-categories. In turn, we yielded some statistical findings that may assist us in making better sense of the target students' tool-based conceptions of learning, which we will explicate below.

Findings and Discussion

As stated before, we performed chi-square tests on the data set in an exploratory manner after re-coding. A summary of the tests is shown in Table 2. Note that most of the students had depicted more than one physical tool in their respective pictures. The counts listed in Table 2 refer to the number of students who depicted the particular types of tools, not the accumulated frequencies of individual tool types across all the students.

Table 2: Summary of chi-square tests on the coded data.

Topic	**Achievement: HA (n = 72)**		**Achievement: MA (n = 92)**		$\chi 2$
	Count	**% within HA**	**count**	**% within MA**	
No tool	16	22.2	19	20.7	0.06
Non-ICT tool(s) only	48	66.7	49	53.3	3.00
ICT tool(s) only	3	4.2	12	13.0	3.83 *
Non-ICT + ICT tools	5	6.9	12	13.0	1.62
At least 1 non-ICT tool	53	73.6	62	66.3	1.02
At least 1 ICT tool	7	9.7	24	26.1	7.06 *

* $p < .05$

In addition, we present two examples of drawings by a HA and a MA students respectively (see Figure 1). Both drawings are supplemented by textual annotations. The text in the HA student's drawing at the left is originally written in Chinese (as we borrowed a Chinese lesson to conduct the survey). To benefit international readers, we overlay the English translation on the Chinese text. In this picture, we see (and coded) a whiteboard and a textbook in the top-left frame (classroom scenario), a textbook and an assessment book in the bottom frame (study room scenario), and desks/chairs in all frames. In the MA student's drawing at the right, we see both non-ICT tools (pencil, eraser, ruler and assessment book) and ICT tools (computer, accessing to the school's e-learning portal, "AskNLearn", which is an assessment-oriented portal) being depicted by the student.

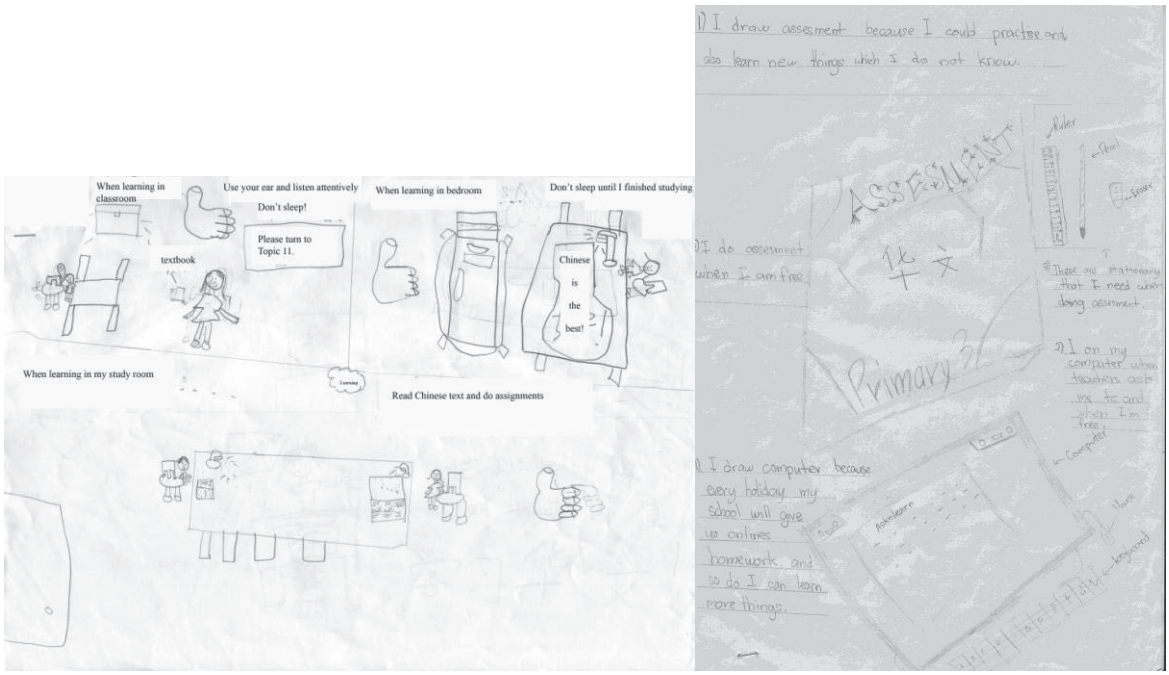

Figure 1. Examples of drawings by a HA student (left) and a MA student (right).

From Table 2, we notice that there is no significant difference between the number of HA and MA students who foregrounded non-ICT tools in their drawings (see the columns of "non-ICT tool(s) only" and "at least 1 non-ICT tool"). Conversely, general MA students had been far more inclined to highlight ICT tools than their HA peers. In any case, how do the students perceive the affordances of such tools that may be conducive for their learning effort? Indeed, the right-most column in Table 1 may delineate the most prevailing learning strategies in their mind. For example, the "personal stationery", the "books and references", and especially the

"assessment-related tools", are mainly employed for assisting in the study of prescribed knowledge or drill-and-practice activities. The "classroom-based tools" are those used by the teachers in their classroom teaching; in such pictures, students usually portrayed themselves as attentive and obedient students in uniforms, sitting still on their respective chairs next to their desks. Such behaviorist- and transmissionist-inclined depictions (or, in Van Rossum & Schenk's (1984) view, the "reproduction of knowledge") of the functionalities of the non-ICT tools are also seen in their ICT counterparts. Examples are the use of phones, tablets, notebook or desktop computers to access to the school e-learning portals (containing essentially digital learning materials and online quizzes), doing assignments or even searching and downloading past year exam papers. What makes the use of ICT tools seemingly more open-ended is that they are also depicted by fewer students as the tools for searching for online learning resources, supporting outdoor learning and creating simple artifacts. There are also certain domain-specific tools such as those used for sports activities (or physical education), music, arts and science learning, which are however depicted by fewer students as compared to ICT tools and general non-ICT tools.

The findings presented here suggest two salient themes we will discuss more in more depth: the discrepancy in the use of ICT tools between HA and MA students and the missing of social media. Though the two seem to be irrelevant phenomena, they are interconnected at a much deeper level.

The Discrepancy in the Use of ICT Tools between HA and MA Students

Based on Table 2, HA students, students who are academically superior to MA students, tend to associate non-ICT tools, especially tools related to contents and standardized tests, with learning. MA students (average students), conversely, think of learning tools more broadly when it comes to the choices of physical tools for learning. Initially we were befuddled by the finding as we assume that high-achieving students should have been savvier than average students on using ICT tools for learning. Assumingly, HA students will use ICT tools as often as MA students, if not more. However, their drawings reveal a different story—ICT tools are far less relevant to learning for HA students even when they are situated in an ICT rich school.

Our follow-up interviews with teachers from the school shed more light to the interpretation of pictorial data. HA students are much more focused on success in exams and the most frequently depicted learning strategy is to "work hard". Therefore, ICT tools, besides their limited affordances in providing access to school portals, exam questions and occasional on-line research, are often seen as distraction by many HA students as they do not serve the direct purpose of helping students score well in high-stake assessments. Oftentimes, the use of ICT tools in these families is limited, if not banned as they are perceived as irrelevant activities. Teachers also shared that HA students, with schedules packed for enrichment activities, have very limited informal learning spaces for other exploratory activities. MA students, conversely, have more informal learning spaces to dabble with technologies and are often savvier than HA students when it comes to computer and information literacies. On example cited by the teachers is that MA students appear to be more attuned to the nuances of technological affordances and are able to figure out how location-based technologies can be harnessed meaningfully on their own within a very short period of time during fieldtrips, as compared to HA students who encountered more problems trying to understand the functionalities of the technology.

The Missing of Social Media

Drawing ICT tools or not, students across HA and MA groups depict a consistent epistemology for how they will use tools for learning in their drawings—as carrying contents (such as books and blackboard), providing access to contents (such as desktop computers and iPad), and performing assessments (such as worksheet, and notebook with the assess to the school's e-learning portals). The finding is somehow expected as research from Kuhn, Cheney, and Weinstock (2000) reveal that students of this age group tend to hold an "absolutist" epistemology. As absolutists, students tend to identify knowledge as facts discovered by great people, and can be accessed via external sources such as books and the Internet.

The unexpected to us is the rarity they depict artifacts that represent social media and participatory culture (Jenkins, Purushotoma, Clinton, Weigel, & Robison, 2009) in their drawings. Rarely do we find students depict how they hang out, mess around or geek out (Ito, 2010) in the world of new media and participatory culture (Jenkins, et al., 2009). Yes, some students do draw iPhone, iPad and computers. But they ways they associate these ICT tools with learning in the classrooms do not reflect the spirit of participatory culture. This finding raises an important question for educators who attempt to bring participatory culture to schools. Students participating in this research are all digital natives born around 2001 and 2002. In other words, their life experience should be parallel with the growth of Web 2.0 technologies. In fact, in the follow-up interviews, students reveal that most of them are using Facebook, Twitter and other social media. But why do students predominantly picture ICT tools as extension of classroom activities?

How might the missing of social media and the discrepancy in the use of ICT tools between HA and MA students be connected? Both findings are pertinent to how students perceive the functions of technologies for learning. The missing of social media, together with the consistency in using ICT and non-ICT tools for carrying contents, providing access to contents, and performing assessments, is an indicator about the perceived

affordances (Norman, 1993) of technologies, which is pertinent to students' learning epistemology (Jan, 2011) and desire for learning (Pea, 1993). The discrepancy in the use of ICT tools between HA and MA students is another revealing case about the perceived affordances of ICT tools based on the students' concept of learning. When students perceive learning as equating to performing well in schools, ICT and non-ICT tools are often used as tools for achieving better performance in exams. That is, ICT tools, regardless of their affordances, are used by as content delivery tools like books. This argument supports Entwistle & Ramsden's (1983) notion of how "strategic learners" will maximize their resources primarily for the purpose of achieving high grades. When tools are used as content delivery tools, efficiency becomes the main concern when it comes to usage. Though ICT tools provide convenience to contents, they are also tools of distractions for parents and many students with just one click away from the targeted contents.

Conclusions

In this exploratory study, we investigate Primary 3 students' concept of learning via analyzing their drawings. Specifically, we foreground the analysis of physical tools and the affordances of these tools perceived by students. The purpose of our analysis is not to depict how individual students picture the conceptions of learning, and provides a thick description. Rather, we aim at uncovering collective thinking patterns about students' conceptions of learning. We found that these students, who grew up with the omnipresence of ICT, mostly identify non-ICT tools as their preferred tools for learning in the drawings. When computational media are depicted, they are often used to support learning in the same fashion non-ICT tools. Students' learning epistemology, manifested via how the functions of physical tools are identified, suggest that these students predominantly view learning as familiarizing themselves with formal subject contents. Perhaps the most revealing finding is that the HA students, as defined by schools, are more inclined to identify non-ICT tools as preferred learning tools than average students.

We believe that such an understanding is pivotal if schools wish to transform learning for the 21st century learning skills—a transformation from teaching standardized skills to fostering creativity and innovation (Shaffer & Gee, 2005). With the hefty investment in providing students new technologies, do we also equip students with frameworks for using technologies properly? If students view an iPad, for example, mainly as a tool for easy access to exam questions and contents, it is less likely for them to use iPad as a tool that situates their life experience in a participatory culture. We believe that such a framework for using technologies must encourage students to use technologies for sharing, collaboration, critical knowledge consumption and creative production. In other words, the framework for using technology fosters *prosumer* (Tapscott & Williams, 2008) identity via transforming epistemology and enculturing students in the practices of participatory culture.

References

Bernhard, J. (2009). Learning through artifacts in engineering education: Some perspectives from the philosophy of technology and engineering science. *Proceedings of the 6th European Forum on Continuing Engineering Education, Quality Developmentin Lifelong Learning - in Theory and Use*, Rotterdam, Netherlands.

Biggs, J. (1994). Student Learning Research and Theory: Where Do We Currently Stand? In G.Gibbs (Ed.), *Improving Student Learning: Using Research to Improve Student Learning* (pp. 1–19). Oxford: Oxford Centre for Staff Development.

Borthwick, A. (2011). Children's perceptions of, and attitudes towards, their mathematics lessons. *Proceedings of the British Society for Research into Learning Mathematics* (pp. 37-42), Bristol, UK.

Burnett, P. C., Pillay, H., & Dart, B. C. (2003). The Influences of Conceptions of Learning and Learner Self-Concept on High School Students' Approaches to Learning. *School Psychology International, 24*(1), 54-66.

Chuk, J. Y. P. (2004). Promoting learner autonomy in the EFL classroom: the Exploratory Practice way. *Proceedings of the Supporting independent English language learning in the 21st Century: Independent Learning Association Conference* (pp. 57-74), Melbourne.

Clarebout, G., & Elen, J. (2006). Tool use in computer-based learning environments: towards a research framework. *Computers in Human Behavior, 22*, 389-411.

Cotterall. (1995). Readiness for autonomy: Investigating learner beliefs. *System, 23*(2), 195-205.

Duffy, T. M., & Cunningham, D. J. (1996). Constructivism: Implications for the design and delivery of instruction. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 170-198). New York: Simon & Schuster Macmillan.

Entwistle, N., & Ramsden, P. (1983). *Understanding Student Learning*. London: Croom Helm.

Ito, M. (2010). *Hanging Out, Messing Around and Geeking Out: Kids Living and Learning with New Media*. Cambridge: MIT Press.

Jan, M. (2011). Fostering learning paradigm shift with game-based learning. *Journal of Advanced Technology and Management, 1*(1), 47-60.

Jenkins, H., Purushotoma, R., Clinton, K. A., Weigel, M., & Robison, A. J. (2009). *Confronting the challenges of participatory Culture: Media education for the 21st century*. Cambridge, MA: The MIT Press.

Jolley, R. P. (2010). *Children and Pictures: drawing and understanding*: Wiley-Blackwell.

Jonassen, D. (2000). *Computers as Mindtools for Schools* (2nd ed.). Upper Saddle River, NJ: Prentice-Hall.

Krampen, M. (1992). *Children's Drawings: Iconic Coding of the Envrionment*. New York: Plenum Press.

Lai, P.-Y., & Chan, K.-W. (2005). *A structural model of conceptions of learning, achievement motivation and learning strategies of Hong Kong teacher education students*. Paper presented at the AARE Conference, University of Western Sydney.

Lange-Kuttner, C., & Thomas, G. V. (1995). Introduction. In C. Lange-Kuttner & G. V. Thomas (Eds.), *Drawing and Looking: Theoretical approaches to pictorial representation in children*. New York: Harvester Wheatsheaf.

Lodge, C. (2007). Regarding learning: Children's drawings of learning in the classroom. *Learning Environ Res, 10*, 145–156.

Looi, C.-K., Seow, P., Zhang, B. H., So, H.-J., Chen, W., & Wong, L.-H. (2010). Leveraging mobile technology for sustainable seamless learning: A research agenda. *British Journal of Educational Technology, 42*(1), 154-169.

Müller, R. H. (1940). American apparatus, instruments, and instrumentation. *Industrial and Engineering Chemistry: Analytical Edition, 12*(10), 571-630.

MacPhail, A., & Kinchin, G. (2004). The use of drawings as an evaluative tool: students' experiences of sport education. *Physical Education & Sport Pedagogy, 9*(1), 87-108.

Martin, E., & Ramsden, P. (1987). Learning Skills or Skill in Learning. In J. T. E. Richardson, M. W. Eysenk & D. W. Piper (Eds.), *Student Learning* (pp. 155–167). Milton Keynes, England: Open University Press.

Marton, F., Dall'Alba, G., & Beaty, E. (1993). Conceptions of learning. *International Journal of Educational Research, 19*(3), 277-300.

Norman, D. A. (1993). *Things that Make Us Smart: Defending Human Attributes in the Age of the Machine*. Reading, MA: Addison-Wesley.

Pea, R. (1993). Practices of distributed intelligenceand designs for education. In G. Salomon (Ed.), *Distributed Cognitions* (pp. 47-87). Cambridge, U.K.: Cambridge University Press.

Prosser, M., & Trigwell, K. (1997). *Understanding Teaching and Learning: The Experience in Higher Education*. Buckingham: Open University Press.

Saljo, R. (1979). Learning from the Learner's Perspective. I: Some Common Sense Conceptions (Vol. Rep. No. 76): Goteborg, Sweden: University of Goteborg, Institute of Education.

Shaffer, D. W., & Gee, J. P. (2005). Before every child is left behind: How epistemic games can solvethe coming crisis in education *WCER Working Paper No. 2005-7*. Madison, WI: University of Wisconsin-Madison, Wisconsin Center for Education Research.

Strauss, A., & Corbin, J. (1990). *Basics of Qualitative Research: Grounded Theory Procedures and Techniques*. Newbury Park, CA: Sage.

Tapscott, D., & Williams, A. D. (2008). *Wikinomics: How Mass Collaboration Changes Everything*. New York: Portfolio Hardcover.

Van Rossum, E., & Schenk, S. (1984). The Relationship between Learning Concepts, Study Strategy and Learning Outcome. *British Journal of Educational Psychology, 54*, 73–83.

Vygotsky, L. (1978). *Mind in society*. Cambridge, MA: Harvard University Press.

Weber, S., & Mitchell, C. (1996). Drawing ourselves into teaching: Studying the images that shape and distort teacher education. *Teaching and Teacher Education, 12*, 303-313.

Wong, L.-H., Chai, C.-S., Chin, C.-K., Hsieh, Y.-F., & Liu, M. (2011). Leveraging Ubiquitous Technology for Seamless Language Learning: From "Move, Idioms!" to MyCLOUD. *Proceedings of the mLearn 2011* (pp. 231-239), Beijing, China.

Wong, L.-H., Chen, W., & Jan, M. (in-press). How artefacts mediate small group co-creation activities in a mobile-assisted language learning environment? *Accepted by: Journal of Computer Assisted Learning*.

Wong, L.-H., Chin, C.-K., Tan, C.-L., & Liu, M. (2010). Students' personal and social meaning making in a Chinese idiom mobile learning environment. *Educational Technology & Society, 13*(4), 15-26.

Wong, L.-H., & Looi, C.-K. (2010). Vocabulary learning by mobile-assisted authentic content creation and social meaning-making: Two case studies. *Journal of Computer Assisted Learning, 26*(5), 421-433.

Xu, D., Read, J., Sim, G., & McManus, B. (2009). *Experience It, Draw It, Rate It – Capture Children's Experiences with Their Drawings*. Paper presented at the IDC 2009, Como, Italy.

Zhang, B. H., Looi, C.-K., Seow, P., Chia, G., Wong, L.-H., Chen, W., et al. (2010). Deconstructing and reconstructing: Transforming primary science learning via a mobilized curriculum. *Computers & Education, 55*(4), 1504-1523.