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A Rubric for Assessing *Seamlessized* Science Learning Lesson Plans

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Abstract: Seamless learning is "when a person experiences a continuity of learning, and consciously bridges the multifaceted learning efforts, across a combination of locations, times, technologies or social settings." To promote a sustainable culture of seamless learning, there is a need to *seamlessize* regular school curriculum for developing students' seamless learning disposition and skills. In this conceptual paper, we propose a rubric for primary school science teachers to formatively self-evaluate the *seamlessness* of their lesson plans. The rubric is underpinned by a consolidated set of seamless lesson design principles and the technological model of "division of labor", for primary school science teachers to formatively self-evaluate the *seamlessness* of their lesson plans. The paper focuses on elaborating the rubric, its connection with the salient features of seamless learning, and how it was derived from various sets of seamless lesson design principles reported in prior publications. The future plan of validating the rubric will also be laid out at the end of this paper.

Keywords: Seamless learning, science curriculum, rubric, lesson plan evaluation, mobile and ubiquitous learning

1. Introduction

This conceptual paper proposes a rubric for K-12 science teachers to formatively self-evaluate their seamless science lesson plans. Seamless learning is "when a person experiences a continuity of learning, and consciously bridges the multifaceted learning efforts, across a combination of locations, times, technologies or social settings." (Wong, 2015, p. 10; adapted from: Sharples et al., 2013). Although seamless learning can be carried out without the use of mobile and wireless technologies, such infrastructure can enable a fluidity of learning activities (Sharples et al., 2012). To promote a sustainable culture of seamless learning, there is a need to *seamlessize* a regular school curriculum with the objectives of delivering the formal syllabus and developing the seamless learning disposition and skills in students. "Seamlessizing" a curriculum or lesson design refers to substantially adapting from predominantly classroom-bound lessons to a cross-temporal and cross-contextual learning experience utilizing available digital or non-digital tools in the learning spaces.

One of the seamless curriculum development efforts was the WE Learn project (2008-2015) (Looi et al., 2010; Looi et al., 2014) in Singapore. With the aim of transforming Primary 3-4 (3rd-4th grade) formal science curriculum into a seamless and inquiry learning experience supported by 1:1 (one-mobile-device-per-student) settings, the learning model was enacted in 10 more schools after the successful proof-of-concept in a seed school. More recently, a follow-up project, Science4C, aims to redesign some parts of the science curriculum to address the limitation of most of the Singapore primary schools of not being able to implement full-fledged 1:1 learning – as many younger students do not own personal devices. The "4C" in Science4C refers to science learning in four types of learning spaces (Classroom, Cyberspace, Common daily life, and Community); and constitutes four salient features of seamless learning (Connective, Contextualized, Constructivist, and Collaborative).

From WE Learn to Science4C, our team has been practising the approach of ongoing teacher-researcher lesson co-design for both teachers' professional development (PD) and curriculum development. After our initial introduction to the features of seamless learning, the teachers were empowered to develop and enact lesson plans based on local needs (Barab & Luehmann, 2003), with our continual guidance and initial supply of previous seamless lesson plans for them to model after.

Nevertheless, during the Science4C project, the teachers have frequently asked us, "Am I indeed implementing seamless learning?" While this reflects the high motivation from the teachers, there is the sense of uncertainty of their own capacity in *seamlessizing* their lessons. Thus, we derived the idea of developing a rubric for the teachers to formatively self-evaluate their lesson plan designs. This paper focuses on elaborating the aforementioned rubric, its connection with the salient features of seamless learning, and how it was derived from various sets of seamless lesson design principles reported in prior publications. The future plan for validating the rubric will be laid out.

2. Seamless Learning: The Seams to Remove, the Technological Models, and the Lesson Design Principles

2.1 What Seams are We Removing? For What Purpose?

The intent of seamless learning lies in removing the seams so that the learners may learn whenever they are curious and seamlessly switch between different contexts. In the literature, researchers have studied the cognitive learning processes behind each type of learning space, such as learning individually, in the group, online learning, classroom learning, informal learning, and through the construction of digital artifacts. Different affordances in the physical space or digital space or over time lead to different episodes of learning experiences (Wong & Looi, in-press).

Indeed, the unit of analysis of a seamless learning journey is the integrated continuous learning processes, rather than individual learning activities. For example, the design of learning in online learning is distinguished from the design of learning in the face-to-face settings. Even if both designs are considered together, the linkages may not be brought to the fore in the design. Thus, a key design consideration in seamless learning is to design for removing the seams or planning for the linkages first, before elaborating the design in the separate learning spaces. Seamless learning has been explained by the recontextualization (Wong, Chai, Aw, & King, 2015) of learning.

2.2 The Technological Models for Seamless Learning

The notion of seamless learning was first developed within the context of mobile learning, i.e., the use of mobile technology in 1:1, 24x7 setting to facilitate individual students' ongoing, cross-contextual seamless learning (Chan et al., 2006). Under this perspective, mobile devices are treated as a personal 'learning hub' with (1) a suite of affordances to support a wide range of learning activities and (2) the stored resources and learner-created artifacts which (s)he may refer to and build on in her/his subsequent learning activities (Zhang et al., 2010).

Over the years, the research foci of seamless learning have been shifted from developing innovative technologies to the unpacking of the nature of seamless learning and to making impacts at schools. The perception of mandatorily 1:1, 24x7 for seamless learning has been challenged. More recent literature argues that seamless learning is a learning notion on its own right. Thus, alternative technological support models have been proposed, such as the "division of labor" (i.e., using different digital tools available at various locations) model (Wong & Looi, 2011) and the use of social media (Charitonos, Blake, Scanlon, & Jones, 2012). Such alternative technological models are constituting plausible solutions to the limitation of after-school accessibility of mobile devices for many students.

2.3 The Seamless Learning Design Principles

Learning design principles are key guidelines that are derived or extracted from pedagogical framework(s) and encapsulate salient features of a given pedagogical approach. Such principles typically offer concrete advice for researchers and practitioners to design lessons, learning activities or learning spaces. According to our literature review, three sets of seamless learning design principles were reported (Looi & Wong, 2013; Wong, 2013; Zhang et al., 2010) prior to the Science4C project, with a total of 21 overlapping design principles being laid out. For the Science4C project, we consolidated and synthesized the principles into eight key themes, which were later adopted as the criteria in the rubric for evaluation of seamless science lesson plans. The eight themes are, (1) bridging formal-informal learning (corresponding to MSL1 and MSL4 in 10D-MSL); (2) bridging individual-social learning (MSL2); (3) meaningful use of ICT tools to facilitate learning connectivity (MSL5; MSL6; MSL7); (4) constructivist learning (MSL9); (5) cross-contextual formative assessment (MSL2; MSL8); (6) authenticity (tapping on resources in informal settings); (7) cross-idea/topic/disciplinary learning (MSL9); (8) personalized learning (MSL8; MSL10).

3. The Seamless Science Lesson Evaluation Rubric

Based on the eight identified themes, our team proceeded to develop the seamless science lesson plan evaluation rubric. The rubric is positioned as a formative evaluation tool for teachers to reflect upon "how seamless" their draft lesson plans are. That is, the rubric may serve as a fine-grained, concrete reminder for the teachers to (further) *seamlessize* their lessons. As stated before, the "unit of analysis (or evaluation)") for using the rubric is the entire seamless lesson flow.

The rubric criteria (corresponding to the consolidated themes) and the descriptor for each level of the different criteria were first subjected to expert review for content validity. This was carried out with two learning scientists at a college with the experience in co-designing seamless curriculum with teachers and research expertise in seamless learning, and a Master Teacher[1] with vast science teaching experience at primary schools who has recently been involved in reviewing seamless science lessons designed and enacted by local teachers. The appropriateness of the criteria with respect to the conceptions of seamless learning adopted to underpin the rubric development, i.e., the consolidated set of design principles and the technological model of "division of labor" of seamless learning were reviewed. Areas of inconsistency were negotiated between the experts until there was full agreement. The revised rubric after the review is presented in Table 1.

Table 1: The seamless science lesson evaluation rubric after expert evaluation

	Undeveloped (0)	Basic (1)	Developing (2)	Advanced (3)	Exemplary (4)
Formal-informal	Learning activities are fully or almost fully classroom-based, perhaps with some home-based activity(ies) that is(are) NOT tapping on students' out-of-school, authentic living environment (e.g., drill-and-practice assignments, accessing teacher-specified online resources, playing behaviorist online educational games, etc.)	Learning activities are mostly classroom-based, with some home-based activities requiring students to find out on-topic "close-ended" information (i.e., perhaps with standard answers which are less cognitively challenging to figure out) (e.g, through Internet/book/ newspaper search; by asking more knowledgeable others; observing real-life phenomena)	Learning activities are mostly classroom-based, with 1-2 home-based activities requiring students to find out on-topic "open-ended" information (with the expectation of diversified findings and is more cognitively challenging) (e.g., Internet/book/ newspaper search, negotiation of meaning with others such as family members, observing real-life phenomena, etc.)	Learning activities are essentially classroom-based but also include 2 or more activities that require students to observe or manipulate (e.g., experiments) authentic out-of-school living spaces (not necessarily confined within home) with respect to the learned knowledge	Balanced formal and informal learning activities; students are required to observe or manipulate authentic out-of-school living spaces with respect to learned knowledge (or to construct knowledge), make and share diversified meanings with their peers online and/or in the classroom for deep reflection and knowledge co-construction
Individual-social	No cooperative or social activity	The lesson incorporates mostly teacher-centric and/or individual	The lesson incorporates both individual and cooperative/social	The lesson incorporates both individual and social learning activities;	The lesson involves activities that explicitly bridges individual meaning

[1] In the Singapore context, Master Teachers are teacher leaders at the national level representing the pinnacle of the Teaching Track in the government schooling system run by the Ministry of Education.

		activities, with very few cooperative or social activities; and there is no connection between individual and social activities	activities; both types of activities are functionally but not intellectually connected (e.g., divide a big task into sub-tasks and assign them to a few students, each work on one task, and then the group piece their sub-products together; either each of the sub-tasks or the synthesis effort, but NOT both, is cognitively challenging)	both types of activities are largely functionally connected but also with one intellectually connected point (i.e., bridging individual and social meaning making) (e.g., a student posts a social media on an authentic experience and discusses its implication; his classmates reply and discuss alternative views and share similar experiences)	making and social meaning making in multiple points (e.g., individual-to-social-to-individual- …)
Meaningful use of ICT tools to facilitate learning connectivity	No ICT tool is used to facilitate cross-contextual learning (even if some ICT tools may be used in isolated learning activities)	A specific ICT tool is used in multiple settings but there is no bridging of those ICT-supported activities	A specific ICT tool is used in multiple settings with 1-2 points of bridging of the activities	ICT tool(s) is/are used in multiple settings with more than 2 points of bridging of the activities but the bridging efforts are largely fragmented.	ICT tool(s) is/are substantially used to facilitate a full trajectory of learn-observe/apply-reflect process across formal/informal and individual/social settings
Constructivism	The lesson is merely transmitting subject content rather than facilitating meaning making	The lesson requires the students to reproduce the canonical knowledge or standard answers (either verbally, written, or product-oriented) at some point(s)	The lesson requires the students to express some degrees of divergent knowledge with respect to the subject matter	The lesson requires the students to synthesize information in order to construct verbal, written, visual, conceptual or product-oriented expressions of the subject matter	The lesson requires the students to articulate their personal reflections of subject matter, hands-on or daily experiences, and let students challenge each other's view
Cross-contextual formative assessment (FA)	No FA	FA with questions or instruments developed by the teacher, and student responses evaluated by the teacher	Student-generated "ideas" for FA which are evaluated by the teacher (the "ideas" could be in intangible forms, e.g., scientific claims/arguments, provoking questions, experiment designs, association with past experience or prior knowledge, new knowledge or skills; or as tangible products, e.g., digital/social media, invented tools, performances)	Student-generated "ideas" for their self-evaluation (so that individual students are aware of their own learning gaps and will subsequently try to fill the gaps)	Student-generated "ideas" for FA – created in one context (e.g., personal, authentic daily-life) and evaluated AND improved in another context (e.g., social settings such as among classmates)
Authenticity (Tapping on resources in informal settings)	The teacher does not explicitly connect the lesson to students' authentic experiences in any way	The teacher carries out classroom talk to relate students' relevant past authentic experiences with the lesson topic	Teacher facilitates in-class, in-lab or in-campus activities to let the students generate and relate their new experiences with the lesson topic	A problem associated with a real-world phenomenon related to the topic is used to anchor the largely in-class, in-lab or in-campus activities where the students investigate the phenomenon	There is at least 1 activity where the students should observe/manipulate authentic out-of-school living spaces and subsequently reflect or generate knowledge/ assumptions upon the findings
Cross-idea/ topic/ disciplinary	No connection between ideas (e.g., concepts or learning points within a topic), or with other topics/disciplines	The teacher directly explains the connection in a didactic manner (i.e., students are just listening and are perhaps allowed to ask questions thereafter)	The teacher carries out simple inquiry dialogue with the students to figure out the connection	The teacher guides/ challenges the students to identify and reflect on the connection by relating to previous lesson activities (e.g., refer to students' previous	The teacher designs a context (e.g., a word problem pertaining to an authentic scenario) that requires the students to synthesize two or more scientific

				social media postings)	concepts
Personalized learning	All the learning activities are teacher-centered and follow closely the syllabus-specified learning goals	There is a mixture of teacher- and student-centered activities. However, all learning activities are pre-planned by the teacher with respect to syllabus-specified learning goals. The students are required to follow closely the activity design while variations are not favorable	There is a mixture of teacher- and student-centered activities; and All learning activities are pre-planned by the teacher with respect to syllabus-specified learning goals. However, the students may carry out the activities with a small degree of variations (e.g., choose their own roles in collaborative learning activities, decide the ways of carrying out specific learning tasks)	The teacher facilitates activities that are mostly student-centered and allows a large degree of variations (e.g., flexible learning pathways, etc.)	Teacher encourages/ facilitates students to set and pursue their own learning goals on top of the syllabus-specific learning goals; and which are connected to the syllabus-specified learning goals

4. Conclusion and Future Work

This conceptual paper is intended to propose a rubric, underpinned by a consolidated set of seamless lesson design principles and the technological model of "division of labor", for science teachers to self-evaluate their seamless science lesson plans. Such a rubric may constitute a formative assessment tool for teachers who are novices in designing seamless science lessons to continually improve the seamlessness of their lesson designs.

Notwithstanding, the rubric is still at the early stage of its development process. After the expert validation, the next step is to establish user validity by inviting the participating teachers of the Science4C project to assess their own lesson plans. Comparison between their scores and researchers' scores on the same lesson plans will then be made. Discrepancies in the scores will be discussed so that we can identify the potential sources of inconsistent interpretations across the scorers (be they researchers or teachers) on the rubric descriptors. Revision on the descriptors in question will then be made to prevent such problems. Concomitantly, two researchers will solicit all the seamless science lesson plans from both the We Learn and Science4C projects developed over the last nine years, score them independently, and investigate the rubric reliability by conducting Cronbach Alpha test.

In a long run, we may attempt to extend or customize the rubric for *seamlessization* of other subjects such as mathematics or language learning at different grade levels in K-12 schooling as well as for beyond. We may also envisage a generalized, subject-independent version of the rubric. Such tools can make concrete the implementation of teaching and learning under a seamless learning framework, serving as tools and resources for teachers to design their lesson practices.

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