CONTEXTUALIZING STEM LEARNING: FRAMEWORKS & STRATEGIES

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Abstract. *STEM studies provide crucial knowledge and understandings for students to perform tasks as part of daily life. However, there are issues with regards to students showing a lack of interest, persistence, and fail to see the relevance of STEM concepts. Empirical evident show that contextualized outdoor learning approaches can connect students to STEM learning in a meaningful way increasing interest, motivation, and relevance to all students. This paper highlights the factors involved in effectively using technologies for outdoor STEM learning. This includes an examination of the technology integration frameworks of the Technological, Pedagogical, Content Knowledge (TPACK) framework, and the Mlearning integration ecological framework. Followed by an examination and examples of outdoor contextualized technological pedagogies, including mobile learning, situated learning, authentic learning, outdoor experiential learning, and context-aware ubiquitous learning.*

INTRODUCTION

Science, Technology, Engineering, & Mathematics (STEM) are a collective group of subjects that each involve a network of complex systems, theories, and axiomatic concepts. While having an understanding of STEM concepts are critical in providing students with an awareness of modern society, fundamental concepts from each area, and application fluency to perform tasks relevant to daily life (NAE & NRC, 2014), students often show a lack of persistence, and interest in STEM studies (Koul, Lerdpornkulrat, & Chantara, 2011; Vedder-Weiss & Fortus, 2011). STEM enrollments are low, dropouts are high, and the general STEM pipeline of students has been highlighted as an issue that needs to be addressed (Cannady, Greenwald, & Harris, 2014; van den Hurk, Meelissen, & van Langen 2019).

These lack of interest and the discrepancies in STEM are often connected to curricula (PCAST, 2010), stereotype, implicit bias (McGee, 2013; McGee, & Pearman, 2015), social dynamics, students feeling disconnected from STEM (Perry, & Morris, 2014; DeNisco, 2015), and students not understanding STEM relevance (Habiba & Odis, 2019). Empirical evident show that context based outdoor learning approaches can connect students to STEM learning in a meaningful way increasing interest (Swirski, Baram-Tsabari & Yarden, 2018), motivation (Pilot & Bulte, 2006), and relevance to all students (Eliks & Hofstein, 2015).

CONTEXTUALIZED OUTDOOR LEARNING

STEM concepts are often presented to students in abstract forms, rather than contextualized to provide meaning to students. For example, angles are often presented as lines on paper, rather than contextualized as angles on window frames, door ways and many other architectural forms recognizable to students, and this can cause misconceptions, and errors in understanding the true nature of the content knowledge (Crompton, 2015a; b; 2017a). Scholars have advocated for students to learn by connecting to the physical phenomena to provide meaning to these abstract concepts.

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Contextualizing outdoor learning is not a new idea. For many years, scholars, such as Dewey (1916), Mumford (1946), and Orr (1992) have advocated for locally situated, culturally and environmentally informed pedagogies. Dewey in particular is known from his early work that he wrote about the need for curriculum to have "real-life" relevancy (Dewey, 1902, 1938). Outdoor contextualized learning is a pedagogical method of bridging the gap to difficult STEM concepts, and the world we live in, to make learning more meaningful (Kortland, 2007). It is not just the "place", but place has a locus of shared social values and norms (Williams, 2014), place is not must equivalent to location (Semken, Ward, Moosavi & Chinn, 2017). Pedagogies connecting students to real-world contexts, especially those connected to students' own knowledge and experiences can promote conceptual understanding and motivation to learn (Sugimoto, Turner & Stoehr, 2017).

Understanding best practices for teaching STEM in contextualizing learning is important, the next step is supporting educators in facilitating this pedagogical approach. Scholars have uncovered a variety of difficulties educators can encounter in trying to incorporate relevant real-world contexts into learning (e.g. Sugimoto et al., 2017). Within academia and practicing teachers, a plethora of evidence show that technology is a tool that extends and enhances in the process of contextualizing learning. These findings will be explored in the following section.

TECHNOLOGY TO SUPPORT CONTEXTUALIZED LEARNING

Empirical findings reveal that the incorporation of technology into learning activities provides new ways of teaching and learning, which are often more hands-on, active learning approaches, improving student focus and understanding, (Alijwarneh, Radhakrishna & Cheruvu, 2017). Technological tools are especially beneficial for students learning outdoors in authentic environments (Blackburn, 2017, Hwang & Chen, 2017; Liu, Chen, & Hwang 2018).

Technologies for Contextualizing Learning

With the advent of portable technologies, students no longer need to be tethered by the use of technologies plugged into electrical sockets, such as desktop computers. Mobile phones, then the expanded societal use of tablets in 2010, provided learners with Internet connected technologies that are easily portable and can be used across spatial and temporal domains (Crompton, 2015c). Systematic reviews of the literature show a trend towards the use of mobile devices to facilitate contextualize outdoor learning in science (Crompton, Burke, Gregory & Gräbe, 2016), mathematics (Crompton & Burke, 2015; 2014), STEM subjects (Crompton & Burke, 2018; Crompton, Burke, & Gregory, 2017) and reveal extended opportunities for learning outdoors (e.g. Crompton, Burke & Lin, 2019; Crompton, & Burke 2018).

Technology Integration Frameworks

When incorporating mobile devices into learning, a variety of educational components need to be considered, such as the device, how the device is used, curriculum, policies, technical support, infrastructure. To highlight these factors Crompton, (2017b) developed the Mlearning integration ecological framework, (see Figure 1).

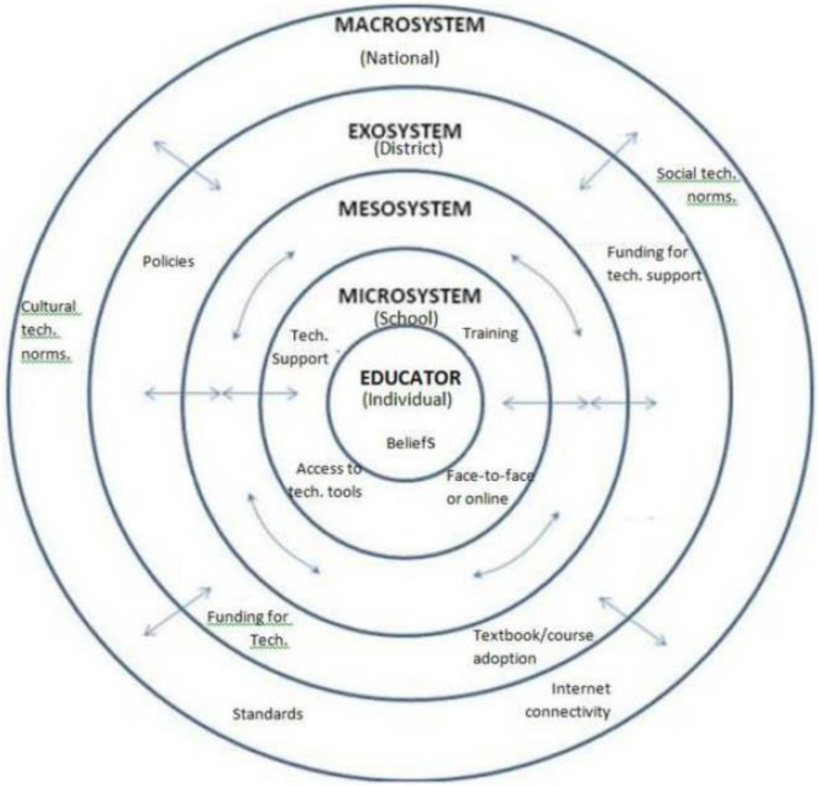

Figure 1: Mlearning integration ecological framework (Crompton, 2017).

This framework is based on Bronfenbrenner's (1979) Ecological Framework, that has the child at the center of the framework and describes ecological influences on the child. Crompton's framework places the educator at the center of the framework and the concentric circles represent the different systems influencing how the educator integrates technology. The ecological influences include the social ecology of interactions with people and ecology relating to environmental factors of the physical environment.

The educator in the center is influenced by their own beliefs on mobile devices, such as their effectiveness for learning and methods of use. The microsystem represents the school and includes factors such as training, access to technology, and modality of teaching. The exosystem is the district, including policies and funding, and the macrosystem is the national level that involves influences, such as social, and cultural technology norms, and Internet connectivity. The mesosystem in the middle of the frameworks with arrows pointing different directions, highlight that a factor in one area may also be present in other areas. For example, policies are included in the exosystem (district level) and policies may also be at the school and national level.

As educators are considering outdoor education, it is important to first start with the educator in the center. The beliefs of the educator in the efficacy of the outdoor learning approach and the use of technology can ensure the activity is a success or a failure as their actions will often hinge on these beliefs. At the microsystem – school, devices are needed, technology support to ensure the devices are working effectively out of school, and training on what pedagogies would be effective in mobile assisted outdoor educational activities. The various support factors need to be in place across the school, district, and national level. Teacher education on how to use mobile devices for outdoor learning is important.

Other technology integration frameworks were developed to support educators in integrating technology into teaching and learning, such as the technological, pedagogical and content knowledge (TPACK) framework (Mishra and Koehler, 2006). Based on Shulman's (1986) model, the TPACK framework highlights the three knowledge groups that educators have as separate entities (technology, pedagogy, and content knowledge), then how the three should be considered working together to be effective (see Figure 2).

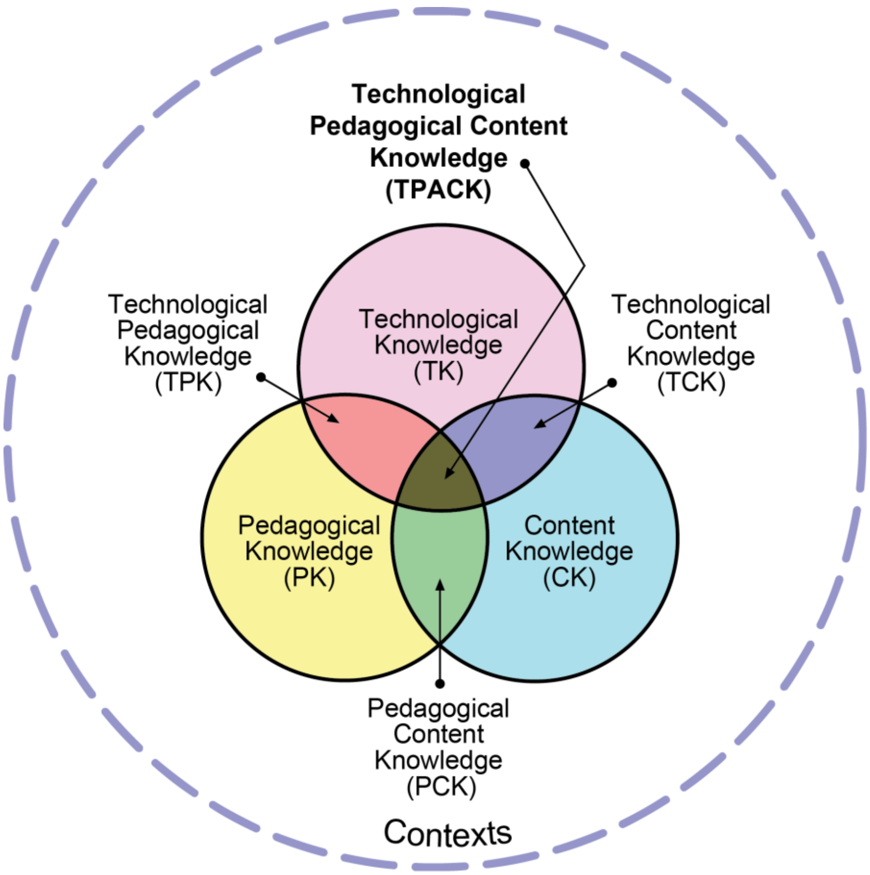

Figure 2: TPACK framework (Mishra and Koehler, 2006).

This framework has the educator thinking about the content knowledge they are to teach. In this case what STEM concepts the student is to learn. Then the educator thinks about the best pedagogy to teach that content knowledge and the technologies that can support in that activity. Pedagogy is the Greek word meaning "to lead the child". It is how you organize learning: is it with the students working individually or in pairs; are the students learning outdoors, or in the classroom; are they using technologies, manipulatives, or other tools. The context circle around the Venn diagram reminds the educator to think about other aspects such as the ages and interests of students.

The content knowledge in this paper is focused on STEM with topics such as angles, place value, ecosystems etc. As discussed earlier, these concepts are often presented in abstract form on paper in textbooks with little to no concrete connection to the students real-world that allows them to gain a firm understanding of the topic. Therefore, this paper advocates for the pedagogical choices that the educator would make are those making that concrete connection with outdoor learning. This outdoor education would use those mobile devices to extend and enhance learning. These three decisions on the content, pedagogy, and technology working effectively together are the center point of Figure 2 as TPACK. While this framework for technology integration may be helpful for the educator in thinking about bringing together the three aspects, further support is needed in what type of pedagogies work well outdoors with the use of technology (Sugimoto et al., 2017).

Outdoor Contextualized Technological Pedagogies

Scholars have connected learning theories to the use of contextualize learning as students solve problems within information-rich settings, such as discovery learning, problem based learning, inquiry learning, experiential learning and constructivist learning (Cheng, Hwang & Chen, 2019) and using mobile devices (Sharples, Taylor & Vavoula, 2016), with personalized, learner centered, situated, collaborative, ubiquitous, lifelong learning.

Pedagogies and technology can work effectively together for outdoor contextualized learning (Blackburn, 2017, Hwang & Chen, 2017). There are a variety of contextualized outdoor pedagogical approaches that use technology and these terms have changed over time as they have following trends in pedagogy and the emergence of new digital technologies (Crompton, 2013a; 2015). Following the authors review of recent literature, the outdoor contextualized technological pedagogies include *mobile learning, situated learning, authentic learning, outdoor experiential learning, and context-aware ubiquitous learning.* These are explained with examples below. These pedagogies can have many similarities and some names may be used interchangeably.

Mobile learning by definition is “learning across multiple contexts, through social and content interactions, using personal electronic devices” (Crompton 2013b, p. 4). This highlights the very nature of learners moving across and within contexts. The mobility, ubiquity, and connectivity of mobile devices help to foster meaningful learning experience across contexts unrestricted by environmental restraints. For example, students were tasked with designing an engineering solution for how to water an outdoor classroom garden (Apul, & Philpott, 2011) could use mobile devices to photograph, collect data, and measure distance and angles.

Situated learning technology has been shown to improve learning outcomes and increase student motivation in situated learning environments (Hwang & Chen, 2017). This is learners studying while within an environment relevant to the content knowledge. For example, Pfeiffer, Gemballa, Jarokzka, Scheiter, and Gerjets (2009), had students learn about fish biodiversity via mobile devices in a situated learning scenario. Students received video support from mobile device during a snorkeling activity.

Authentic learning is having the learner connected to authentic environments and involved in practical situations (Chen, Hwang & Tsai, 2014). For example, Fessakis, Karta, and Kozas (2018), that had students learning mathematics in an authentic context. Primary students took part in a math trail. The students were guided through the trail using a digital map and guided to a set of preselected sites of a park where they explored and solved math problems using data from the environmental context.

Outdoor experiential learning is learners obtaining scientific knowledge from the phenomena of conceptualization and transfer of experience (García-Sánchez & Luján-García, 2016). The experiential learning process has four parts, concrete experience, abstract conceptualization, reflective observation and active experimentation (Kolb, 2014). Schnepp and Rogers developed an app that delivered reflection prompts and content before, during, and after an experiential learning activity. This idea could be used across a variety of STEM topics with educators using various tools to deliver information to students when relevant. For example, Chan & Tam (2018) developed an application that enabled students to use an electronic map which tracks the location of the student and highlights locations that the student needs to go to complete tasks. As the student reaches the location of the task they are presented with a connection and investigation scaffold of an authentic task the student has to complete. These are activities that involve, experimentation, data collection, investigation, and reflection using the mobile phone.

Context-aware ubiquitous learning refers to mobile technologies being used while connecting with real world phenomenon (Hwang, Wu & Chen, 2007). For example, Crompton (2014) had students study angles by connecting with their surrounding environment. In the school grounds and playground, students used a mobile application to take photographs of angles and then used a dynamic protractor to measure the angle and discuss the angles with peers while seeing the real-world version and the 2D version on the device.

CONCLUSION

STEM studies are crucial for students to perform tasks as part of daily life (NAE & NRC, 2014). However, there are issues with regards to students showing a lack of interest and persistence (Koul, Lerdpornkulrat & Chantara, 2011), and fail to see the relevance of STEM concepts to their lives (DeNisco 2015). Empirical evident show that contextualized outdoor learning approaches can connect students to STEM learning in a meaningful way increasing interest (Swirski, Baram-Tsabari & Yarden, 2018), motivation (Pilot & Bulte, 2006), and relevance to all students (Eliks & Hofstein, 2015). This paper highlights the factors involved in effectively using technologies for outdoor STEM learning. Technology integration frameworks, such as the TPACK (Mishra & Koehler, 2006) framework, and the Mlearning integration ecological framework Crompton, (2017b) provide educators with a lens to consider how technology can be used to extend and enhance learning outside the classroom.

The mlearning integration ecological framework highlights the many aspects involved in using mobile devices outdoors and the TPACK frameworks presents an overarching consideration of learning as three parts, technology, pedagogy, and content. The pedagogy is then covered as the final part of the three as there are various teaching approaches to contextualize the often abstractly presented concepts in STEM. The pedagogies of mobile learning, situated learning, authentic learning, outdoor experiential learning, and context-aware ubiquitous learning are offered with examples for educators, school leaders, policy makers, and funders to use as a springboard to advocate for outdoor contextualized STEM learning.

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