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FORUM

Science education through informal education

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Abstract To develop the pedagogic efficiency of informal education in science teaching, promoting a close cooperation between institutions is suggested by Monteiro, Janerine, de Carvalho, and Martins. In their article, they point out effective examples of how teachers and educators work together to develop programs and activities at informal education places such as science museums. Their study explored and discussed the viability and relevancy of school visits to museums and possibilities to enhance the connection between students' visits in informal contexts and their learning in schools. Given that students learn science by crossing the boundaries of formal and informal learning contexts, it is critical to examine ways of integrated and collaborative approach to develop scientific literacy to help students think, act and communicate as members of problem solving communities. In this forum, we suggest the importance of students' lifeworld contexts in informal learning places as continuum of Monteiro, Janerine, de Carvalho, and Martins' discussion on enhancing the effectiveness of informal learning places in science education.

Keywords Science education · Learning environments · Informal education

Monteiro, Janerine, de Carvalho, and Martins elaborate the importance of alternative, innovative ways of learning and teaching sciences in informal contexts. They describe the current challenges, visions, and potential of out-of-school educational places such as science museums and centers of science and technology through specific examples of research educational programs and practices in Brazil and international contexts. There has been some degree of disagreement and confusion on the term use among informal, non-

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formal, out of school, and free-choice learning (Eshach 2007) and the authors chose the term non-formal in their paper. However, we have chosen the term, *informal* to embrace students' learning taking place in out-of-school contexts. Undoubtedly, students learn in diverse contexts not only from schools where pedagogical interventions are oriented to specific learning outcomes but also from casual, spontaneous, and non-structured places such as learning centers, schoolyards, and even local beach. Going back and forth the boundaries of formal and informal contexts, students learn to think, act, and communicate as members of community to solve problems. As Dewey (1938) explained learning is deeply connected to learners' experiences of everyday lifeworlds, learners' knowledge emerges and develops through their interactions with the environments. While interacting with their everyday environments, learners *re*interpret everyday phenomena and develop and utilize their knowledge and skills to examine the world around them. The interactive relationships of learners to their environments bring out the depth of meaning and understanding of knowledge, experiences, and actions in the world. Constructivist approaches have suggested that learning is a process of constructing and contextualizing knowledge and skills based on personal and social experiences in the environments (Stocklmayer, Rennie and Gilbert 2010). School science has strived to implement constructivist approach by inviting (engaging and challenging) students' experiences and prior knowledge of their life contexts and to develop science learning more relevant and meaningful to students' lives. This approach advocates the construction and contextualization of students' knowledge in real life contexts. Unfortunately, there still remains the tendency that when knowledge and skills are taught in classrooms, it is expected that students will utilize school knowledge and skills in real lifeworld situations, yet, this border crossing of students' experiences and knowledge application has been a challenge in school science education (Aikenhead 2006). School science still remains the gap of knowledge between school science and everyday lifeworlds, lacking the relevance and connection of science knowledge and skills to everyday and societal contexts (Feng 2012). In this regard, it is critical and timely to question how we bridge students' knowledge and experiences between school and out of school contexts in order to develop scientific literacy for everyday citizenry problem solving actions for the society. The contextualization and application of students' scientific knowledge in real life problems have been critical concerns in the discussion of scientific literacy (Korfiatis 2005) (Fig. 1).

By recognizing the importance of bridging school science and real-life contexts (Barker and Slingsby 2003) educational researchers and teachers look into ways of informal education, going beyond school classrooms to expand students' learning in out of school contexts (Greenfield 2009). Beside school science classrooms, informal science learning places such as science museums, science centers, botanic gardens, zoos, aquariums, and so forth can be effective venues to help learners acquire competence, knowledge, skills, and attitudes of science. By offering innovative information and social and cultural contexts of science and technology in times and places, these places often provide open-ended,

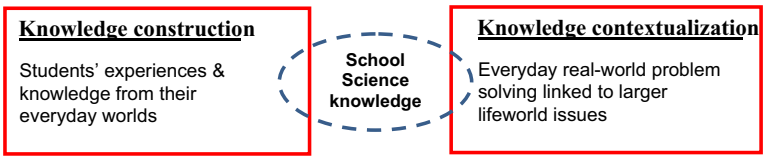

Fig. 1 Critical view on gap of knowledge between school science and lifeworlds

pleasant, and continuous learning opportunities to attract students' interests and curiosity. Learning in those places is normally not rigidly planned or limited by educational goals of science curriculum, thus, the openness of the learning environment would help students and teachers feel less pressure on achieving certain learning outcomes and assessment compared to school contexts. The rich resources and attractive contexts of informal learning environments have much potential to amplify students' science learning and development of scientific literacy, yet as the authors pointed out, there require more critical angles to examine students' learning in those places. Close partnerships between formal (school) and informal learning places are crucial for students' learning, and yet, it could be challenging to agree on what could be fundamental bases of the partnership since the two contexts (formal and informal) have such different goals and agenda. Whereas there are specific goals of science learning in schools, those goals are not primary concerns in informal places. Because of the conflicts of specificity versus multiplicity of goals and agenda, there emerge challenging questions on the ground level of collaboration and partnership. The authors point out the inclusion of science teaching in non-formal contexts in initial teacher training program and collective developments of educational resources could assist students' learning and reduce the gap between schools and informal institutions. Another challenge lies in the notion of epistemic approach to scientific literacy. Informal institutions such as science centers and museums share scientific knowledge with visitors mainly through visual representations of expert knowledge, which might cause another level of gap in knowledge and communication. The authors mentioned in the final consideration that "cultural mediators of non-formal environments sometimes ignore the level of information held by the visitors and they also consider the teachers unable to conduct visits successfully". The knowledge exhibited in those places is disconnected because the presenters and visitors (teachers and students) do not share the same paradigm of experience, worldview, and knowledge as experts and presenters. There co-exist different language and worldviews of scientists and laypeople's and different levels of adults and children's knowledge. In the complexity of epistemological paradigms, children's learning gets challenged. Given that learners' everyday experiences and real life contexts are significant in learning process (Batsleer 2008), it would be worthwhile to question how we bring the *connectedness* of knowledge and lifeworld experiences in and through the collaborative partnership.

Informal education environments and gap of knowledge

In their article, Monteiro, Janerine, de Carvalho, and Martins discussed how informal science learning contexts such as science centers, museums, discovery centers, etc. could develop students' learning through close collaboration among schools, non-formal education institutions universities, and communities. They pointed out there have been disconnected and mutually excluding relationships between schools and those informal places due to diverse reasons, e.g. different goals and expectations and lack of communication. They also mentioned that teachers did not seem competent to transfer learning contents at museums back to classroom learning. The collaborative partnership between schoolteachers and educators in informal contexts is critical such as sharing goals of curriculum, the framework of activities, and joint program development. In this forum, we intend to discuss further on how educators in formal and informal contexts could frame learners' everyday contexts as the groundwork of collaboration to reduce the gap between learning in and out of schools and develop knowledge integration and problem solving for the

present and future society. Even though informal learning contexts are recognized as engaging and fun places to learn science, compared to formal school contexts (Eilam 2002) it sometimes fails to grasp students' interests and appreciation toward exhibition materials and contents when presentations are too abstract and disconnected to learners' prior knowledge and experiences. For instance, during a visit to museum, it is not clear how meaningful the content of collections is to junior high school students who do not share the same paradigm of culture, experiences, or values as museum staff members who organized the collections and exhibitions. Research shows that the level of understanding and interests in resources in informal learning places deeply depends on education, age and gender of visitors (Miller 2001). That is, attentiveness and cognitive engagement in those places are related to personal experiences and contexts. The disjuncture between students' experiences and learning texts is not only the problem of school science but also of informal learning places.

Science museums are public places with collections of sciences, technology, cultures, values, histories, etc. They are structured and designed from an intended pedagogical and communicative perspective, and contribute to the development of individual and social knowledge, communication, and values by exhibiting material testimonies of human beings and their environment for enjoyment, acquisition or extension of knowledge (Alexander and Alexander 2008). Museums traditionally have aimed to attract their visitors primarily through exhibitions and collections and thus, much research on museums as informal learning context has reflected on their roles on educational efficiency through taking into account the characteristics of collections, visual presentation and spatial organization (Montenegro 2005). And yet, when it comes to students' cognitive development, it is more crucial to question *if/how* the visual *re*presentation activates and transforms students' knowledge and experiences into new ideas. When there are active *sense-making* and transformation of knowledge, exhibitions and resources in museums could be effective learning tools. However, the depth of scientific knowledge and information in exhibitions are sometimes too abstract and beyond visitors including students. Without relevant knowledge and skills, it is beyond the level of students' understanding and interests. Places of artificial habitats such as botanical gardens, aquariums, zoos and planetariums are another common informal learning environment of science learning (Sellmann and Bogner 2013) and their ways of communicating also tend to focus on visual presentations with certain types of scientific knowledge and jargons. For instance, in botanical gardens, plants are labeled and classified with scientific terminologies for visitors to recognize and learn the knowledge of botany; however, those terms are foreign to most of visitors. Sometimes, teachers take their students to a botanical garden, and ask them to learn those terminologies in reference to Theophrastus as an integral part of learning during the visit (Johnson 2004). In the case of planetarium as representations of knowledge of astronomy, recreational observation of night sky in a dome with a mobile planetarium projector is more acknowledged than the actual knowledge of space science. From museum staff members' perspectives, affective domains through display and exhibition are the primary goals and roles of their institutions. They do aim to attract and entertain audience; develop images of science and further initiate people's learning (Lumley 1988). Beside the affective domains of learning, it would be also critical for educators and researchers to question how learners cognitively and socially interact with and learn from those resources (Doyle 2005). While we acknowledge awes and wonders generated in students' minds during their visits, we also question what and how pre-, onsite-, and post-activities could generate students learning more effectively.

How learning environments influence students' learning is an important question for educational research (Bekerman, Burbules and Silberman Keller 2006). Focusing only on learner's mental structures without understanding their situatedness in physical and social environments cannot explain how they learn (Leach and Scott 2003). Thus, it is crucial to understand how students cognitively and socially interact with resources in informal learning contexts. Currently there is an emphasis on interactive relationships between objects and visitors in museums, parks, and centers of sciences as media of public communication and understanding of science in the society (Pellegrino 2012). Participatory and interactive engagement of museum visits could optimize the understanding of knowledge in collections. In our sense, 'participatory and interactive' does not mean only students' hands-on or bodily engagement but minds-on where students cognitively and socially construct and contextualize their observation and experiences with exhibited resources in their worldview and understanding of science. Shifting the understanding of museums from exhibitory to participatory place is necessary to develop museums as a place for active learning. Learning will not take place without a further reflection on what learners experience (Davies 2008). If we intend to develop learners' enacted participations of minds in science learning, the contexts of learners' life experiences and prior knowledge are to be invited (Friedman 2008). This challenges museum educators and exhibitors to understand students' learning and experiences in both schools and everyday lives and school teachers to find the ways of connecting resources in informal learning places to school curriculum.

Informal learning, schools, and science education

Educational literature reveals that students have a very high consideration towards scientists but they do not like science as a school subject. Nonetheless, they like to take part in science activities outside of school (Fallik, Rosenfeld and Eylon 2013). Compared to the structure of school science with heavy content-based curriculum, informal contexts definitely attract students' attention through visual and tactile presentations, innovative science and technology, and free choice of learning opportunities (Falk 2001). Most of learning in our lifetime takes place outside of school curriculum (Harper 2010). With the advancement of information technology in the current era, the context of informal learning extends its boundaries of learning environment to virtual space such as mass media, internet search, and social media. The infrastructure of informal learning is becoming more diverse, broad, and influential in students' learning, providing much potential for open-ended, continuous, and inquiry-based learning process for personal and social knowledge and problem solving (Rogers 2014). With the every-expanding informal learning context, it is challenge how we invite students' experiences of the world from the diverse contexts into school science to facilitate students' learning more meaningful.

To develop pedagogical effectiveness of informal science education institutions, Monteiro, Janerine, de Carvalho, and Martins emphasized the need of collaboration to bring the synergy effect of the two contexts for students' learning. The discussed examples of how infrastructure, programs, and resources could be developed through collaborative framework between formal and informal contexts are effective ways of developing the practicality and relevance of learning activities in both school classrooms and museums. These efforts well address the need for building bridges between school science and science learning obtained in informal settings (Martin 2004). By linking what knowledge students' learn in science classroom and how the knowledge is developed and utilized in real life contexts, collaboration between two places could help students' border crossing

meaningful and connected. To help the link emerge in students' cognitive development, both places need to discuss how to *share* and invite students' prior knowledge and experiences as scaffolding strategies to develop the connectivity and transformation of students' learning.

Thus, we found the authors' suggestion on inter-institutional dialogue critical and essential to develop the grounds of collaborative framework. Since the both parties (schools and museums) have different goals and agenda on their practices, they often feel excluded from the other party in the process of decision making and program development. Recognizing the evidence that a longer learning time takes place in out-of-school contexts (Falk and Dierking 2010), now the challenge is how to develop the inter-institutional dialogue between informal and formal institutions to maximize the learning of science and scientific literacy for the future society. Mercer (2000) suggested the way of *interthinking* in collaborative problem solving. To help communities enable collective thinking to solve certain problems, the community members need to shar ground goals, collective identity, and reciprocal obligation in their discourse development. What could be common ground goals between the two places? What would be collective identity and reciprocal obligation? It might be important to accept differences in the goals and agenda of the two places. Whereas schools focus much on the development of students' knowledge and skills, out-of-school contexts bear diverse foci for multiple stakeholders. With the different nature of goals and intentions in two places, it might be unavoidable that there is a gap in the representation of science and in ways of approaching students' cognitive experiences. And yet, whatever experiences students have and whatever goals the two places have, it is clear that both of the contexts are concerned about educating citizens to become knowledgeable critical thinkers and problem solvers for personal and social developments. It is clear that both contexts formal and informal attempt to develop students' science knowledge and skills in connection to real-life contexts so that students could contribute creative knowledge and contribution to the present and future society. These are the main goals of science literacy for citizenship, which could be the ground goals and shared framework. To achieve this common goal, students' learning needs to be relevant to their life world experiences and social contexts they live in.

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