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The Application of School Science by Urban High School Youth through Problem-solving in Everyday Life

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ABSTRACT: This qualitative study investigated non-guided applications of school science by high school youth in Ontario in non-school contexts. Although science education (in Ontario and elsewhere) mostly focuses on the meaningful learning of science, learning that can lead to knowledge application, non-guided application of acquired knowledge is rarely documented. The data were obtained from demographic questions and focus group discussions, based on sociocultural theory of learning and complex cognitive processes. The findings demonstrate that youth had the sociocultural and cognitive knowhow to serve as a springboard for independent knowledge application through problem solving, and noted the youth's apparent affinity for personal relevance, absence of initiative for societal problems and collaboration, and lack of integration of indigenous knowledge.

KEY WORDS: science education; knowledge application; sociocultural learning theory; complex cognitive processes; high school youth

INTRODUCTION

The application of school science in contexts other than where it is learned, a process known as transfer (Pea, 1987), is evidence of successful science pedagogy (Bransford, Brown, Cocking, Donovan, & Pellegrino, 2000)**. This assumption is built on the understanding that there are a myriad of factors, in addition to complex cognitive

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**Other closely related frameworks that explain knowledge use in everyday life with respect to science education are scientific literacy, scientific mindset, funds of knowledge, and public understanding of science.

processes and social and physical resources, that influence learning outcomes (Aikenhead, 2006; Brinker & Bell, 2014; Brown, Collins, & Duguid, 1989; Harding, 1998; Jenkins, 2009; Reif, 2008). Building on this assumption, Fensham (2004) discusses initiatives aimed at modelling meaningful science learning globally in hopes of enhancing transfer. Subsequently, Hodson (2010) suggests that topics that touch the personal lives of youth (e.g., environment, food, energy and so forth) inspire knowledge application. Indeed, the literature reports on a strand of research efforts whose aim is to have students demonstrate embodiment of meaningful science. These efforts are facilitated by teachers and researchers, in non-school contexts, (see e.g., Alsop & Bencze, 2010; Birmingham & Barton, 2014; Barton, 2003; Nashon, Ooko & Kelonye, 2011; Pedretti, 1997; Roth 2009; Barton, 2003; Bolte, 2008). However, the literature is lacking in documentation of knowledge application by youth without direct guidance by researchers and teachers. Arguably, such application personally relevant school science (Fensham, 2004; Resnick, 1987).

In an attempt to fill the gap in the literature, this exploratory study required high school attending youth to report the application of school science, which involved problem-solving incidents, that had occurred in the past, that invoked the use of scientific knowledge, and whereby teachers and/or researchers were not directly involved. Thus, during a focus group discussion (FGD), the participants were prompted to name the scientific knowledge that they had integrated into the unstructured, problem-solving process. It was also assumed, consistent with the multi-science perspective in science education (see, Decoito & Gitari, 2014; Aikenhead & Mitchell, 2011; Dei, 1999; George & Glasgow, 1988; Ogawa, 1995; Snively & Corsiglia, 2001), that the participating youth would incorporate knowledge other than school science (e.g., indigenous knowledge) into situations involving problem-solving. This was because knowledge application, through problem-solving in everyday life, might tap into as many resources, from as many domains, as deemed necessary to solve the problem (Roth & Barton, 2004).

Further, given my interest in global perspectives of science education, I was inspired by a 14 years old boy from Malawi, William Kamkwamba, who built a windmill in the course of his daily life and used the windmill to pump water and generate electricity for his family during a severe drought in 2000

(Kamkwamba & Mealer, 2009). Several years later, Kamkwamba helped transform the living conditions of entire communities in Malawi (Kamkwamba, 2015). That was the reason why a documentary of his creative solution was shown to the participating youth in thisstudy before they became involved in the FGD. And given the significant role of context in knowledge application (Hatano & Miyake, 1991; Thornton, Paterson, & Yeung, 2012), the FGD research questions probed for interactions with people and artifacts whendiscussingproblem-solving incidences. The questions looked for:

(i) the goal and solution process for the problem (what, for what, how);
(ii) the context for the problem (where, when, with whom);
(iii) the school science or knowledge fromeveryday domains such as indigenous knowledge.

Definition of terms: This paper adopts Reif's (2008) explication of **a problem** as "a task requiring one to device a sequence of actions that lead to some desired goal" (p. 201). An **unstructured problem**satisfies all or some of the following criteria: a vague goal, undetermined procedure and several possible solutions (Reif). The term **knowledge** is used in a general sense to refer to concepts and skills (Cajete, 1999); **scientific knowledge** is used synonymously with school science. And **everyday life** is the humdrum existence outside formal expectations and routines(Highmore, 2002).

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

In science education, the application or transfer of scientific knowledge is fostered through problem-solving pedagogy. As such,most research in science education has focused on science topics and thinking processes that involve the decomposing of a problem and the devising of a solution path for well-structured and unstructured problems (Dabbagh & Dass, 2013; OECD, 2007; Olaniyan & Omosewo, 2015; Park, 2004; Reif, 2008). Hamza and Wickman (2012), for example, determine the solution matrix used by high school science students to explain the working of a real galvanic cell. Ibánez-Orcajo & Martínez-Aznar (2007) employ problem-solving methodology to document how high school students apply their understanding of the nature of science. And Laxman (2010) correlatesthe effective application of information searching skills for first-year university students with successful solving of problems in the context of a problem-based, learning approach. Further, Grigg and Benson (2014) use problem-solving to identify how engineering students structure and apply their thinking to solveengineering problems.

Other studies, such as Keselman, Kufman, Kramer and Patel (2007) investigate the capacity for primary school students to reason using scientific knowledge when dealing with real-life HIV case scenarios. Their study highlights the fact that context is important in knowledge application for problems related to everyday life. Other authors (Meacham & Emont, 1989; Harding, 1998; Schmidt, 1997) have also established this fact, observing that context includes the interaction with other people in the process of utilizing physical resources. This occurs, for example, when one consults written text by an author she/he has never met in person (Hatano & Miyake, 1991). In this study, such case scenarios are expected. The collaboratorsinclude experts who mediate the cultural knowledge for the less knowledgeable (novices), through the use of available tools, such as language, and resources in the environment (Bereiter & Scardamalia, 1996; Bransford & Schwartz, 1999; Greeno, 1998; Johnson, 2002; Lave & Wenger, 1991; Marshall, 1995; Rogoff, 1998; Stillman, 2000).

Additionally, studies, with interest in how the cultural context affects learning, view the conceptualization of scientific knowledge in the everyday science framework, as a springboard for learning canonical science (e.g.,Aikenhead & Jegede, 1999; Birmingham & Barton, 2014; Chi, Slotta, & Leeuw, 1994; Driver, Squires, Rushworth & Wood-Robinson, 1994; Koslowski, 1996; Keselman, Kaufman, Kramer, & Patel, 2007). A strand of this literature is focused on ethnic contexts, for instance:

- the analysis of curricular health knowledge in relation to traditional knowledge on health, as practiced by men and women in the community (Gitari, 2006, 2003);
- a study of the integration of school science with indigenous and street knowledge in market place transactions of health knowledge (George & Glasgow,1988); and,

- a look at the knowledge of heat among Sotho adults and middle school students in South Africa (Hewson & Hamlyn, 1985).

The research reported in this paper is cognizance of how such non-school conceptions of phenomena can be integrated with school science, in knowledge application when solving problems.

Another helpful perspective is Reif's (2008) differentiation between everyday science and school science frameworks. The former constructs knowledge by naturalistic means, whereas the later builds knowledge through "deliberate pursuit of ... explicit goals" (p. xiv). (See also, Fleer, 2009). Accordingly, a heuristic in everyday life is not a step-by-step solution process, as depicted by most knowledge application, problem-solving models in computer science and artificial intelligence (see also Ohlsson, 2012). Instead, a heuristic delineates probable think-spaces, characterised by functions such as "describe the problem, analyze the problem, construct solution, assess, and exploit" (Reif, p. 203). Nokes (2009) also outlines a similar problem-solving matrix, characterised by "generate, evaluate-revise transfer cycle to obtain a ... solution" (p. 4-5). And Reif adds that the assess or revise phase is not a necessary stage for the solution to the problem, but it gives one the opportunity to learn new information, as "one ordinarily has ulterior goals beyond a particular problem ... one usually wants to gain further useful knowledge and to improve one's abilities to solve future problems" (p. 203). Additionally, Omrod (1995) posits, in concert with the cognitive processes mentioned above, that new information may also be acquired, through observing others model behaviour (*vicarious learning*), trial and error, self-critiquing one's goals and outcomes (*metacognition*), and devising ways to attain set goals using mental and social habits (*self-regulation*).

To explain this further, as people apply what they already know to a new challenge, they may tap into prior knowledge, acquired by the means outlined above, intentionally or unintentionally. Prior knowledge then fosters thelearning of new knowledge, when a person is challenged with a novel problem-solving situation (Bransford et al., 2000; Dixon & Brown, 2012; Reif; Steiner, 1999; Ormrod, 1995; Thornton & Dumke, 2005). These processes of acquiring new information (*for the purposes of this study, through the application of knowledge as one solves an unstructured problem*) underlie learning in everyday life and constitute an activity frame, appropriately termed 'free-choice learning' (Falk, Storksdieck & Dierking, 2007). In this respect, free-choice learning is best viewed as a cultural pathway in the domains that span all of life, be they sociocultural, historical, material, and affect laden practices (Bricker & Bell, 2014).

METHODOLOGY

Given the role of context in knowledge application and learning, this study analysed the composite description of a youth's lived, problem-solving experiences, by focusing on a similar activity by several participating youths. Creswell (2013) referred to this approach as the interpretation of "the 'texts' of life" (p.79). Accordingly, the study sought to "study the lived experiences of persons," based on the assumption that "these experiences are conscious ones" (Creswell, p. 77), and that not all knowing can be verbally articulated (Polanyi, 1966).

The Participants

The participants were ten high school students between the ages of 14 and 17 years. An invitation to participate in the study was sent out, after successful ethical review, to members of the community within a ten kilometre radius in the municipality where the author resided. The ten youth formed two focus groups (by sheer coincidence, the two focus groups each had five members).The first focus group consisted of youth who were recruited through the local secondary school, using a networking method as posited by Creswell(2007). The participating youth in the second focus group were recruited through an invitation by a librarian at the central library who oversaw the outreach reading program for youth in the community. The self-discloseddemographic composition of the participants was as follows:

FG1: Rahul[†](male, Grade 12, Indian; Raj (male, Grade 12, Indian; Ali (male, Grade 12, Pakistani); Aman (male, Grade 12, West Indian); Vijay (male, Grade 12, Pakistani).

FG2: Belo (male, Grade 12, cultural background not identified); Leah (female, Grade 10, Punjabi-Canadian); Pam (female, Grade 10, Ethiopian); Kate (female, Grade 9, Asian); Ayin (female, Grade 11, Asian-Filipino).

[†]This and all names are pseudonyms.

The Setting for the Data Collection

The initial preparation for the data collection consisted of watching a brief documentary of Kamkwamba's[‡] problem-solving activity, and scribbling problem-solving experiences based on a writing prompt. Kamkwamba's creative endeavour (referred to earlier as the inspiration behind the conduct of this study),was intended to help, by remembering, to activate knowledge schemas, as discussed by Marshall (1995). Additionally, the 20-minute writing prompt requested the participants to:

(i) recall several problems that they have encountered in their everyday lives;

(ii) select one of the problems, and indicate, on paper, the manner in which the problem was solved.

Writing as a memory tool was seen as consistent with the use of writing in the school curriculum (see Langer, 1987). For the participants who could not immediately come up with a problem that had occurred in real life, there was the option to think of an imaginary problem. An example of an imaginary problem was - strategizing to win a cricket game, suggested by Vijay. Although some of the participants initially claimed they did not have real problems to share and therefore started off by recording imaginary problems, he purpose of undertaking the writing prompt and viewing the documentary was to, eventually involve real life problems during the FGDs. Imaginary problems were not part of the data and were not included in the findings.

Contextual Questions

The participants answered contextual questions in survey format to provide basic demographic information as background for data interpretation. The collection of this information was also intended to help build rapport: although the researchers were relating to them within a group, they (the researchers) were interested to communicate to the participants how each of them, individually, applied school science.

The school science, related questions were on the participants' view of science as a subject, what they believe science was, their approach to learning science, and the common avenues from where they acquired their scientific knowledge. The questions provided alternative selections (a, b, c, d, e),which referred to the

[‡]http://www.ted.com/talks/william_kamkwamba_how_i_harnessed_the_wind.html

following preferences: very low, low, average, high, very high. In order to encourage thoughtful selection of applicable answers, the responses were placed in random order, so that the "very low" selection for all the questions was not the first in sequence and "very high" was not the last in sequence, or vice versa. Following Bogdan and Bilken (2007), the questions contextualized qualitative findings without the statistical correlation of variables.

The authenticity of the data collection and its analysis was predicated on the research team's (RA1[§], RA2, and PR)professional qualifications and intuitive assessment of the quality of the experiences that the participants shared. Hatano& Miyake (1991) suggested these considerations were acceptable criteria for authenticating culturally based research.

Data Collection

Focus group discussions (FGDs) were used for data collection. The FGDs involved five students at a time for 90 minutes. The participating youth were requested to give two incidences

(i) a situation where they solved a problem successfully, and
(ii) a situation where a problem was not solved but (now thinking back) could have been solved.

The questions were predicated on the assumption that a narration of past events could be reliably used as data.For instance, Camp, Doherty, Moody-Thomas, & Denney (1989) utilized recalled events and researcher-generated events to analyse how adults view their problem solving abilities in everyday life. Although Camp et al., posited that one could not be entirely sure of the accuracy of past events, they did acknowledge that such accounts might be reliably gauged in the context of the study's overall framework. Subsequently, interview probing was utilized to check with the narrator about the consistency of the reported events. Probing was by using questions, paying close attention to group dynamics to ensure fair participation, such as: How long ago was that? How did you do that? Why did you decide to do it that way? Where did that

[§]Two research assistants (RAs) were involved in certain aspects of the study. The first RA, referred to as RA1 in the rest of the paper, conducted focus group discussion and recorded the participants' conversations. The second RA, referred to as RA2 in the rest of the paper, assisted with data analysis.

idea come from? Which of the information or skills you used were learned in science classes in high school science? Were other people involved in the problem solving activity? If so, who are they, and were they involved? From where do you think they learned or acquired the information they used for problem-solving? etc. .

Furthermore, the FGD facilitated the recall of experiences (see Macnaghten & Myers, 2007), as the participants established rapport and “explore[d] individual and shared experiences”; Tong, Sainsbury & Craig, 2007, p. 351) within the loosely structured environment of a group discussion. This occurred, for instance, when Rahul explained about his fishing experience with the opening line "that reminds me of some things: fishing," and Ali interjected, "I thought of something ... . (p. 8)[**].The conversations were audio recorded and the FGD facilitator (RA1) noted instances in the conversations that informed the problem of study and the research questions.

Data Analysis

The data were analyzed using the general inductive approach to establish theoretical connections between the data and the research questions. LeCompte (2000) and Thomas (2006) suggested to systematically and repeatedly sort through the data,identify analytical codes, and then thematize the data. The analytical codes were taken from the problem of study and research questions and include topic, goal, process, outcome, and knowledgefeatures, such as its source and domain. Bogdan & Bilken (2007) propose these types of codes (setting, process, activity, etc) for qualitative data analysis.

The contextual questionswere analysed by reading through each question and deriving percentages from all the responses. The FGD data generated 30 single-space pages, 12-point print detailing the experiences that the participants had during problem-solving events. The analysis for the FGDdata was conductedin four rounds by myself (the principal investigator) and an additional research assistant (RA2). I firstread through the transcripts to familiarize myself with the vignettesand to map out possible analytic codes. Next, I read the transcripts, notingaspects of the participants' and RA1's interactions that had potential to influence the narratives. For

[**] Page numbers for direct quotes taken from the transcript booklet are provided here and elsewhere.

instance, RA1 told the participants that "Kamkwamba wanted to help his family irrigate the crops so they could harvest twice a year instead of just once, so he was looking toreally solve a big problemwith his family" (RA1, June 2nd, 2012). I also used the analytical codesto formulate the questions for in-depth data analysisby RA2. Sheread through the questions before assigning her own analytical codes to the transcripts. We then compared our codes in the final stage of data analysis (we found our independent interpretation to be similar). We also agreed on other pertinent observations about the data. For instance, RA2 observed that RA1's reference to Kamkwamba's "big problem" couldbiasthe participants to share experiences in the big problem category. Upon further analysis of the data, we agreed that the participants were able to share their relatively "small" problem solving experiences and that they were not evidently swayed by the mention of Kamkwamba's big problem. Inter-reliability was not quantified; instead, we discussed transcript segments and, after building consensus, we assigned corresponding analytical codes.

However, RA2's category labels were different than mine, although, as noted above, there was a similarity in our selection of transcript segments for the analytical codes. In this case, the different category labels were a matter of different packaging. Different "packaging" by independent raters was likely to be common in qualitative data analysis and was shown not to compromise the integrity of data interpretation (Armstrong, Gosling, Weinman & Marteu,1997). Further, Taylor-Powell and Renner (2003) observed that the naming of themes in inductive data analysis could make use of a combination of emergent categories and research questions. And given that there was no methodological inconsistency in how we each packaged the data, in view of the research questions, I decided to follow Taylor-Powell and Renner's suggestion for the naming of the categories.

FINDINGS

The interpretation of the youths' problem-solving vignettes was in the context of the middle range figures computed from the contextual questions. Forty percent of the participants indicated that their interest in science was “moderate,” while 60% viewed science as a very important subject; in a tie, 40% said they worked hard in order to succeed in science and pursue a career in science, and 40% said they learned as much as possible, because they might need the knowledge in the future. Finally, also in a tie, 40%indicated they got their scientific knowledge from school and digital media, while 40% got their knowledge from school, leisure reading, science museum and digital media.

These results showed that the participants viewed themselves as an average high school population with respect to engagement with school science. It was against this background and a myriad other factors in the participants' urban environment, some of which were apparent in the narratives, that the participants discussed their knowledge application in problem-solving. The categories that emerged from the narratives were topic and goal, process and outcome, and knowledge resource.

Topic and Goal

Problem-solving events, involving the application of scientific knowledge, ranged from baking a cake for New Year celebration to deterring boredom while on a cruise. In the first focus group (FG1), the problem-solving incidences were as follows: installing a surround sound system; working with Photoshop; understanding mother’s illness; ridding the house of strange animals; catching fish in a dam; determining a person’s velocity on a cruise; learning to throw a Frisbee; fixing computer hardware; stopping strangers from using a personal Internet; and improving physical workouts. In the second focus group (FGD2), the problem-solving events consisted of: overcoming the current while canoeing; resetting the circuit breaker at home; baking a cake with a missing ingredient; and building an inverted cake. These findings detailed two settings, namely *home and family* related, and *play and recreation* situations.

Home and Family

Rahul’s problem was to do with animals getting into the house:“ where I used to live, at my grandfather’s house, there were a lot of animals, and raccoons would get in" (p. 7). Raj's issues were the setting up of a sound system and the stealing of his family's Internet usage. Other electronic related activities included Vijay's attempt to install a surround sound system alone, and Ali's attempt to fix his big desktop. Ali also remembered using the Internet to understand his mother's illness so he could help her, once she was back home from the hospital. At this point in the conversation, Vijay also shared a medical problem, whereby he needed to understand the clinical circumstances surrounding the death of his uncle. Another incident was the baking of a cake without enough eggs, by Leah. Pam also described constructing a cake for the New Year, starting with the smaller tier at the bottom. Pam and her friend encountered a problem in that "the structure of the cake was all wrong" (p. 14). And Kate explained how she was watching TV at home when the TV suddenly turned off.

Play and Recreation

These situations included Ali's fishing adventure. He recounted, "I was confused. I did not know what fish there were, what type were the majority, and what did they eat" (p. 8). And Raj needed to help a friend with Photoshop. Aman attempted to overcome boredom on a cruise, whereas Raj and Vijay tried to learn how to throw a Frisbee properly in windy conditions. There was also an experience having survival value, much like Kamkwamba's windmill building experience, in that Belo tried to stay alive by keeping his canoe from being buffeted by strong currents.

Process and Outcome

When Vijay tried to install a surround sound for his home theatre system, he found the manual difficult to follow. Asked by his peers if he tried to use the manual, he responded:

> Yes I did, but it made no sense. It was like in ancient languages. So, I started putting up the speakers. I put them up in such a way that they would give back some sound, but, they weren't comfortable enough, and they weren't surround sound. So, I changed them around, until I decided it was a small field. And I went and returned the home theatre system. (p. 3)

Raj also explained how, in assembling a sound system he worked on with his dad and an electrician. But, he was unsuccessful in installing the system. Raj's other challenge involving the stealing of Internet usage resulted in the use of YouTube to figure out how to stop the theft. And Ali spoke of his successful attempt to fix a desktop alone: “I opened it up, it was one of those big ones you don’t see any more” (p. 15).

He also used the computer, assisted by Google to understand why his mother was hospitalized. He recounted:

> ... so, I did research on it when she got back. ... . And it was unsuccessful, because I really didn’t know what to do after that. Yeah, and then I was like; it doesn’t make sense to me. Cause there’s a lot ofcomplex words. So you read one paragraph, you get ten words, put that word into Google, you get another five words, so it’s just an ongoing chain, and I gave up. (pp. 5-6)

Following Ali's story, Vijay told the FGD how he learned about the circumstances leading to the death of his uncle, and new biological and medical terms, by listening to his parents’ discussion on the situation. Similarly, Rahul learned about "different medicines" by listening to his grandfather and father telling him what to do in order to feel better when sick.

And Leah's cake-baking experience involved her manipulation of the ingredient ratios to make up for missingeggs; she used more water, because she intuitively knew it would otherwise taste dry. Further, Kate describedhow she handled the situation with the TV that turned off suddenly: "I realized later that the circuit had tripped and from what I learned in science, when too many appliances and devices were plugged in, the fuse or a circuit breaker stoppedtoo much amps from traveling and setting the circuit on fire"(p. 41). Another participant, Amancalculated "my own velocity as the boat was traveling” in order to overcome boredom in a cruise ship:

> I know the boat; there’s a television in my room, and it shows the speed of the boat, there’s a channel, and I remember I was walking that same direction and I just added the two velocities together and found out my own velocity (p. 11).

In addition, Belo and his team survived a rough water current by manipulating the canoe's motion: “the more we pushed it, the more the current was pushing backward against us" (p. 34).

Knowledge Sources

The science subject areas emergent from the narratives were technology, math, chemistry, ecology, biology and physics. In the narration about finding information regarding his mother's illness, Ali referred to the scientific term ‘haemoglobin’ that he acquired from sources in the Internet. As he explained: but it was basically a haemoglobin deficiency. Obviously now I knew what it meant, right, but back then, it was a year and a half ago when I was in grade 11 (pp. 5-6).And Vijay told the FGD of how he acquired phrases and terms such as valve, and leak in the heart, from his parents who are both doctors, as he overheard them discussing the circumstances surrounding the death of his uncle. This was before he had learned anatomy in Grade 12. Further, systems biology and the repairing of body parts (medical domain) came up in the conversation involving Vijay’s uncle.

In explaining the source of his knowledge, Ali spoke of his successful attempt to fix a desktop alone: "That’s back when I actually knew something about engineering, I took grade 10 and 11 engineering ... I knew all about that kind of stuff, you know, disconnecting your floppy drive and stuff to run faster, right?" (p. 15). Rahul then referred to Ali’s skill for fixing his computer as “computer engineering," and Vijay” used the physics concept, force, with reference to the way Ali reacted to his computer by punching it. Further, Amanreferred to speed and velocity in relation to overcoming boredom on a cruise. He acquired the knowledge through a baseball case study in grade 11 physics. As well, Raj told the FGD that he later learned how to use Photoshop in a Grade 10 Media Arts class. And Belo, when asked by RA1 about the "action and reaction force” (p. 34), said he did not have these concepts at the time of the canoe incidence, which occurred when he was in Grade 10; he knew about speed as a concept in motion at the time, but the new terms were learned later in physics classes.

Additionally, in narrating how she baked a cake with inadequate eggs, Leah mentioned ratio, a concept that is common in the math and science curriculum, and in everyday scientific framework. Like Leah, Pam used everyday terms such as “the cake was all wrong,” “the cake could not stay,” when describing the experience of baking a two-tiered cake. Further, in an animated discussion, Aman mentioned lactic acid when explaining muscle pain, which he experiences during physical workouts. Subsequently, other youth talked about energy drinks DOMS and P-90X in relation to lactic acid and exercise. At one point in the discussion, Raj and Vijay asked Aman to explain how many parts there were in an arm, and Rahul quipped in with a suggestion that one could get all that information from exercise posters in the gym. They also talked about Internet 'stealing,' and referred to YouTube and Google as common sources of new information.

DISCUSSION

The application of school science through problem-solving is influenced by the situations in urban life, in which the youth find themselves, based on among other things, the resources and the interpretation of resource availability. Resource availability is a key factor in the know-how to solve problems (Harding, 1998; Rogoff, 1998; Schmidt, 1997). The case of Kamkwamba, which is used to prime the participants' memories of problem-solving incidents, is a compelling illustration of how individuals, inspired by their circumstances, can appropriate the resources in their environments to ameliorate the conditions in their everyday lives.

Firstly, unlike in Kamkwamba's windmill project, some of the youth in this study did not persist in applying school science and other know-how to help in the completion of their problem-solving projects. With the exception of Belo who navigated a canoe against a dangerous current, the motivation to persist in knowledge application through problem-solving, for the participants in this study was not driven by survival-type situations. Instead, there were competing alternatives presented to the participants from their situations in that, there were people who were more knowledgeable about the installation of surround sound, for example, who could have helped with the problem-solving. But it was also likely that the seeming lack of motivation and consequent abandoning of problems solutions was prompted by gaps of knowledge. The gaps of knowledge might exist, because the information was not available at that point, or simply because the youth *chose not to know,* even though the information was available and probably intellectually accessible, like the manual that was said by Vijay to be in "ancient languages." This finding was instructive for problem-solving heuristics that underlie free-choice learning in science pedagogy.

Secondly, like Kamkwamba, all the youth engaged in free-choice learning, through the heuristics posited by Reif (2008) and Stokes (2009), albeit not necessarily the assess phase of problem-solving and knowledge application. The assess phase opened up opportunities to learn new information, even if the problem solution was unsuccessful. Again, it was likely that the youth who did not persist in the assess phase might have been influenced by the absence of dire consequences for incomplete projects. Knowledge application through problem-solving was likely to enhance the acquisition of new information through purposeful trial and error, and by vicarious means. In the literature, trial and error was recognized as the basis for adapting prior knowledge, while at the same time incorporating current understanding in the performance of a task (Nokes, 2009). Cognitively, this led to the re-conceptualization of existing knowledge schemes, or learning, that might involve surface-mapping of similar structures in an everyday scientific framework (Gartmeier & Schuttelkopf, 2012; Peterson, 1926). For instance, although Raj did not eventually install the surround sound, he satisfied the parameters of this approach to problem-solving, whereby he generated an initial solution, based on general problem-solving strategies and then evaluated that solution with respect to his prior knowledge of sound fields. Then, unable to unravel the movement of sound waves by himself, he sought help from his dad and an electrician. Arguably, if this team had persisted with a self-regulated approach, as in free choice learning, they likely would have overcome all the constraints and succeeded in installing the equipment, while learning new information (Falk, Storksdieck & Dierking, 2007; Durand, 2013).

Further, when Leah tried to bake a cake with water to replace missing eggs, she was, in a manner, working with surface similarities of wetness for water and eggs. Nokes (2009) described this process as “retrieving a prior exemplar, creating a mapping between it and the current problem or situation, and then using that mapping to draw an inference relevant to the application context” (p. 3). Kamkwamba, for instance, used old bicycle wheels in place of the recommended parts for building a windmill. Through the study of principles of electricity, and trial and error, he acquired new information as he attempted to make his imitation windmill generate electricity. Surface similarity was involved in this kind of knowledge used in everyday life. Whereas, Leah's attempt was that of a novice, Kamkwamba's was that of an expert. Experts rely mostly on “deep structures” (Nokes, p. 3). For example, in the baking example, if Leah had been aware of the chemical qualities (expert understanding) that render eggs suitable for baking, she would not have opted to substitute an egg with water (novice understanding). Instead, in keeping with free-choice learning, she would have sought knowledge from sources such as the Internet or knowledgeable others.

Similarly, Vijay and Raj did not attempt to learn any expertise from the declarative knowledge available through the installation manuals. Instead, they preferred to use trial and error, exclusively relying on intuition and common-sense. The opportunity to learn new information would have consisted of looking upin the manual, knowing well in advance to determine what was helpful information and what was not. And, for other youth like Vijay, in the case of medical and biological terms, new knowledge was acquired vicariously in the sociocultural context of mediation, as explained by Ormrod (1995).

Finally, the situations that prompt some of the youth to solve problems have personal relevance; they are in the personal spaces of relevance, as opposed to the global/societal spaces of significance. The youth are looking to learn to play Frisbee well, bake a special cake, master proper exercise techniques, learn to fish, fix a tripped circuit in order to continue watching television, and so forth. Hodson (2010) underscores the significance of personal relevance for effective science education, and by implication knowledge transfer. In this regard, he lists areas of societal dimension that are of personal relevance, such as food, energy, and the environment, among others. But, in this study, although the issues are of personal relevance, they are not necessarily societal as envisioned by Hodson.

This is of concern given the youth are not inspired to solve problems of significance for society on their own in everyday life, as argued by Hodson and as promoted by several pedagogical perspectives with the aim to engender knowledge application through problem- solving. Among these perspectives are:

- STSE (science, technology, society, and environment) and action research work in schools (Hodson, 2010; Pedretti & Nazir, 2011),
- science for social justice (Barton, 2003),
- activism in the science curriculum (Alsop &Bencze, 2010; Roth, 2009);

- integrated curriculum (Wallace, Venville, & Rennie, 2010); and
- multi-sciences (Aikenhead & Jegede, 1999; Elmesky, Olitsky & Tobin, 2006).

Because their overarching theme is to promote the practical application of scientific knowledge in non-school contexts, by ordinary citizens such as youth, these pedagogical perspectives are well positioned to coach students to solve problems in local and global arenas, through the application of school science and in collaboration with others in everyday life. Following on from the first and second finding, the pedagogical perspectives must coach youth how to:

- recognize problem-solving opportunities in socioscientific issues;
- master effective heuristics;
- bolster motivation by collaborating with other, and expand the scope of problem-solving.

CONCLUSIONS

This study has demonstrated the types of problems that youth attempt to solve in the course of their everyday lives. The problems attest to the youth's life circumstances that include their urban sociocultural contexts and persistence in problem-solving. In most cases, the motivation to persist with problem-solving is minimal. One consequence of not completing their projects is that most of the youth miss the opportunity to collaborate with others and acquire new scientific knowledge through free-choice learning. Another conclusion is that the youth could benefit from coaching that would show them how to work with problem-solving heuristics in everydaylife.

Furthermore, the existence of societal problems and their recognition by the Ontario science educational policy (OME, 2014), highlights the need for educators to appraise the implementation of relevant curriculum initiatives. In all, the youth already have the relevant sociocultural and cognitive knowhow to serve as the springboard for knowledge application through problem-solving, in the local as well as global arenas. What is lacking is the *mobilization of the know-how*. Looking to the future,a variant of this study needs to focus on the application of indigenous knowledge and knowledge, from other everyday-life domains,for problem-solving in everyday life by high school attending youth in urbanOntario.

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