From a Network of Research-Practice Partnerships to a Multi-Expertise Learning and Design Community

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Abstract: Taking Citizen Science to School (TCSS) is a network of design-centric research-practice partnerships (DC-RPP) intended to promote incorporation of citizen science into science classrooms. This study explores the nature of shared knowledge developed by participants as part of a workshop intended to increase cross-fertilization among participants. Interaction mechanisms included storytelling and abstraction of cross-project insights, using a tool designed to share design knowledge. Seventeen unique emergent design-principles were found to correspond with well-established STEM education design-principles, but also with new notions of learning through citizen science. This illustrates that the TCSS community is beginning to shift from functioning as a network of DC-RPPs into a learning multi-expertise community that seeks to steward the domain of knowledge on school-based citizen science.

Introduction and theoretical background

Scaling of educational innovation is one of the most challenging aspirations of educational research and the learning sciences community (Looi, Teh, Law, 2015). The challenge becomes especially prominent when radical change is required including organizational, cultural, social and conceptual aspects of change within schools. To increase the applicability of educational innovations, researchers suggest various strategies to explicitly tailor design products and processes to fit the needs of not only learners, but also of teachers and schools, as described in McKenney's (2013) notion of zone of proximal implementation. One strategy that has proved to increase the applicability of innovative instructional models within schools is amending such models with design principles (Kidron & Kali, 2017) serving as reification artifacts (Law, Yuen, Lee, 2015), which can assist members of research practice partnerships to negotiate underlying design principles and adapt them to local needs, constraints and affordances. This approach becomes specifically important when networks of design-centric research-practice partnerships (DC-RPPs) are concerned (Hod, Sagy, Kali, & TCSS, 2018; Kali, Eylon, McKenny, & Kidron, 2018), and design adaptations are made to meet the various requirements of different school settings. In such networks, especially when the instructional model is flexible, and affords adaptations that can greatly differ from each other, it may become quite challenging to coalesce the lessons learned in each of the DC-RPPs. However, this challenge is one that is worthy of pursuing not only because the whole network can benefit from the collective wisdom that can develop from synthesizing the insights developed within the various RPPs, but also because such knowledge can further advance the design principles underlying the instructional model for the benefit of additional school implementations, as well as for advancing learning sciences research.

The Taking Citizen Science to School (TCSS) initiative was initiated in 2017 as a network of DC-RPPs, with the specific intention of incorporating citizen science into science classrooms (Hod et al., 2018; Sagy et al., 2019; in-press). The rationale was that citizen science—generally defined as the direct participation of citizens in different stages of scientific research projects—when carefully designed to be incorporated within school science, can promote meaningful science learning of middle and high school students. With this rationale in mind, we invited members of various expertise, including school-practitioners, members of non-formal education organizations, scientists who seek to involve public participation in their studies, and educational policy-makers, to partner with our core team of learning scientists. This resulted in the establishment of the TCSS network which pursues a school-based Mutualistic Ecology of Citizen Science (MECS) (Atias et al., 2017; Hod et al., 2018; Sagy et al., 2019; in-press) where all participants benefit from their involvement. The network consists of about a dozen of multi-expertise RPP teams, where each team designs, implements and studies the incorporation of citizen science projects within classroom settings. These RPPs are facilitated by a member of the core team and build on the notion of MECS and key learning sciences conceptualizations, such as:

- Connect between the learning of students, school practitioners and scientists in a mutualistic manner (e.g., by making visible and committing to address the various parties' goals)

- Support students’ enculturation of norms and practices characteristic of citizen science (e.g., building on diverse expertise, advancing knowledge collectively, contributing to and using shared databases, often using technology and in direct contact with the phenomenon explored, e.g., the natural environment)
- Adopt a societal situated approach (e.g., situate problems of inquiry in real, important, and even controversial issues that gain the public’s interest).

In addition to regular meetings within each of the RPPs, in which most of the co-design work took place, three whole-network meetings were conducted yearly, intended for all participants to reflect on practice, share ideas and present new opportunities for collaboration (e.g., a scientist’s presentation of a new citizen science platform to invite collaboration with schools). We were encouraged that people from many of the RPPs, as well as additional representatives of all types of expertise originally invited, voluntarily participated in these meetings on the expense of their own time. However, our engagement in these meetings enabled us to notice that much of the knowledge developed within each of the RPPs during the first two years of the TCSS center’s work had typically remained local wisdom despite these meetings. Moreover, many of the participants were not fully aware of the values and underlying principles of the MECS approach that our team brought to the table, even though they were implicitly employed in many of the RPPs’ designs and implementations of citizen science projects within schools. In other words—using Wenger, Trayner, and de Laat’s (2011) conceptualization—although many aspects of a *network* (e.g., information flows, making helpful linkages) took place within the group, aspects of a *community* (e.g., seeking to steward a domain of knowledge) were missing. We realized that additional designed activities within the network are required for cross-fertilization, and even for the development of common language that would enable such learning. Thus, towards the end of the second year, we decided to devote a half day workshop within the summer whole-network meeting to promote this goal. The current study explores the nature of the shared knowledge developed within this workshop.

Methods

Participants

Of the 70 participants in the summer meeting 38 participated in the workshop (others were involved in a parallel session) comprising of: 7 scientists and other citizen science project leaders; 16 education practitioners; and 15 education researchers; About two thirds of the attendees had some experience in school-based citizen science in about ten different citizen science projects across 17 schools (e.g., a marine ecology study based on public jellyfish observations, a small-mammal ecological study based on animal footprints data collection, an air quality project integrating sensory and observational data).

Means of intervention

We view the activities implemented in the workshop to support cross-fertilization among participants as a change we made into the TCSS center’s learning architecture to increase learning between the RPPs. Law et al (2015) define learning architectures within DC-RPPs as consisting of (a) stable organizational structures, (b) interaction mechanisms for participation, and (c) reification artifacts that communicate ideas and consolidate consensus and alignment. In the case of TCSS, the main organizational structure (i.e., the network of DC-RPPs that had been established and continually working for two years) had not changed, but new interaction mechanisms and reification artifacts were introduced into the workshop, which served as the means of intervention in this study.

Interaction mechanism introduced: Storytelling and abstraction of cross-project insights

The workshop was comprised of three main activities: (1) a storytelling session, in which participants worked in 5 heterogeneous groups of 7 to 9 participants to share reflections on their practice of integrating the citizen science activities within their science classes, elucidating on what contributed (or impeded) successful school implementation in their case; (2) an abstraction of cross-project insights session, in which each group identified commonalities among the participants’ stories and suggested formulation of design principles for school-based citizen science based on these commonalities; (3) a sharing and discussion plenary session, in which participants presented their suggested design principles and sought for similarities between them.

Reification artifacts introduced: insighTCSS

To support the groups in the cross-project abstraction activity, we developed a mockup version of an online interactive platform we call insighTCSS. Based on the notion and contents of its precursor Design Principles Database (DPD) (Kali, 2006), this platform is designed to enable participants in our network of DC-RPPs to use, negotiate and contribute to existing design knowledge for developing and implementing technology-enhanced activities that integrate citizen science within school science. As in the original DPD, the design knowledge is represented in three interconnected levels of design principles: meta principles (relating design to general notions of socio-constructivist and socio-cultural theory for STEM education), pragmatic principles (providing insights as to how the meta principles can be translated into learning environments), and specific principles (illustrating how the pragmatic principles can be employed in specific contexts of use).

Figure 1 is a screen-dump of the mockup version of the interactive platform. Workshop participants used a similar, paper version of InsighTCSS, which was intended to inspire their own formulation of cross-project insights in the form of design principles. Each of the bubbles in the mockup represents a design principle title, where the uppermost principles (white) represent meta principles, and lower principles (yellow) represent pragmatic principles. The leftmost meta design principle—tentatively entitled "Break school boundaries to support meaningful learning via citizen science" (or in short, the TCSS principles)—was added to the four original meta principles that we adopted from the DPD, so as to enable participants' exploration of principles that specifically characterize school-based citizen science. Based on the MECS values, we added under the TCSS principle four tentative pragmatic principles that may support its application. (Note that the interactive version in the mockup includes more information on each principle, which pops up in mouse roll-over, which cannot be seen in Figure 1. The level of specific principles, and additional linkage are also missing from the figure).

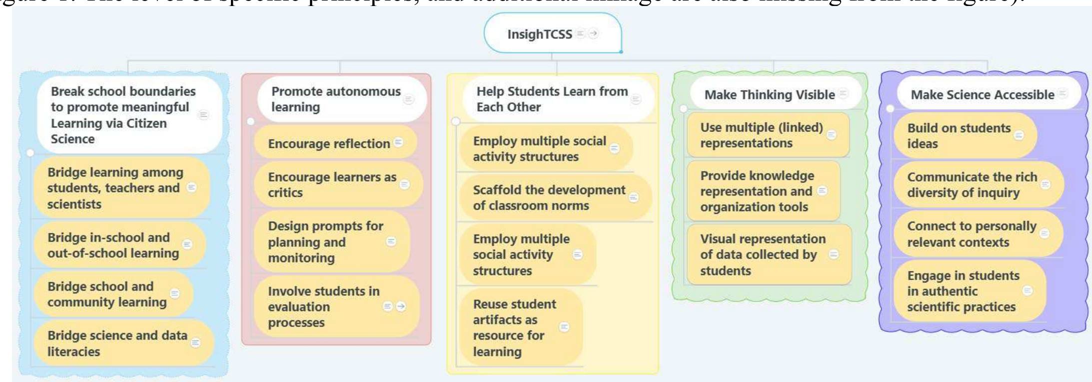

Figure 1. Screen-dump from the insighTCSS mockup (workshop participants used a similar paper version to inspire their own formulation of cross-project insights in the form of design principles).

Data sources and means of analysis

A shared presentation that participants used during the workshop to develop and present each group's cross-cutting insights was used as data for the analysis. As a first stage, one of the authors conducted content analysis of the suggested design principles. This included identification of similarities between the ideas raised by the different groups to develop a short list of the workshop principles, including a count of repetitions between groups. The shortlist was then compared with the DPD to examine whether the newly suggested principles may be seen as different formulations of principles that already existed in the DPD, or of the TCSS design principles, or whether they may be considered as new design principles. Following this stage, two more authors joined in to review the analysis process, confirming and refining the findings.

Findings

Altogether 55 suggestions for design principles that cut across the projects were raised by the five groups, which were compiled into a shortlist of 17 unique principles (each raised by at least two groups). The comparison with the DPD and TCSS principles revealed that the shortlist was comprised of: (a) 13 principles describing rationales that correspond to existing DPD principles; (b) 3 principles corresponding to TCSS principles (5 groups related to bridging between in and out-of-school learning; 4 groups related to bridging school and community; 2 groups related bridging the learning of students, teachers and scientists); (c) 1 new principle that interestingly, was not mentioned either in the DPD or the insighTCSS principles, but had emerged in three of the five groups in the workshop. This principle was formulated as "acknowledge and make visible the contribution of students and teachers to the advancement of real science". Specifically, this principle encapsulates the importance that participants found in providing students and teachers with opportunities to recognize their own contribution to the advancement of science and scientists, and to be acknowledged for this contribution. For example, a science teacher who partnered with a scientist from an oceanographic research center involved 9th grade students in identifying fish in photos and analyzing dolphin soundwave graphs. The teacher noted that the students' interaction with the researcher as well as the opportunity to engage with advanced technologies used in this research provided them with the sense of meaningful participation and advancement of real research, which was acknowledged by the researcher. In another example, the coordinator of an RPP between a school and another marine ecology project indicated that when 5th grade students studied a visualization of jellyfish data collected throughout the country, they were excited to see the significance of their own contributions to the research.

Discussion and conclusions

The fact that many of the shared design insights raised by workshop participants resonate with general STEM design principles, such as those described in the DPD is not surprising. The incorporation of citizen science activities into the science curriculum required participants, as a first step, to apply their knowledge of what it means to implement good science teaching. However, the fact that a significant portion of the shared insights resonate with the TCSS design principles, illustrates that school-based citizen science affords unique opportunities for science learning that the TCSS community is beginning to coalesce. Of particular interest is the emergence of the new design principle on making visible the contribution of students and teachers to the advancement of real science. We view this as an important principle for designing activities that leverage on the affordances of citizen science. But perhaps even more importantly, the process of joint articulation of this principle, which will now serve the community for further implementation and research, illustrates that the TCSS community is beginning to shift from functioning as a network of DC-RPPs into making first steps in becoming a learning and design community. To use Wenger et al's (2011) terminology, TCSS participants are beginning to develop "shared identity around a topic or set of challenges" (p. 4), while the shared knowledge developed is beginning to represent "a collective intention—however tacit and distributed—to steward a domain of knowledge and to sustain learning about it" (ibid). The interaction mechanism and reification artifact developed in this study and introduced in the workshop (i.e., the storytelling and abstraction activities and the preliminary use of the InsighTCSS mockup) served to support this shift. Finally, we view this shift as an important step in scaling and sustaining the innovation while exploring its challenges and benefits within a multi expertise community.

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