

'More than particle theory': Action-oriented citizenship through science education in a school setting

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Responses

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Abstract

The body of literature connecting science education and citizenship is growing, linked through the lens of scientific and technological literacy. The case study presented here offers a new analysis of science-civic engagement, examining the opportunity given to an Intermediate science class to include opportunities for activism and engagement with citizenship through the topic of waste management. A teacher encouraged her students to develop and implement Action Projects based around their own understanding of required change for waste reduction. By analyzing outcomes of the Action Project, the students' personal change, and the factors influencing their change, it was found that the students formed new connections between science education and citizenship. They experienced authentic empowerment, contextual knowledge acquisition and exceptional teacher influence. Through their empowerment, they gained recognition of the impact that an individual can have on the wellbeing of self, society and environment. This case study points to the need to expand the study of the pedagogical interaction of science and action-oriented citizenship education.

Keywords: citizenship education, science education, youth, empowerment

Introduction

Politicians and legislators make rules and decisions about children,

which often fail to work.

But who asks the child for his opinion or consent?

Who is likely to take note of any advice or

approval from such a naïve being?

What can a child possibly have to say?

- Janusz Korczak (Joseph, 1999)

The intersection of science and technology literacy and citizenship education through environmental action is under investigation in this case study. The question of engaging students in action-oriented citizenship through science education in a school setting has three main areas of focus: science education, citizenship education and activism. This case came about under the umbrella of a publicly funded, curriculum development and research project, herein known as 'STEPWISE' (Science and Technology Education Promoting Wellbeing for Individuals Societies and Environments). STEPWISE addresses six

components of science education, of which this case study focuses on WISE activism and STSE (Science, Technology, Society and the Environment) education. The case presented here was facilitated by a teacher-researcher who chose to follow the work of her seventh grade students as they implemented personal change projects (Action Projects) related to waste reduction and management, and she has allowed this researcher to evaluate the outcomes.

As an action research project, the key question that arose is what are the outcomes for students who are engaged in a personal action project in their science class? Drilling deeper, further questions arise: Do their experiences result in any outcomes that are aligned with the overarching expectations of participatory citizenship education? Do the students express a sense of empowerment from their actions? What are the experiences of the teacher through implementing the project with her students? Were the outcomes as she expected and if not, were the deviations improvements? And finally, is the Action Project a positive contribution to science and citizenship education?

By examining the literature around science education, citizenship education and the intersection thereof, and applying current theories to outcomes from this case study, the researcher has developed a model that can be used to explain particular interactions of science and citizenship activation.

Theoretical Framework

Scientific Literacy

The concept of scientific literacy is one that has evolved and taken many incarnations and definitions over time. From its beginnings it was grounded in the ideology of expert/scientist development and ‘truth’ production, through to the broad spectrum of components now recognized and examined, such as a means of responding to economic, social and environmental issues and preparation for responsible citizenship (Davies, 2004; Hodson 1998; Roth & Désautels, 2004). Hodson (2003) refers to a four-stage approach to issues-based scientific literacy, where Level 1 is the appreciation of the societal impact of scientific change, and the cultural impact; Level 2 is the recognition of stakeholders in scientific decisions and the link to wealth and power; Level 3 is the development of individual views and establishing value positions; and Level 4 is the preparation for and taking of action (p. 655). This four-level approach could be referred to as critical-responsible scientific literacy, for its emphasis on the actor to take a stand on issues which leads to responsible action around those values. A further framework for assessing scientific literacy, which can be seen as an expansion of Hodson’s Level 4, is as Fourez (1997) explains. In the preparation for and taking of action, people are scientifically literate when their knowledge provides “a certain autonomy, [the possibility of negotiating decisions with minimal dependence on others]; a certain capacity to communicate, [finding ways of getting one’s message across]; an ability for coping with specific situations [in practical ways]; and the ability for negotiating over outcomes” (Fourez, 1997, p. 906). Bringing Hodson and Fourez together amounts to a means of evaluating action-based or issues-based scientific literacy, which was used in the analysis below.

Another aspect to include in scientific literacy is life-long learning. Knowledge and experience acquisition, for students, are of minimal value if it does not carry forward, both beyond the classroom and beyond the schooling years. “Science education, in schools and as a life-long endeavor, is of little use if it does not allow students to care for and, in particular, engage in action” (Roth & Désautels, 2004, 2). It is the action engagement that intersects with citizenship education, in its equally complex manifestations.

Citizenship Education

Similar to scientific literacy, there are multiple approaches, variations and incarnations of citizenship education. It is contested in its political nature and it has varied through time, geography and required social and learning outcomes. At present, there continue to be various models of citizenship education. The key defining concerns are the purpose and the method of delivery. In response to the question of purpose, the literature points to several variables, for example, the desire for nation-building, the desire for future economic sustainability, and the desire for social and/or political action (Leach, Scoones and Wynne, 2005; Westheimer & Kahne, 2004). In response to the question of the method of delivery, solely considering the formal education models for this case, there are integrated, separated and overarching (i.e., whole school/board culture) methods. In Ontario, for example, a discrete half-course is offered in grade ten for Civics education. Prior to that, forays into the realm of citizenship and civic life are either in blocks of information in social studies, or left to the teacher's discretion based on his or her comfort with the topic and its possibility for integration.

Regarding the importance of action in citizenship education, Holden and Clough (1998) express that

education for participations involves reflecting on values, assisting children to acquire the skills necessary for taking action and ultimately providing opportunities for them to become involved as active citizens. Such education is endorsed by the Convention on the Rights of the Child ([UN], 1989) (Articles 12 and 13), in which children are given the rights to seek and impart information, to express their thoughts and feelings, to have these listened to, and to partake in decisions affecting them (p. 14).

Citizenship education is complex as the implications for current and future outcomes are great. And like other areas of education, the learning of citizenship, of social responsibility, of policies and protocols, of nation and neighbour and the world, are not to be absorbed in a vacuum. Rather, the lessons may not truly be learned without the context beyond the classroom.

Intersection and Integration with Science Education

The possibility of integrating citizenship education across the curricula is appealing for many reasons, and especially so in science education. Hodson's critical-responsible interpretation of scientific literacy is important as citizens feel the pressing need to demand and implement action in their societies and from governments in many realms, including the environment, consumer safety and energy consumption. Scientific literacy in its relationship to citizen-development is expressed as STSE (or Socioscientific Issues [SSI] in the American context) through the lens of formal science education (Hodson, 2003; Ratcliffe & Grace, 2003; Roth & Désautels, 2004; Sadler, Barab & Scott, 2007). As a component of formal science education, STSE education can be a means of enhancing social justice. It is a tool for the accumulation of social capital, which can break down barriers, especially when combined with participatory citizenship (here, in the form of activism within the STEPWISE model) (Bencze, 2000; Zembylas, 2005). For children, in particular, access to social capital has been questioned. As Morrow (2003) writes, "Putnam's emphasis on civic participation as a key aspect of social capital is obviously somewhat limited in the case of children, given that they are positioned outside of democratic structures by their very nature as 'minors'" (p. 175). And yet, their interactions in their science classroom, their school and their community allow for the possibility of both a current and long-term accumulation of social capital, through the access of skills, relationships and networks of knowledge.

Hodson (2003) writes, "science curriculum oriented toward socio-political action ... [will develop] a generation of scientifically and politically literate citizens who are not content with the role of 'armchair critic'" (p. 645). STSE education is a tool to promote and engage democratic citizens who make informed decisions toward a sustainable future (Davies, 2004; Hodson, 1999; Jenkins, 1999; Ryder, 2002; Wellington, 2003). Social activism often has been thought of separately from the sciences, but science often has been implicated in social, economic and political decision-making and outcomes. The decisions require the

participatory and justice oriented citizenry that is complemented by a science education that promotes lifelong learning for all, for engaged youth will ideally become engaged adults, who are socially minded, scientifically knowledgeable citizens (Bencze, 2000; Hodson, 2003; Leach *et al.*, 2005; Ryder, 2002). The STEPWISE educational framework provides an approach to science education that addresses many of the intersections with citizenship, in that it aims to help all students to gain their maximum potential literacy in science and technology, broadly defined, and then encourage and enable them to use this literacy for not only improving their own wellbeing but, as well, that of (other) individuals, societies & environments ('WISE') (Bencze, 2007). The goal of activism through science is not necessarily to develop justice-oriented citizens but to instill a sense of engagement that may lead to justice orientation through participation (Westheimer & Kahne, 2004). Under the umbrella of citizenship education, one can drill down into opportunities for what Miller (1999) considers transformative processes, which can encourage both participatory and justice oriented citizenship.

Activism

It must be noted that there are certainly challenges of engagement – facilitating the empowerment to advocate; avoiding hypocrisy of education; and interconnectedness of issues not being equal to the isolation of change and the outcomes (Ashley, 1998). In addition, working within an anti-racist education framework ideally facilitates the empowerment to advocate. A teacher who is aware of systemic hegemonies, of marginality and knowledge production biases, could engage her students in ways that empower them and also work to promote equity, both in her classroom and in society as a whole (Dei & Calliste, 2000). Within the context of citizenship education, the antiracist pedagogy serves to facilitate both a sense of entitlement as a student and as a citizen – of the school, the city or the world, depending on the scope of the activism project.

As Ashley (1998) acknowledges, fragmentation of knowledge and experience is undemocratic; rather it is coherence and interconnectedness leads to global citizen identity.

Finally, it must be recognized that there is a discourse on science and citizenship within the pedagogy itself. For in the teaching of science through the lens of citizenship, it can be seen as a tool to engage learners in science, to demystify it through social action and to empower students who might otherwise feel marginalized in the culture of science (Aikenhead, 2001; Costa, 1995). This is the aspect of science pedagogy that is of key concern to this study.

Research Context and Methodology

Context

The report is derived from a study of one teacher of seventh grade science and her pilot project work encouraging students in her class to take action to promote personal, social and/or environmental wellbeing. The Action Project was introduced by the teacher as an opportunity for students to make a personal change in their lives around the topic of waste management. She initially introduced the topic by helping the students to understand about hazardous waste and waste disposal, specifically investigating the practices of their local municipality. The students had full choice of: whether they would work alone or with a team; focus their efforts at school, home or in the community; involve their families or not. She tracked their planning through learning logs that she required them to maintain, their classroom discussions and their culminating presentations. The recorded work of the students' Action Project was 6-8 weeks in length, depending on presentation dates. Once the Project was introduced, the students were mainly independently developing and following their plans.

The data from this study were collected over a five-month period from February to July, 2008. The teacher-participant in the study was a member of an action-research group for STEPWISE during the academic year and thus had a relationship with the researcher, who was the Research Assistant to the STEPWISE project. The data for this case study was collected over three individual meetings with the teacher-participant over six months, five interactive classroom visits, and two group interviews with students. Each class period was 40 minutes in length, with five minutes often before and after the class, chatting with the teacher or debriefing about the lesson that day. The first visit was in April and the final visit was six weeks later in June. All of the data was derived from the classroom setting except for the teacher interviews in some cases.

The class consisted of 22 grade seven students, of which 20 were female. Ethical approval was given for 6 of the students, all female, as part of the greater STEPWISE research project. The teacher was not privy to which students had been given ethical approval from their parents to participate in the study. The school, a middle school for grades 7 and 8 only, is situated in an area of moderate-high economic status in the City of Toronto. The parent council is very active and tends to have a high rate of success fundraising for school projects (Teacher-participant personal communication, June 6, 2008).

The initiation of the Action Project involved a directed examination of hazardous wastes and their labels, a directed search on local municipal processes for waste management (hazardous waste, water filtration, composting and recycling, for example). The teacher then introduced the idea of SMART Plans. By having her students work with the framework of a SMART (Specific, Measurable, Attainable, Realistic and Timely) plan, thus providing a guideline to the students without specific direction. The Action Project allowed for students to meet the SMART plan objectives within their own interests; they were encouraged to use, and evaluate, their own methods of tracking and reporting, and to provide and seek out feedback to and from their peers.

Methodology

To study the outcomes of the teacher-participant's implemented project towards promotion of citizenship education in school science, she was engaged in cycles of action research; that is: "self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own practices, their understanding of these practices, and the situations in which the practices are carried out" (Carr & Kemmis, 1986, p. 162). Action research involves carrying out actions (intended to improve situations) and, through those, learning about situations relating to the actions. In many ways, this case study is a micro-study of the action research that the teacher-participant was doing with her students, as their Action Project required their reflection and re-evaluations throughout their project, in their learning logs and in their formal and informal discussions with her and with their peers in the class, while her work with the STEPWISE action research group allowed her to explore ideas and feedback around WISE activism.

Data Collection and Analyses

To determine the interaction of science education and citizenship education in the Action Project case study, data-collection and analyses relating to this action research are naturalistic (Guba & Lincoln, 1988), allowing conclusions to emerge from studies of events in the action research. From the naturalistic perspective, it is possible that neither the teacher nor the students have been engaged in this sort of pedagogy, of participatory citizenship activity in science. Related to this, qualitative, ethnographic research methods (e.g. Hammersley & Atkinson, 1990) were employed. As a small study sample size, the research is qualitative but with a depth of reflection. There is also a rationalistic aspect to this research, in the sense that there had been previous classroom observation, and that there has already been some theoretical backing from researchers such as Hodson (1999) and Davies (2004) to support possible outcomes. For example,

within the investigation of student orientations toward citizenship, there was an analysis along the lines of Westheimer and Kahne's (2004) three types: Personally Responsible, Participatory and Justice-Oriented Citizenships. Mainly, examples of degrees of responsibility, degrees of outreach and organization and degrees of critical analysis were focused upon, with options for other descriptors if they were presented.

The data included semi-structured interviews, artifact analysis and observational studies. From the interviews, data collected included interview transcripts with the teacher and the students. The transcripts of the teacher interviews were from two three-hour interviews, one before she began the Action Project with her students and one at the end of the school year; a five-minute interview before the first class about the Action Project; and a ten-minute interview after the first class. The student transcripts were from a ten-minute interview which took place a week into the Action Project implementation, and a 40-minute interview which took place at the end of the official Project. Both the teacher and the students were interviewed at the start of the project and at the end of the project. For partial reflection on the teacher's views of science and pedagogy, Repertory Grids (RepGrids) were used, both before and after the implementation of this project, as part of the greater STEPWISE research project. From Bencze, Bowen and Alsop (2006), RepGrids are "graphical and numerical depictions of possible relationships among individuals' 'constructs' (e.g. learning outcomes) and 'elements' (e.g. pedagogical approaches)" (p. 405). Figures 1a and 1b show the RepGrid outcomes, before and after the Action Project respectively, for the teacher in this study. For further elaboration on the method of RepGrid completion and analysis, refer to Bencze, Bowen and Alsop (2006).

Artifact data included two samples of students learning logs, with student-written reflections on the progress of their Action Projects. Students were asked to record both successes and challenges through their Action Project and to follow its progression. As well, four images were captured to represent some of the pieces the students developed in the process of their actions, which can be found in the Appendices of this report. The observational data included six sets of classroom visit field notes by the researcher, and an assistant for two of the visits and recordings of student presentations of their Action Project outcomes. Each classroom visit was 50 minutes in length.

For analyses, constant comparative methods based on constructivist grounded theory (Charmaz, 2000) were used. This is an abductive-deductive dialectic process, in which data were carefully reviewed and coded (as abductive acts). Codes were, then, grouped into categories and themes relating to knowing about and performing citizenship through science, which was evaluated through references to data (as deductive acts). These processes were repeated until 'saturation' of themes was achieved. Checks with the participant were conducted to ensure 'trustworthiness' of claims, each of which was based on at least three corroborating data sources (i.e. semi-structured interview transcripts, researcher observations, RepGrid analyses, student project artifacts) — for 'triangulation' purposes (Lincoln & Guba, 2000). There was also ongoing interaction between the researcher and the teacher-participant through action-research group meetings, as part of the larger research project.

Results and Discussion

Student Outcomes

As a result of a project instigated by their science teacher, the students designed and implemented Action Projects to create significant change in their lives, their families and even communities — such as changing where their personal and home waste was being directed (i.e. away from the landfill), encouraging their neighbors to be mindful of their littering, or reducing their water usage. From data analyses, two key intersections of science and citizenship have emerged: 1) Personal Change; and 2) Factors Influencing

Change. From the data, while it is evident that there was an impact on the teacher, which will be discussed further below, it is the impact of the project on the students that came to be of significance in this study.

1) Personal Change

The first theme encompasses the personal change that is brought out by participating in the Action Project. Personal change can be sub-divided into several theme areas identified through the data analysis: a) tendency of students toward active citizenship; b) intention of students to maintain their change beyond the completion of the Project; and c) their attitude toward science education.

Tendency of students toward active citizenship

First of all, personal change reflects the change in the tendency of students toward active citizenship. It is expected that issues-based approaches should lead to preparing for and taking action (Hodson, 2003; Sadler *et al.*, 2007). Many of the students indicated the success of their projects. This success was measured, in their words, by setting goals for changes they would make in their waste management practices, and seeing them through. Student B reflected on the Action Project when it was completed, with particular emphasis on concepts like helping, teaching and being responsible:

It helped the environment, but it also helped us. It teaches discipline and to set goals, and you also get to record it down. And it does teach you to be responsible (Interview June 6, 2008).

The students also felt rewarded in their changes when others became involved, and validated their efforts, as Student D states:

I liked it because I knew that I wasn't the only one who was fulfilling my Action Plan. I was getting other people to help as well, and save, maybe not conserve more, [but] at least try and get involved or make the effort (Interview June 6, 2008).

This statement also shows recognition of voice, responsibility and impact, which are key to citizenship education (Roth & Désautels, 2004; Davies, 2004; Westheimer & Kahne, 2004; Ratcliffe & Grace, 2003; Holden & Clough, 1998). Recognition of responsibility is shown by the awareness of laws and practices that had to be negotiated in the development of their Project, as well as setting and meeting goals that impact their environment, both social and environmental. When students recognize that they are making an impact not only on their environment but also on the people around them, they are given validation of their voice, and thus feel that they are participating as citizens in a broader unit than simply their classroom.

Students' intentions to maintain their personal changes

The second category revolves around the students' intentions to maintain their personal changes beyond the duration of the Action Project. Certainly, their responses are speculative, but their honesty with the project is also evident. Many statements such as the following indicate obvious intention:

I'm going to continue my showers to reduce the minutes... I'll still have the posters up to remind people in my family ...[but] I won't record it (Student E, May 30, 2008).

The lack of desire to continue recording waste management-related outcomes after the completion of the official Action Project was consistent for all students. While they described in great detail the methods they employed to record their data, rarely was it an activity that the student indicated enjoying or wishing to continue. However, it was observed in artifacts, such as posters, interviews and class presentations, that the gratification of creating change in family members was supportive to the students to maintain their personal change. The recognition, consciously or unconsciously of the community of support and practice, is

expressed by Wenger (1998). The participation of the students in their respective projects is often legitimated by the actors within their community – family, school, neighbourhood, etc.

Change in attitude toward science education

Thirdly, as a result of the Action Project, the students expressed a change in attitude toward science education. The students felt this was a new approach to science class for them. Student E noted that the Action Project did not seem to be part of the official curriculum and her feelings about that:

Something I did like was that it wasn't part of the ... textbook. You couldn't find this plan. We did something and I guess it is science, but it's not energy or like [what] we are doing right now [in class], so it is a bit different so I liked that (Interview June 6, 2008).

Another student elaborated on the impact of this approach to science education, versus “getting into the particle theory”, when she stated:

I found science more interesting because we got to share how we felt about everything we did and we got to fix what we didn't like...the environment...and so I think I like science a bit more now (Student B, June 6 2008).

Recognizing the constrictions of school versus the impact on the world, Student B stated:

...when I was doing it, I was under a lot of pressure because I knew I wanted to get a good grade and I don't think that I was doing it as much for the environment. I was doing it more to sort of help myself (Interview June 6, 2008).

This limitation leans toward an inability to wholly meet the standards of scientific literacy laid out by Fourez (1997), where one must negotiate the change that is taking place, for within the confines of the institution of education, the students may be limited. For example, a student may feel that she is making an impact on the environment through her home, but may feel less validated by a grading system that requires certain outputs, such as tracking and reporting.

Overall, there was mainly third and fourth level attainment under Hodson's (2003) prescription for scientific and technological literacy. The students were able to establish their value positions based on the actions they designed, Level 3, i.e. organic matter should go in the green bin for compost, and prepared and took action, Level 4, i.e. creating a reminder poster for one's family to redirect organic waste and observe that the organic waste being diverted by measuring the volume in each bin per week. Thus the students in the case study experienced an intersection of science education and citizenship education through the personal change that took place in their tendencies toward active citizenship (taking responsibility and initiating projects), their intentions of maintaining the actions they had started as part of an individual project (highly positive and likely) and their changes in attitude toward science (experiences of increased enjoyment and applicability to their worlds).

2) Factors Influencing Change

Recognition of personal change leads to the second emergent intersection of science education and citizenship education, which is the Factors Influencing Change. Personal Empowerment and Contextual Knowledge are two causal themes, which are each categorized below. A third causal theme is the Influence of the Teacher, explained through the categories of a mentor and a facilitator. These themes can be connected to the area of personal change through Wenger's (1998) knowledge duality theory; that is, meaningful learning (and action) arises when there is a close reciprocal association between participation in the world (developing plans and taking action) and representations of them (e.g., reflections on the plans).

Personal empowerment

Personal empowerment may lead to inclination toward activism (i.e., acting toward the betterment of one's community, society or the world). The students connected their work in the science classroom with making a positive impact on their environment(s) and their communities. Two categories of personal empowerment emerged: empowerment as a leader and empowerment through taking ownership.

Empowerment as a leader

As leaders, several students encountered a positive response to their Projects from family or community members. For example, one student used her parents' restaurant as a place to encourage reusing. She put up posters outside the restaurant offering a 15% discount to anyone who brought in a representation of reusing their garbage. Appendix A shows an example that she received, of a model motorcycle made of coke cans. She felt that the whole experience went well for everyone, but had to stop offering the discount as an incentive. However, she was empowered by her engagement with the public and her ability to rally her family and immediate community to act on her project of reusing waste items.

Another student explains her sense of empowerment through her ability to choose her project, work through it and make constructive changes to her life and the life of her family. From her preparation and research, she was aware of the positive impact she made on the environment:

[The Action Project] was really good because we all got to do something that we felt was really important to us. . . . I felt strongly about how plastic bags are wasted a lot, and so I got to make my own plan and encourage my family and friends to help to start conserving more plastic bags (Student D, June 6, 2008).

Another student explained a situation where she caused a lot of stress to her young sister by asking her to reduce her water usage, due to the global freshwater shortage. When her sister began crying, she had to realize the implications of role in implementing her Project, and negotiate a way of still leading the Project and helping her sister to be empowered, so, in Student E's words

I talked to her and I made that poster with her [about water usage]... and she wrote her name on it too. She was really happy she pitched in (Interview May 30, 2008).

After six weeks, her sister's showers had reduced by more than half the time and Student E was very pleased. In several cases the students recognized their abilities to influence their family and friends around an issue that was important to them.

Empowerment through ownership

The idea of taking ownership was empowering to the students. Student D noted that the process by which the Action Project was implemented and tracked in school was empowering, when she said

We all got to show our point of view on things. If we had a problem with something, we got a chance to fix it and we got a chance to *make our own plan how to fix it* (Student D, June 6, 2008, researcher's emphasis).

Student B also commented:

I don't think we need school and a teacher to tell us to do that. I think we should know to be able to do it on our own (Interview June 6, 2008).

This is supported by the work of Cargo, Grams, Ottoson, Ward and Green (2003), as they found that "an empowering environment was characterized by adults' acting to create a social context for youth to take responsibility for their [quality of life] issues." (p. s70) In this case, the quality of life is improved by the sense of reward from their own project work and by the less direct impact of diverting from the waste system.

Contextual Knowledge

Another sub-theme that emerged from the data relates to scientific literacy as content and skill knowledge acquisition, or Contextual Knowledge. Using the STEPWISE model of science education, two categories for contextual knowledge became apparent in this case: Products education, i.e. knowing science facts, such as how waste products are disposed of or reused; and Skills education, such as knowing how to create a data table or communicate outcomes to an audience.

Products education

This recurred in multiple spaces as the students connected their experience in this project with the ability to enhance their knowledge of waste management, as the constructivist and affective nature of the Action Project would suggest (Hodson, 2003). The students built their own projects from the needs they identified in their personal lives and/or communities. Because they had ownership of the project, they took responsibility, for the most part, for finding out the information that would help them to be successful. For example, one of the students was curious about how a garbage disposal works in her sink and where the water goes. So she did a lot of research around gray water disposal and treatment in the City of Toronto and returned with some new information that she could share with the class. It followed that their contextual knowledge enabled the students to feel justified in their decisions for personal and community change, while in parallel their change decisions helped to enhance their scientific literacy (Ratcliffe and Grace, 2003). For example, Student C reflected on her scientific literacy as she began participating in the Action Project:

We learned science because we were getting more connected with the way we should write out procedures and the way we do things, and we got to figure out how the environment worked and sort of how to fix it (Interview June 6, 2008).

In this way she is also connecting science education with both contextual knowledge and skills acquisition through the Action Project.

Skills education

The students also commented on the skills they gained from having to record their actions, their results and having to present their outcomes. They recognized that procedural practices, such as measuring changes in water consumption or waste disposal, while having possibility for human error, are important to the validity of the project and the presentation of the outcomes. Student B commented that:

It can help us in the long run when we have a plan for work or in our careers or in high school. And also, for just regular projects. Your hypothesis needs to be specific and it makes everything a lot easier if you know what you're doing and if you follow those rules. So, I'm experiencing this project does benefit us (Interview April 16, 2008).

The data supported their skills acquisition. In their presentation of their results, they used sophisticated tracking methods and presentation methods, such as found in Appendix A, with charts and graphs that were clear.

Influence of the teacher

Characteristics about the teacher also appeared to be influential with regards to student learning outcomes. The teacher plays the role of both a role model, by sharing her personal values with the class and allowing them to share their ideas openly, and a facilitator in the project, by introducing and encouraging a type of science learning that is new to the students.

Teacher as role model

The ownership that any student takes of a project is connect to the perceived value of the project to the teacher. The students recognized the value the teacher placed on the environment and identified a key reason for the teacher to assign such a project, for example:

I think she [the teacher] really wanted us to help the environment, become aware and do it, actually

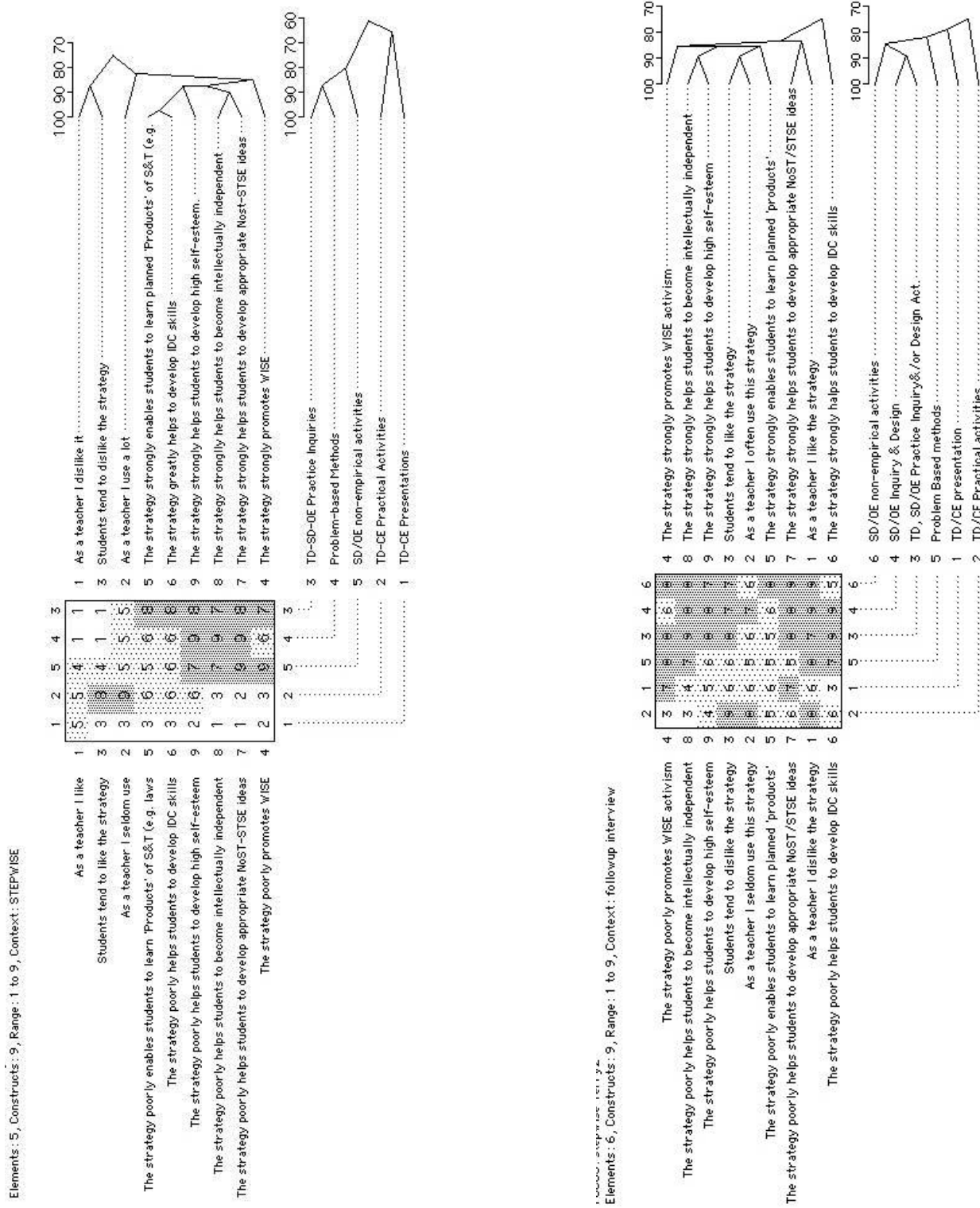


Figure 1: a) On left, RepGrid FOCUS analysis of teacher-participant, pre-Action Project, February 2008; b) On right, RepGrid FOCUS analysis of teacher-participant, post-Action Project, July 2008.

doing something and helping out, so later on in our life we won't not do anything; we'll do stuff. We'll do something to help (Student A, June 6, 2008).

In her work with the STEPWISE action research group, the teacher was consistent in bringing artifacts, teacher supports and samples of ways to teach through an STSE model. With the Action Project, she included a request for students to be reflective about their process and practices, and through classroom discussions, she encouraged the students to participate and contribute to each other's findings, to offer suggestions and insights, while she kept her comments and directions to a minimum.

Teacher as facilitator

The teacher-participant, at the completion of the project, described the evolution of her interest in pursuing an Action Project with her students. She acknowledges the intersection of scientific literacy and activism in her planning, and how it related to her confidence in the pedagogy:

I'd [been trying] to connect to society and environment with ... and for them to be aware of their understanding of science and technology, the public understanding of science, and how it's represented in the 'real world'. We had already started to talk about garbage and landfill and the need for recycling just as a general topic of discussion, and so I thought, well, I could go a lot further with this. And then, I thought, what I would feel comfortable about is just looking at personal change. How one person could make one change and that would be a benefit to social justice or environment. So that was my comfort zone, looking at personal reflection and thinking about personal everyday actions or activities, and making a personal change, knowing that's hard to do ... changing habits (Interview, July 6, 2008).

Through the teacher's facilitation, the community of learners, the students, shared experience of their personal change in the classroom environment that served to reify their practice (Wenger, 1998). The data indicates that she enabled their change by recognizing the possible challenges and creating a comfortable space within which the students could address their problems and solve them, as she did frequently in her classroom practice. In her own words, the teacher stated,

[students] need time to mess around, to make mistakes ... so I am very sympathetic (Interview, July 7, 2008).

There was, it seems, a dialectic relationship between the teacher implementing the Action Project with her students, and the positive outcomes of the students work affecting her views as a teacher. Using the results of the teacher's RepGrid analyses, from the initial interaction in February (Figure 1a) to her final interview in July (Figure 1b), it was obvious that her approach to science teaching had changed over the course of the Action Project and her action research participation with STEPWISE. Her views of pedagogy had expanded to include student-directed/open-ended (SD/OE) inquiry and design where initially, during the first interview in February, she did not even consider commenting on that form of pedagogy. By July she felt strongly about that particular form of pedagogy, as indicated in Figure 1b, that it helped to promote self-esteem, intellectual independence and appropriate ideas about the nature of science and technology, among other things.

As well, initially she had a very strong correlation between learning products (contextual knowledge) and developing inquiry and design communication skills. After the project, this relationship was nearly void, being displaced by strong correlations between intellectual independence and developing self-esteem, among others. More importantly, the teacher changed her pedagogical 'likes' from mainly Problem-based Methods and Teacher/Student-Directed Open-ended practice inquiries to a moderate to strong 'like' of all the methods listed. As well, she initially tended to use mainly Teacher-Directed, Close-ended practical activities, by the final interview, while she continued to use these, she also expanded her use of all the other practices. Both of these outcomes show an increase in her overall confidence as a science teacher, which may be attributed, through Wenger (1998) as a reflection of the positive encounters she was having with her students outcomes in her community of practice.

The role of the teacher is both clear and vague, in just the same way that we may be aware of the official curriculum and the informal curriculum; depending on one's educational philosophy a teacher facilitates transmission, transaction or transformation, given the day, the lesson or the needs of the class at any moment (Miller, 1999). In this case, the role of teacher as facilitator allowed for a transformative process for her students in their personal change (Westheimer & Kahne, 2004; Holden & Clough, 1998). Her ability to let the students direct their projects, to guide them with her questioning but mainly to provide the framework within which they may explore their own empowerment, is very valuable from a social constructivist perspective. For example, she encouraged the students to develop their Action Project based on their own needs or the needs of their family with regards to waste reduction and management. With the SMART plan she laid the groundwork for scaffolding which could help the students to guide themselves through the process, and she supported them in learning from their failures and mistakes.

Fourez's (1997) four components of scientific literacy are addressed at various levels through the Action Project. The students were given autonomy, required to communicate their findings, had to cope with specific situations of their individual families and community responses to their Action Projects, and gained the ability for negotiating over outcomes, by finding ways of adapting their projects through the failures and challenges that came from the action. With this engagement of scientific literacy in effect, Fourez (1997) states that "the concept of scientific and technological literacy refers to a degree of empowerment of the individual" (p. 906).

Mapping the Interface of Science and Citizenship through the Action Project

From reflection upon the outcomes of data analysis, a model was developed. The diagram in Figure 2, the Interface model of Personal Change and Factors Affecting Change for the Action Project case study, shows the three key Factors that are expressed in the data as affecting personal change, around the outside of the triangle: personal empowerment, teacher influence and contextual knowledge. These are each connected and related. Where they intersect an arrow represents the means by which personal change is expressed by the data from the students, moving inwards toward the change. For example, the influence of the teacher (i.e. in her implementation of the Action Project, as a facilitator and a role model) combined with the personal empowerment experienced by some students (i.e. a sense of making a positive impact on the environment as a leader and a community member) leads to personal change through action-oriented citizenship (i.e. developing and activating a plan that impacts their daily lives and the lives of others). This is supported by the work of Holden and Clough (1998), who expand on the literature around the role of the educator in empowering and encouraging participation for children specifically.

The contextual knowledge that the students gained (i.e. how waste is managed in their community and how to communicate their results) combined with their personal empowerment (i.e. seeing the difference in their own and their family's waste output) led to personal change through the maintenance of their action, for some students, by knowing concretely that they are making a difference in the environment, in a small way. From Roth and Désautels (2004), it is shown that authentic knowledgeability, that is authentic engagement with learning beyond short-term facts, leads to inclusive participatory democracy, dialectically dependent with empowerment (pp.19-20). Seeing a change that is based on personal action interacting with knowledge-based decisions is inherently empowering.

The interaction of teacher influence (i.e. knowing that the teacher values the environment and values the Action Project) and contextual knowledge (i.e. learning how waste impacts the environment and how waste can be reduced) leads to personal change through the student's attitude toward science (i.e. being encouraged, directly and indirectly, to find their own meaning and values in science learning and to see that science is 'more than particle theory'). Wenger's (1998) communities of practice theory supports this notion, particularly through the work of engagement (p184). The teacher has facilitated a community in which the work of the students is given meaning and they have each formed their own competencies around their

individual projects. The competencies were founded on their contextual knowledge learning, which in return reifies the meaning of their work.

In addition, the model, if it were represented in three dimensions, serves as a feedback loop, as each of the sides of the triangle are enhanced by the opposing change component indicated on the arrow, such that a greater personal empowerment can be developed by a more positive attitude toward science. Students who enjoy their science education experiences will be more willing to take risks and learn for their successes and failures, in science and in school on the whole. Teacher influence may be enhanced by awareness of student maintenance of the action, for if she feels that she is making a positive impact with her teaching she will continue the project in future classes, reflecting on the student outcomes and making her own changes to the Action Project for its improvement. And more contextual knowledge may be facilitated through action-oriented citizenship, through learning by doing and hands-on authentic experiences.

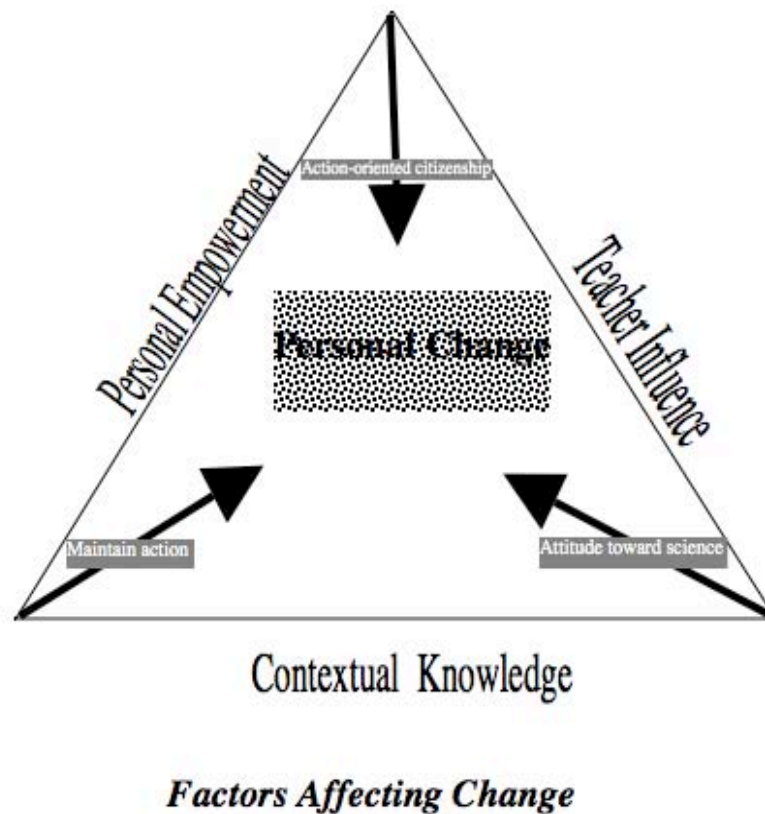


Figure 2. Interface model of Personal Change and Factors Affecting Change for the Action Project case study.

The Action Project intersects and integrates science education and citizenship education toward empowered and scientifically literate youth citizens. It is a democratic activity in itself, in that students, given a basic framework of inquiry as a starting point (investigating the waste management programs of their local municipality), were left on their own to decide which aspect of waste management fit within the SMART goal framework for their own interests and abilities. In this way, the students were given a great opportunity to set out their goal toward positive results. The inherently democratic nature of the Project is that the students were given an opportunity to participate in authentic decision making that was directly connected to their own daily lives.

Within the constructivist perspective of contemporary education, the scaffolding of lived experiences to continual learning within the fields of science education and education for citizenship takes on the form of

assisted participation (Hough & Clough, 1998). Thus, the method by which the teacher implemented the Project, such as her rather hands-off, student-directed, open-ended “instruction”, allowed for a strong sense student ownership over their Projects, another aspect of democratic citizenship education (Bencze & Hodson, 1999; Sadler *et al.*, 2007). Roth and Désautels (2004) explain this process: “Routine collective (authentic) activity includes as much the production of failure as the production of average, ordinary knowledgeable. Both knowledgeable and authenticity are achieved when people participate in on-going activity, which derives its motive form a larger collective, but their participation is at a level matched to the existing competencies of the individual. Authentic activity therefore leads us straight into community, society and participation in inclusive democracy” (p. 19-20). This cause-effect relationship points in new directions for teacher development as well. For the teacher, she noted a significant change in her confidence level with regard to moving from teacher-directed pedagogy toward student-directed activities. Teachers who have the confidence to support their students toward their own self-direction will likely develop a higher sense of personal empowerment in their students.

Authentic and empowering learning experiences have a lasting impact on young students who, in their own words, may say:

We really should start taking the initiative to start making more Action Plans and doing more things because it's better for the environment (Student B, Interview June 6, 2008).

This is a strong statement from young students who have the social capital to make positive changes in their own lives and in the lives of the community and environment around them. The learning outcomes for both the students and the teacher show a distinct challenge between the milieu of the school and its time constraints, the curriculum and its required outcomes and what took place within this case study. Both the students and the teacher acknowledge their positive response to the learning outcomes and feel equally challenged by the school community. For this teacher, her experience with the Action Project and her students was positive enough that she would definitely do it again. Unfortunately, the next academic year has left her without any science teacher opportunities, due to a shuffle in her school. Yet another challenge to address.

Summary and Conclusion: Broader Social and Educational Importance

Empowering, authentic learning experiences are the basis for life-long learning, for genuine concern for self and others, and for critical thinking. All of these outcomes are desirable for citizens of any community, society and ultimately, the world. Personal empowerment and the critical lens that is developed along with it move the agenda forward toward active, engaged and responsible citizenship (Fensham in Bencze & Hodson, 1999) for both the students and their teachers.

Currently, in the teacher-participant's jurisdiction, the revised science curriculum has a greater STSE focus. This case study draws some interesting and compelling starting points for assessing the value of the intersection of citizenship education and science education in support of the new curriculum. By engagement in acts of citizenship, and thereby experiencing empowerment, marginalized students may feel empowered toward both a greater desire for and affinity to scientific literacy in its many facets (Barton, 2003). And furthermore, the engagement of scientific activity with positive outcomes may propel students to further acts of individual, social and environmental wellbeing. As Roth and Désautels (2004) state, “it may not be necessary that all citizens have acquired the same stock of scientific knowledge but rather that all citizens have the competence to enter what ever knowledge they have into the public (political) discourse. It is only when science can participate in such conditions where other knowledge forms are equally considered that science has become truly democratic” (p. 150). For society, these are outcomes that need to be supported in the curriculum, allowing for and engaging resources to support individual and community transformation and active citizenship with and through scientific literacy. Large-scale analysis of such implementation requires further investigation.

Another area for further investigation is the role of gender within the analysis of science and citizenship education. Issues regarding gender and participation, social and cultural expectations, for example, how girls may be empowered differently than boys; if one's sense of accomplishment or social contribution is affected by gender – these are among issues for further exploration beyond this particular project.

As stated in Sadler *et al* (2007), “life in the 21st century is irrefutably associated with science and technology, and formal education should help students prepare for active participation in modern democracies” (p. 373). Science education is important to the development of critical-minded, globally-conscious citizens. Citizenship education provides the opportunity for real-world experiences, social and environmental impacts and allows for a voice for individuals and communities. The integration of science education with active citizenship education is a step toward breaking down barriers between the general public and the scientific elite. It is also a means of furthering the development of critical thinking citizens, who place value in questioning scientific knowledge production. It is, importantly, a method of empowering both students and teachers to ask real questions about what is taking place ‘in the real world’ and to seek out the answers, as life-long learners and global citizens.

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Appendices List

- A. Images of students' Action Project activities: Garbage separation calendar; Conserving Water poster; Reused Coke Cans.



