Notes to The Teacher

This booklet provides some teaching/learning suggestions for use of the graphic novel ‘Ban the Dust’, which describes engagement of citizens from Québec City in science research and civic actions to address problems of industrial dust pollution.

‘Ban the Dust’ is an interdisciplinary novel. In describing real-life events, this novel draws from and can be used to teach knowledge, skills and literacies from different disciplines, such as the Sciences, Civics, Geography, and much more. In this pedagogical booklet, we give some local examples of curriculum connections from Ontario (where we work); however, teachers can make similar connections to their local curricula.

In this booklet, we describe and explain some possible classroom pedagogical applications of the graphic novel, including to teach certain knowledge, skills and attitudes about relationships between science, technology, societies and environments (STSE), nature of research, and nature of civic actions. They can also use other teaching-learning resources (e.g. videos, research articles, newspaper articles, PowerPoint slides… etc.) to teach these concepts and skills.

Finally, other than the pedagogical examples described here, teachers can refer to our STEPWISE instructional book (Science Education for Civic Action, at: tinyurl.com/y26l84o8) for a wider collection of activities to teach about STSE relationships, research and civic actions. These include but are not limited to uses of a graphic novel as a teaching-learning tool.

Graphic Novel: A Rationale

The graphic novel is an artistic representation of real-life STSE relationships that sparked much controversy about possible problems. We decided to use a real-life event to teach about citizen engagement in science and technology related issues because students may be able to relate to the real characters and events depicted in the story. This might inspire and encourage students to get involved in carefully planned civic research and actions.
Our choice of an *artistic* form of representation (particularly a graphic novel) arises from their engaging nature and appeal to teenage students. Our decision was also guided by the need to create spaces for equitable access to STSE education and civic action. From this point, we see the graphic novel as an alternative form of representation that allows diverse students (i.e. from different cultures and/or with varied learning abilities, life experiences, and/or world views, such as English Language Learners) to easily access the information, with the goal to get better involved in STSE related research and actions. The graphic novel also addresses students’ multiple intelligences by combining science and technology knowledge and skills with those of arts and other literacies. While we see graphic novels as a valuable teaching/learning tool in (science) classrooms, we also recognize the significance of using other forms of representations, such as oral storytelling, movie/video, slideshow, drama/theater, poem, dance... etc., and encourage employing them in the classroom.

Finally, as we advocate and support students/citizens’ civic actions to address problems related to science and technology, we see this graphic novel, in itself, as a form of action to support citizens’ effort to address industrial dust pollution in similar contexts. We hope that this inspires students to take similar researched-informed actions (e.g. videos, posters, songs... etc.) to address science and technology related issues and problems highly important for them. Of course, this graphic novel should not be treated as the only source of information about the dust controversy in Québec City. Teachers and students should supplement information in it with what they can learn from the actual citizen action website (https://www.vigilanceportequebec.com/), Chantal Pouliot’s book about this controversy (title: Quand les citoyens.ne.s soulèvent la poussière : la controverse autour de la pollution métallique à Limoilou), related newspaper articles (e.g. "Poussière sur Limoilou: Labeaume s’en lave les mains, déplore Bussières" in Le Soleil, 25 novembre 2012), and other sources of information (please refer to the ‘Notes and References’ and ‘Links’ pages, 29-34, in the actual graphic novel: tinyurl.com/yxa9ptq6).

**Pedagogical Suggestions**

**Age Appropriateness**

As a teaching/learning tool, the graphic novel can be used with varied degrees of complexity. The topics and ideas covered in the graphic novel and the language used can well suit students in grades 6-12 (ages ~ 11-18 years old). Teachers can adapt different reading strategies and choose supporting activities based on the age group they are teaching, their students’ readiness, and the expected learning outcomes of the unit they are teaching.

**Examples of Curricular Connections**

**Ontario Science and Technology Curriculum**

The three main goals of Ontario Science and Technology curriculum, grades 1-8, 9-10 and 11-12 are the following (e.g. Ministry of Education, 2007, p. 3):
The graphic novel can be used as a teaching/learning tool to address these three goals, with specific focus on goal no. 1; i.e. ‘to relate science and technology to society and the environment’. For example:

- Students can learn about positive and negative impacts of developments of science and technology on societies and environments, and how, reciprocally, social, political and economic factors can shape development and knowledge-making in these two fields (e.g. possible causes of industrial dust pollution in Québec City, and legitimacy of related science information produced by citizens).
- Students can also learn about different stakeholders involved in STSE issues and problems, their varied perspectives and positions, and power-relations among them (e.g. how different stakeholders, like citizens, government bodies, and port authorities experienced, perceived and addressed city dust deposits).
- Students are also invited to assess courses of action taken to address these problems, and propose and take similar ones.

In terms of goal no. 2, “to develop the skills, strategies and habits of mind required for scientific inquiry and technological problem solving”, this graphic novel can be used to achieve outcomes like the following:

- Students can develop skills related to secondary research by, for example, evaluating the science information presented in the graphic novel and conducting further research to support related decisions.
- Teachers may also choose to focus on primary research skills (i.e. conducting experiments and/or correlational studies) by supporting students to design and carry out experiments to test characteristics of different elements and compounds found in the industrial dust at Québec City and/or test the quality of air in their neighbourhoods.

Hence, the graphic novel can serve as a springboard to further learn different research skills that match students’ grades and expertise and the unit taught.

To address goal no. 3, “to understand the basic concepts of science and technology”, the graphic novel can be connected to such concepts as:

- Biology: ecological sustainability, air pollution, and human health;
- Chemistry: elements, compounds and mixtures.
Similar to teaching research skills, the graphic novel can be used as an engaging hook to teach about different science concepts.

**Possible Learning Outcomes**

Hodson (2003, pp. 645-670) indicates four main goals of science and technology education:

1. **Learning Science and Technology**
   Acquiring and developing conceptual and theoretical knowledge in science and technology, and gaining familiarity with a range of technologies.

2. **Learning About Science and Technology**
   Developing an understanding of the nature and methods of science and technology, an awareness of the complex interactions among science, technology, society and environment, and a sensitivity of the personal, social, and ethical implications of particular technologies.

3. **Doing Science and Technology**
   Engaging in and developing expertise in science inquiry and problem solving; developing confidence and competence in tackling a wide range of ‘real world’ technological tasks.

4. **Engaging in Sociopolitical Action**
   Acquiring the capacity and commitment to take appropriate, responsible, and effective action on matters of social, economic, environmental and moral-ethical concern.

By using this graphic novel, students can develop a set of valuable learning outcomes related to these four goals of science education:

**Learning Science and Technology:** students can learn...

- Basic concepts of science and technology (e.g. characteristics of different elements and compounds in industrial dust and their possible effects on human health)

**Learning About Science and Technology:** students can learn...

- Possible impacts of human activities on environmental sustainability
- Possible impacts of social, economic and political factors on knowledge production in fields of science and technology
- Views, positions and interests of different stakeholders (including non-human entities) involved in an STSE controversy/problem, and how they are possibly affected
- Power differences and relationships between different stakeholders involved in an STSE problem
**Doing Science and Technology:** students can learn…

- Criteria of valid secondary and primary research
- Skills for conducting secondary research
- Skills for designing and conducting experiments
- Skills for designing and conducting correlational studies

**Engaging in Sociopolitical Action:** students can learn…

- Criteria of effective citizen actions
- Skills for designing and implementing effective students’ actions

**Possible Classroom Pedagogical Applications**

There are different possible approaches to using this graphic novel in classrooms. For example, it can be used as a *hook* to introduce students to STSE issues and problems and citizens’ knowledge production and socio-political actions. It can also be used to allow students to *apply* knowledge and skills that they learned from teachers and others. In all cases, approaches chosen should set students for success, rather than set them back due to lack of relevant prior knowledge and skills. As students arrive to classrooms from varied cultural and social backgrounds and with different expertise, abilities and attitudes, they tend to *construct* their learning differently; i.e. they tend to make meanings of their learning based on their past experiences (for more about constructivism and its influence on learning, refer to our book ‘Science Education for Civic Action’ >>> Appendix >>> ‘Learning Theories: Constructivism’: tinyurl.com/yxku2unx). Hence, students’ capacity to ‘discover’ new complex concepts (e.g. effects of economic and political factors on fields of science and technology), reach certain conclusions (e.g. acceleration due to gravity) or perform new advanced skills (e.g. design and conduct valid correlational studies) varies significantly. This can be particularly challenging for ideas and tasks that students are not usually exposed to in the school system or in their daily life (e.g. power differences among stakeholders involved in a socioscientific issue, or roles of non-human entities - like conflict minerals in smartphones - in influencing initiation and development of certain STSE issues - like armed conflict in The Congo). Therefore, to set an equitable learning environment, bringing students to similar levels of readiness, we recommend that teachers explain attitudes, skills and knowledge that many would find difficult to discover without assistance from others. This would then provide useful lenses and expertise for students to further explore other STSE issues and problems. Additionally, when choosing activities to engage students with the graphic novel, it is worth considering extents to which these activities are *closed-ended* (i.e. with definite end points, predetermined outcomes or specific right answers) or *open-ended* (with different conclusions allowed). While open-ended activities would perhaps better lend themselves to discovery approaches (e.g. inquiry-based learning), we believe that close-ended activities might benefit
more from ‘explain-apply’ approaches - in which the teacher uses direct teaching methods to ensure all students understand essential attitudes, skills and knowledge (‘ASK’); but, then, also engages students in application activities (e.g., teacher-designed questions for answering after reading the graphic novel) that encourage students to use (apply) and evaluate ASK that have just been taught. Of course, while we recommend these possible employments of the graphic novel, educators may have different perspectives and can use it differently in their classrooms.

**Some Teaching/Learning Suggestions Based on the STEPWISE Pedagogy**

In the following, we include some teaching suggestions based on the STEPWISE instructional framework (for more details, refer to the ‘Science Education for Civic Action’ book at: tinyurl.com/y26l84o8). In brief, this framework aims at supporting students to independently lead research-informed and negotiated socio-political actions (RiNA) to address STSE issues and problems important for them. However, as argued earlier, because students come with different background experiences and with varied levels and types of expertise, they might not be well positioned to take this active role independently and effectively. Hence, they might need to be scaffolded first. For this purpose, students may go through one or more constructivism-informed cycles of apprenticeship (Figure 1), through which students express their preconceptions about STSE issues, research and citizen socio-political actions; then, teachers teach related knowledge, skills and attitudes; and finally, students practise, apply and build such expertise.

![Figure 1: The STEPWISE Apprenticeship Cycle(s) in Preparation for Independent RiNA Projects](image-url)
**Students Reflect**

Because of students’ different life experiences, ages, cultures, stages of development, etc., their ASK will vary (sometimes quite a lot) across any one class - and such differences can significantly affect learning. Often, students’ existing ASK are *subconscious*; i.e., students are not very aware of them. So, based on constructivist learning theory (tinyurl.com/yxku2unx), students can benefit from activities that encourage them to become more conscious of their existing ASK. Once they are more conscious of them, they may (or may not) re-consider them when presented with new ASK (e.g., by the teacher).

In this phase, the graphic novel can be used to explore students’ preconceptions about STSE relationships, research and citizen actions and/or to allow them to reflect on and evaluate their prior learning. Activities used at this phase are expected to be mostly open-ended to honour students’ experiences and perspectives. Teachers can vary extents of instruction (teacher-directedness), depending on students’ existing abilities. Here are examples of types of activities that teachers may use as they see fit:

- Examining views, positions and interests of human stakeholders

  **Consider All Stakeholders:** After a brief discussion with students about the idea of ‘stakeholders,’ ask students to list all human stakeholders involved in the industrial dust controversy. For each stakeholder, consider their position (i.e. their views and perspectives about the problem) and their interests (i.e. the underlying causes and needs).
• Examining power differences between different stakeholders involved in an STSE problem

  **Ranking Ladder:** Rank the stakeholders in terms of their position of power (high to low power) using a ranking ladder. Justify the placement of each stakeholder on the ranking ladder.

• Examining students’ perspectives about validity of citizen-developed research

  **Agreement Line/Spectrum Debate:** Véronique and Louis conducted secondary research (examined scholarly and governmental documents) and primary research (collect samples of the dust) to understand their situation, inform their decisions, and support their position. To what extent do you agree or disagree that the data they produced is valid? Place yourself on the agreement line.

  [After students place themselves on the agreement line, the teacher may fold the line, allowing students with opposite perspective to face each other and discuss their perspectives]

If teachers chose to use the graphic novel to explore students’ conceptions in the ‘Students Reflect’ phase, then in the ‘Teachers Teach’ phase (refer below), we recommend they teach about STSE relationships, power, etc. using different topics. Following this approach would probably
honour students’ ideas, while allowing teachers to build on these and address more advanced ones.

Teachers should work to celebrate students’ ASK during this reflection phase, encouraging them to value them and, later, to possibly use them for their own explorations and action projects.

Teacher Teaches

Again, because students’ pre-instructional ASK will vary among class members, and because some (or many) of them may differ from those of professional scientists and engineers, we strongly suggest that teachers teach desirable attitudes, skills and knowledge (ASK) related to STSE issues and problems, such as STSE relationships, power differences and positions in them, research approaches, and citizenship actions using different topics, such as the ‘conflict minerals in smartphone’ (tinyurl.com/yya75pyo), or other topics related to the unit being taught.

After the teacher has ensured that students have learned very important ASK about STSE relationships, power, harms to individuals, societies and environments and actions people have taken to address such harms, the teacher may choose to ask students to use (apply) ASK just taught by reading, analyzing and evaluating the graphic novel. (Note: If the graphic novel is used in this phase, it should not be used in the Students Reflect phase).

For this purpose and considering the nature of the graphic novel as a teaching/learning resource, teachers may consider different reading strategies to get their students familiar with the context and content of the graphic novel.

Reading Strategies - Setting the Stage

Based on the subject/unit taught, time available for teachers, and students’ age, expertise and readiness, teachers can use different reading strategies to go through the graphic novel, such as the following:

Assign the graphic novel to be read at home (i.e. homework): To save classroom time, students might read the graphic novel at home and come prepared for deeper discussion and activities in the classroom. This initial reading would also allow ‘setting the stage’ by identifying place, timeframe, and main characters and events. To support students’ reading and comprehension, teachers might assign the following activities to be completed during the initial reading:

- List 5-6 characters involved in the graphic novel events
- List 5-6 main events in the graphic novel.
<table>
<thead>
<tr>
<th>Who are the main characters involved in the graphic novel events? (5-6 characters)</th>
<th>What are the main events in the graphic novel? (5-6 events)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• e.g. Québec City Environmental Office</td>
<td>• e.g. A new episode of dust in Limoilou</td>
</tr>
<tr>
<td>•</td>
<td>•</td>
</tr>
</tbody>
</table>

Other than a simple table, students might use a sequence flow chart to organize their ideas and better visualize the sequence of main events in the graphic novel.

![Sequence Flow Chart](image)

In the classroom, and before delving into further activities, it is important to make sure that all students are at a similar level of readiness. A take up as a whole class, would allow setting up the stage and bringing students closer in terms of background knowledge. As a whole class, students and their teacher might identify the following:

- The place in which the graphic novel took place.
- The main characters involved.
• Timeline of the main events

Timeline: October 2012
New Dust Episode

Read the graphic novel in the classroom: Alternatively, teachers may choose to read the graphic novel in the classroom. For this purpose, the class might be divided into small reading groups (3-4 students/group). Repeatedly, students will be given some time to silently read a brief section of the graphic novel (e.g. p.4-7), summarize it in their small groups, and then report back to the whole class. Similar take-up activities, as indicated above, can be used to set the stage and identify the setting and main characters and events.

Students Practise

A third possible way in which the graphic novel can be used is in the ‘Students Practise’ phase of the STEPWISE pedagogy (refer above). In this phase, students are expected to employ the expertise and ASKs that they have gained and/or developed to conduct, with supports (e.g. as requested by students) from their teachers, their own research-informed and negotiated action projects about STSE issues important for them. The graphic novel could be used as a stimulus for ideas for students practice projects.
For example, students may list and examine the different types of actions undertaken (throughout the novel and as listed in the ‘Links’ page) to address the dust problem. Students then can apply similar actions to their own STSE problems, or develop new ones (e.g. graffiti).

Similarly, students might be inspired to examine issues around air or water quality in their own neighborhoods, or controversies around industrial activities in their cities (or other parts of the world). They might also benefit from research techniques and approaches used in the graphic novel to inform their own. In all cases, discussions here are expected to be open-ended to allow freedom of students’ thoughts and choices.

References
