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THE DEVELOPMENT OF SIXTEEN YEAR OLD STUDENTS' BIOLOGY CONCEPTS THROUGH OUT-OF- CLASSROOM ACTIVITIES

Miriam Muscat
Giovanni Curmi Higher Secondary School, Naxxar, Malta

Abstract. Classroom based teaching tends to be dominated by teacher talk and passive students are barely involved in their learning. Out of classroom activities offer students a physical context where theory learnt in class can became an authentic science experience. Meta-cognitive tools (concept maps and Vee diagrams) help students obtain a holistic science experience which focuses on feelings, emotions and attitudes together with cognitive development.

1 Introduction

The 21st century society needs to be equipped with scientifically literate citizens able to take informed decisions (Woolnough, 1998), be 'critical consumers of scientific information related to their everyday lives' and continue to learn science throughout their life (NRC, 2011, p.9). Thus, a science education that meets the needs of a minority of students who aim to be the future scientists and ignores the needs and interests of a large majority of students needs to be replaced. Millar & Osborne (1998) acknowledge the need for a paradigm shift in science education; a change in the delivery system that meets the needs and demands of a changing world and addresses and holds the interests of all the students.

Teachers are aware that the school is not any more the primary source of knowledge nor is textbook knowledge the most widely used during one's lifetime. Learning is not confined to school hours but is a continuous and lifelong process. Moreover, students come into the classroom already equipped with scientific information obtained through media, hobbies and family activities. Thus, rather than rooting our science teaching in the laboratory, which often results dull, boring and repetitive for the students (Osborne & Collins, 2001), community resources such as botanic gardens, museums and plant nurseries offer students more accurate and relevant science knowledge, making science more valid and stimulating for the students (Falk & Dierking, 2000). Site-visits offer an authentic picture of science and direct experience with scientists in contextualised settings making the contribution of science to society even more evident.

During site visits, the teacher is the mediator between the learners and the actual world. Students are driven by personal interests and by their intrinsic motivation to explore, discover new environments and ask questions that arise from their curiosities and observations on site. Through such activities, students are actively involved and responsible for their learning. On site, there is no emphasis on competition amongst students, memorization of facts and syllabus boundaries. Rather than sitting passively in class listening to the teacher dishing out information which students may be unable to link to their already existing conceptual frameworks, site visits offer a unique experience for every individual student through multiple stimuli that cater for a variety of students' interests and learning styles.

There are controversial ideas about the value of site-visits. Whereas Shortland (1987, p.213) writes that teachers' and students' clashing agendas make it difficult to reconcile entertainment, interest and motivation with science concepts, Falk, Coulson & Moussouri (1998) explain that when education and entertainment are symbiotically related, this provides significant learning gains for the students. Intrinsically motivated students are more able to judge and filter the information relevant to them and are more emotionally involved in the experience. This makes every experience worth remembering for the learner and thus admitted in their long-term memory (Salmi, 1993 as quoted in Braund & Reiss, 2006; Knapp, 2000)

2 Methodology

Though site-visits are a compulsory part of the practicals presented for the biology MatSec exam in Malta, they do not feature in the Intermediate level syllabus studied at post-secondary level. This study aimed to investigate whether site visits are an effective teaching strategy with sixteen-year old biology students.

Reading through the literature I observed that most research relied on traditional pre and post visit tests to measure the outcomes of the visit. These tests were restrictive because cognitive gains had to be defined in advance so that the measuring instrument could be constructed and measured only cognitive gains leaving little opportunity to measure affective, social and behavioural outcomes from site visits (Rennie, Feher & Dierking, 2003). Also, I did not want the students to write lengthy reports about the site visits using downloaded or copied information which they do not personalize nor understand.

It was decided that constructivist tools offered multiple and creative ways of assessing students' learning outcomes without limiting myself to the cognitive aspect only but explore also emotional and affective outcomes thus giving me a more holistic and realistic picture of the learning outcomes from each site visit. Such tools are valuable to help students think about their learning and use their prior knowledge as the basis to add new knowledge.

Data was collected through concept maps, Vee diagrams, class discussions and interviews. The original Vee presented by Gowin was judged difficult to tackle with students new to this procedure, thus a simpler version of the Vee, devised by Ahlberg & Ahoranta (2002) and used by Vanhear (2006) was used for this study. Before data collection started:

1. The students were trained to draw concept maps using information being tackled in class at the time: students' concept maps were discussed and used as examples of good practice.
2. Each site was visited and the guide was informed about the aims of the visit and the students' misconceptions.
3. The date of the site-visit was planned so as to complement the topic being covered in class and avoid any clashes with the school agenda.

The data collected was divided into three main phases:

2.1 Pre-visit activity:

Students were introduced to the focus question and were given the questions forming part of the planning phase (left-hand side) of the Vee diagram. This included drawing a pre-visit concept map. Worksheets were collected and a class discussion was carried out in order to obtain immediate feedback from the students about the activity and the topic being discussed. Four students were interviewed so as to obtain a more in-depth point of view. All interviews were transcribed.

2.2 Implementation phase:

Three visits were planned along the scholastic year. Each site chosen was related to the topic being tackled in class at the time so that the visit complemented classroom work. Each visit was planned for about two hours in the morning; short enough to avoid students getting bored but long enough to give time to the guide to provide us with all the necessary detail.

2.3 Post-visit activity:

After the visit, students were given the questions forming part of the evaluation phase (right-hand side) of the Vee diagram. This included drawing a post-visit concept map. Another class discussion was carried out to obtain immediate feedback of the students' feelings and attitudes after the visit and the same four students were interviewed. Pre and post visit concept maps were compared and analyzed to check if after the site visit:

- New biological information was added
- Links with already existing concepts were introduced
- Misconceptions were cleared

3 Results

In the following section, the biological development of two students participating in two different site visits will be discussed. This is part of a larger research presented as a Masters in Science Education thesis for the University of Malta.

3.1 Visit to the Greenhouses

This visit was implemented as part of the topic 'Photosynthesis' being tackled in class. The focus question was 'What do plants need to grow?'

As shown in her pre-visit concept map (Figure 1), Roberta focused mainly on factors related to photosynthesis such as ‘carbon dioxide’, ‘chlorophyll’, ‘light’, ‘water’, together with plant adaptations like ‘thin leaves’ as essential elements for growth. However, it was clear that the student failed to extend her ideas beyond what was being discussed in class and was unable to relate this focus question to the real world of plants.

After the visit, her concept map (Figure 2) showed greater awareness of plant needs including ‘temperature’, ‘green manure’, specific minerals like ‘phosphate’ and ‘nitrogen’. She showed knowledge of how the farmer helps to improve plant conditions like ‘crop rotation’ and preventing ‘direct water on plant leaves’. After the visit, Roberta realized that some statements written in her first concept map were useless to the focus question and were not repeated in her post-visit concept map.

Question 6 of her Vee (Figure 5) was essential to add information which she did not write in her concept maps, but which she learned through observation and questioning on site. This new information is underlined in her Vee.

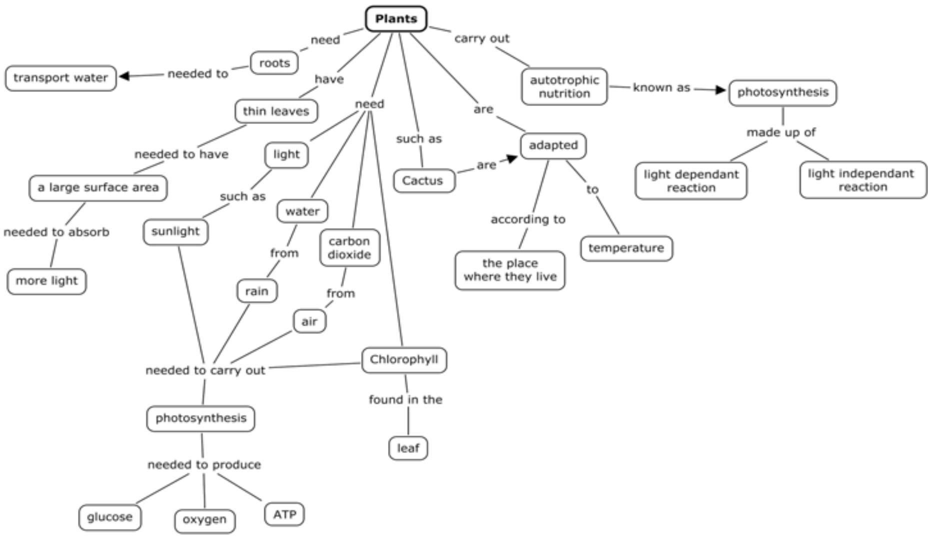


Figure 1: Roberta’s pre-visit concept map

3.2 Visit to the National blood bank

This visit was implemented as part of the topic ‘Transport in animals’ being tackled in class. The focus question was ‘What happens to donated blood?’

Being an action research carried out along the scholastic year, and since this research was being used for personal evaluation, some improvements were carried out from one activity to another. For this visit, a questionnaire was given to the students before the questions of the planning phase of the Vee were distributed. This was important for me to assess what knowledge students have about specific points related to blood donation. Questions included the amount of blood donated, who is not allowed to donate blood, what tests are carried out on donated blood and on the donor, amongst others. This phase together with the planning phase of the Vee were fundamental for the students to realize that there is a lot of information they do not know even though they are very curious about it. This helped to increase enthusiasm and motivation for the visit whilst helping them realize that the visit is not just an outing away from school routine but is a learning experience.

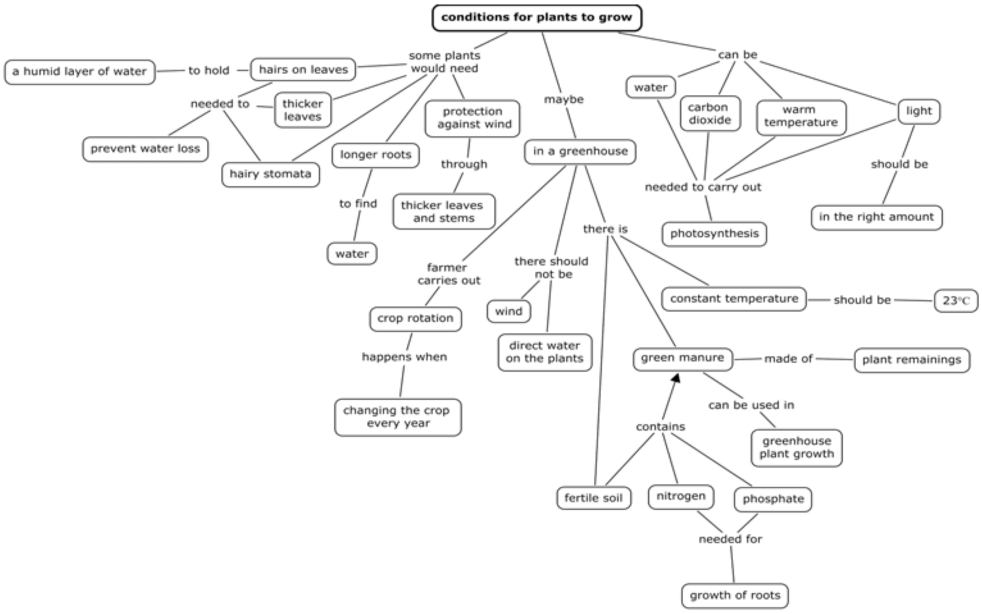


Figure 2: Roberta's post-visit concept map

As shown in her pre-visit concept map (Figure 3), Joanna had scant information about blood donation. Most of her concepts are very general and misconceptions emerged, such as blood is tested for glucose level and cholesterol.

In her post-visit concept map (Figure 4), it is immediately noticed that the amount of concepts and links increased. The information now is more specific and she gives clear details about blood components and how they are stored, the tests carried out on donated blood, the kind of patients that would need the blood, the amount of blood donated and specific procedures that make blood donation a hygienic and accurate process.

In question 6 of her Vee diagram (Figure 6), she added further information which she did not include in her Vee. These statements are underlined. She also pointed out her misconception that was cleared after the visit, stating that 'blood is not tested for cholesterol, glucose level or high blood pressure'.

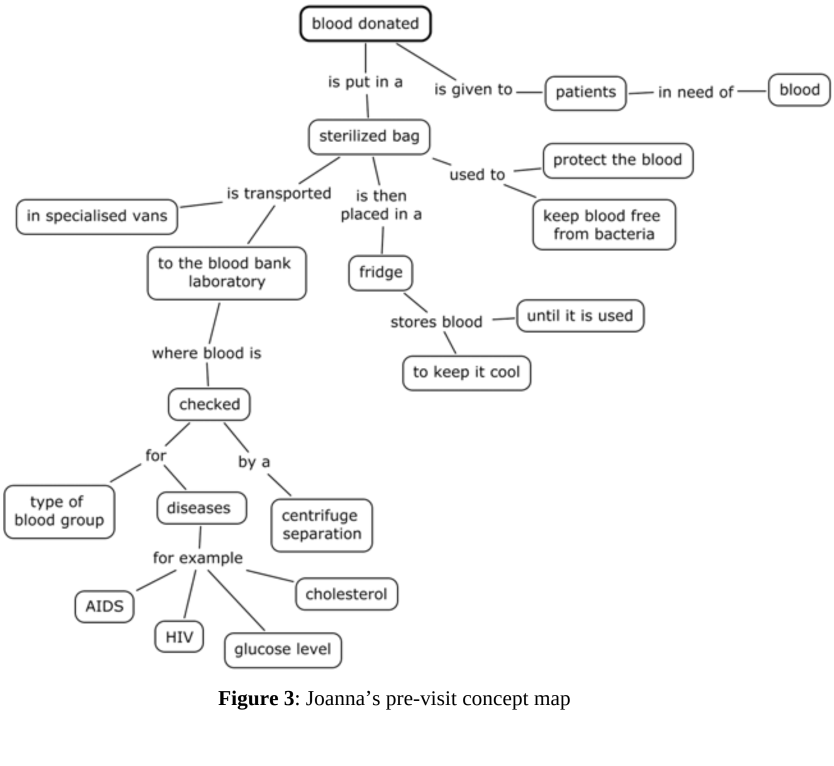


Figure 3: Joanna's pre-visit concept map

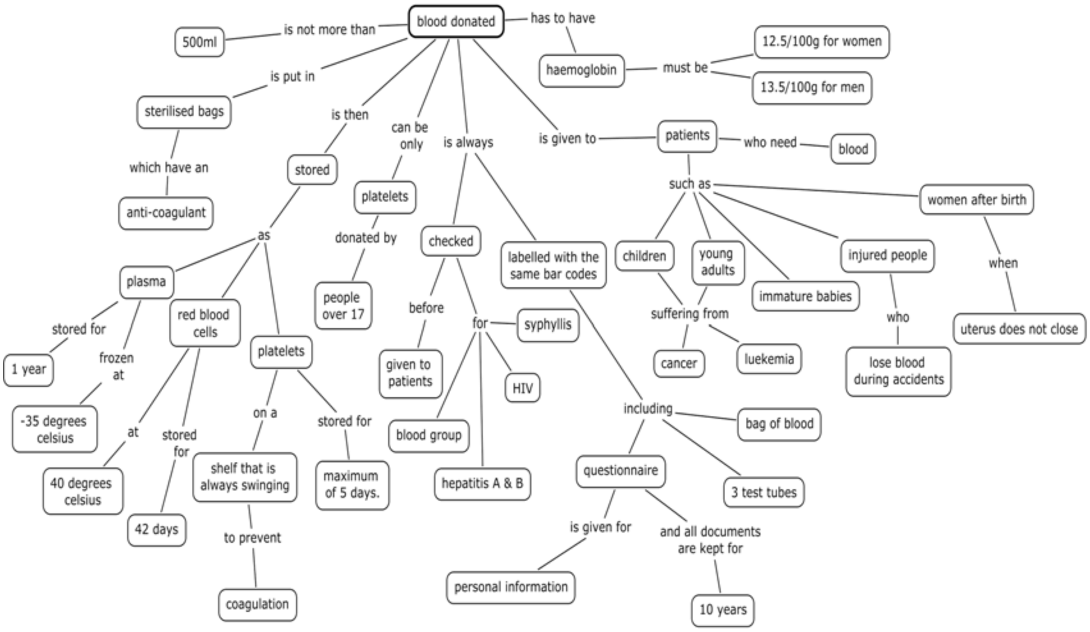


Figure 4: Joanna's post-visit concept map

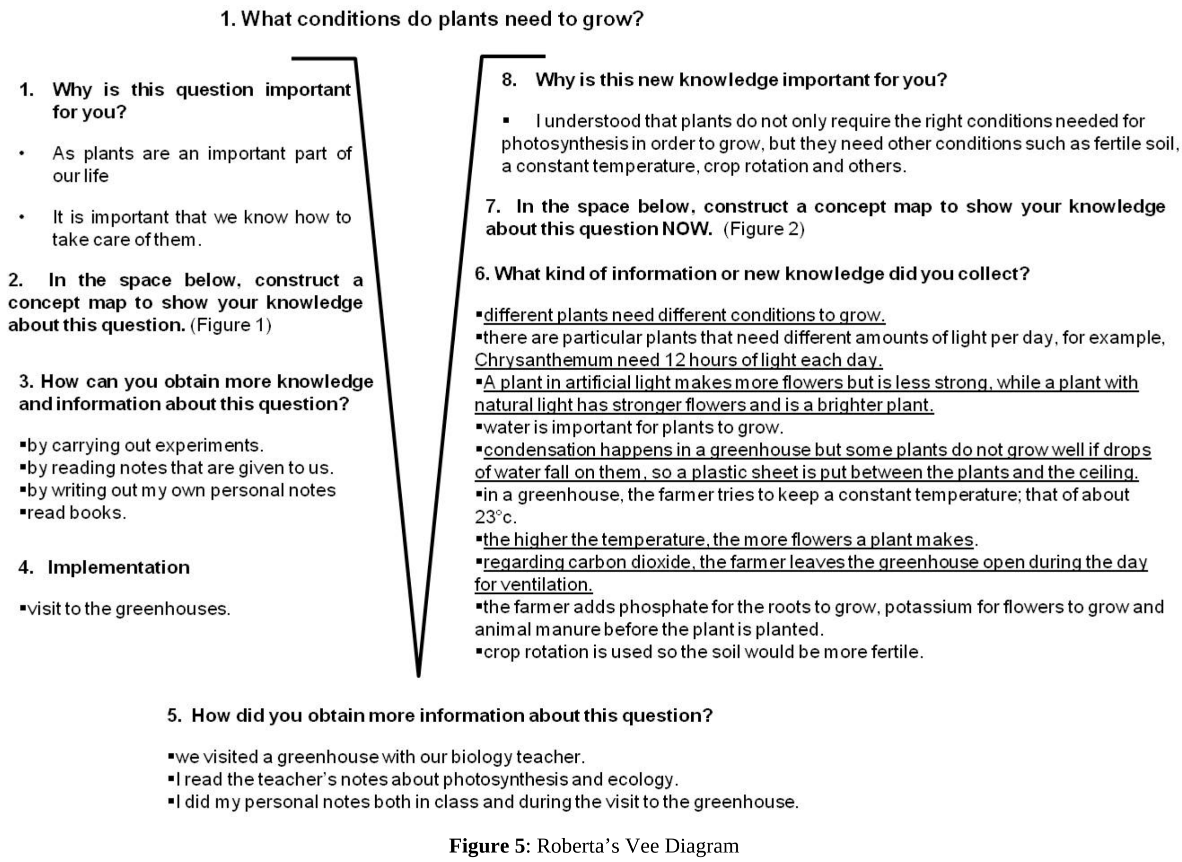


Figure 5: Roberta's Vee Diagram

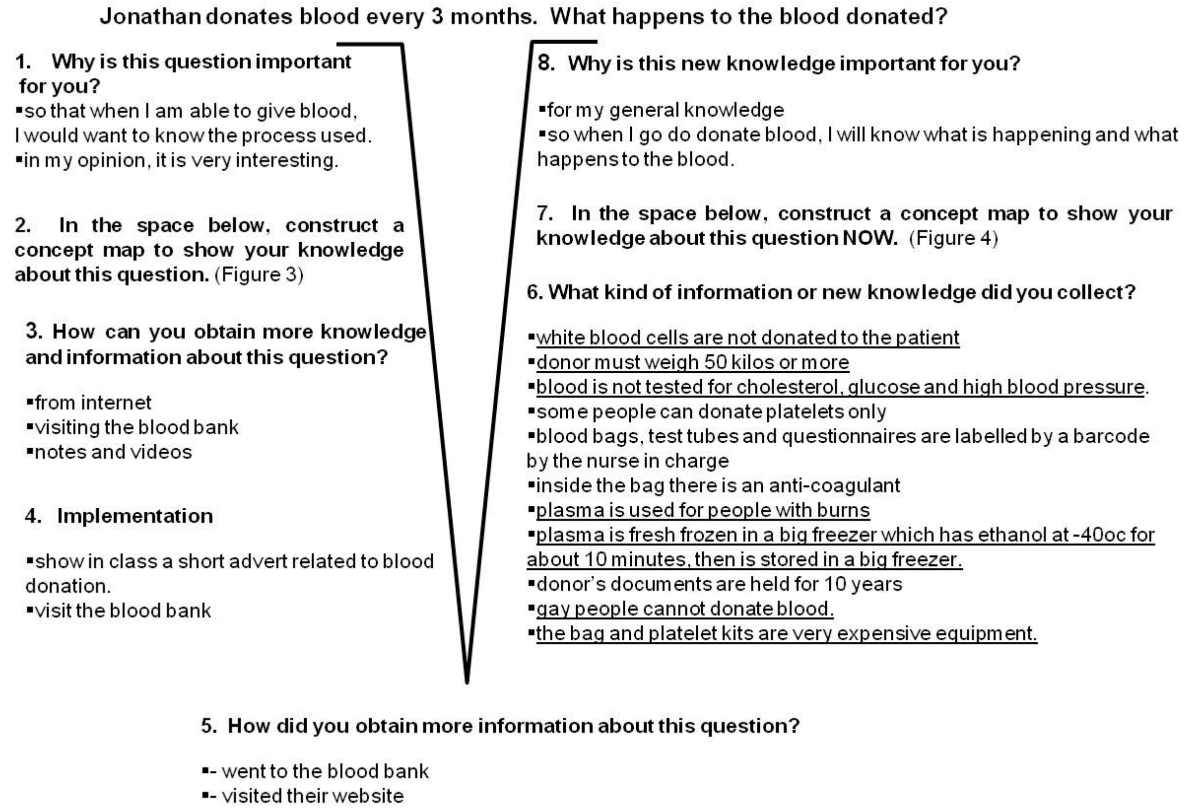
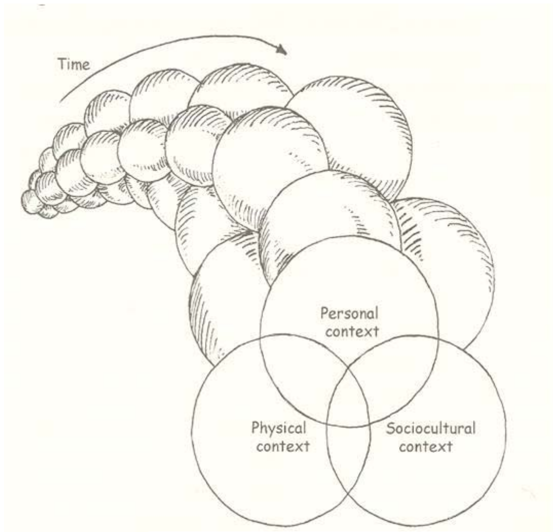


Figure 6: Joanna's Vee Diagram

4 Discussion

This research revealed that the classroom tends to be a restricted environment that limits the development of biological concepts. Whereas in the classroom, theoretical knowledge transmitted is restricted by syllabus boundaries, on site the information is more context specific and students could easily link theory to the physical setting. On the field, students meet experts who can give the information which is not necessarily found on text books but is more practical and often obtained through hands-on everyday experiences.

Falk & Dierking's contextual model of learning (2000 p.12) explains that learning is not an isolated experience, but is a dialogue between the students and the surrounding environment, through time. It was evident during each site visit that students became autonomous learners, free to choose what interests them most, free to observe and ask questions while socializing with their classmates and sharing experiences in a more relaxed environment than the classroom. They linked inert theory learnt in class or past experiences to what was observed on the premises and linked issues discussed to their personal life making biology more authentic and useful.



Falk & Dierking's (2000:12) contextual model of learning

The methodology used moved away from the traditional transmission model of learning and induced students to think critically while experiencing a desire to discover, ask questions and debate on various socio-scientific issues that arose whilst on site.

This methodology avoided the filling in of worksheets and reports often used during site visits which serve to kill the students' enthusiasm to explore new environments (Griffin & Symington, 1997). Through this approach, students were not rewarded for memorizing facts and definitions but allowed them to understand the relevance and application of biology to everyday life. This was evident during the post-visit class discussions when the students were enthusiastic to voice their feelings and opinions about what was learned during the visit.

This not only was useful to make students aware that their opinions are valued in class and help them discuss together and tolerate each others' opinions but it was useful to observe that site-visits offered multiple learning outcomes for the students including:

1. sharing information with family and friends.
2. less compartmentalization between academic subjects
3. consolidation of classroom work
4. introduction to a career and to the world of work
5. positive changes in attitudes towards various aspects of biology
6. more social belonging and social responsibility *(like donating blood some time after the visit)*
7. appreciation of the world around them

Concept maps allowed the students to represent their knowledge in an organized, visual format so as to be able to identify their learning 'at a glance' and points to discuss in class were more easily accessible (Orue, Alvarez & Montoya, 2008). Unlike writing traditional reports, through concept maps, only relevant information was added and overwhelming detail that may not pertain to the focus question was avoided. Motivation to learn is in the hands of the learner. This methodology served to encourage learners to think about what was heard and observed on site. Rather than promoting definitions and memorization, students were encouraged to learn meaningfully and follow their interests. Infact, every student's concept map was unique in terms of information and depth which revealed how learning depends on the student's interest, background, learning style and academic ability.

5 Conclusion

As Burns, O'Connor & Stocklmayer (2003) explain, any changes in awareness, enjoyment, interest, opinion and understanding all represent personal learning outcomes for the students. This is the major advantage of site visits and the reason why they go hand in hand with constructivist tools. Together, they offer both students and teachers a holistic learning experience that goes beyond the academic subject to a more worthwhile learning experience that links theory learned in class to everyday life situations. Concept maps and Vee diagrams offered students a way to express their biology knowledge in a direct, concise way, linking knowledge from different topics and academic subjects together yet not limiting themselves to knowledge alone. Through this exercise, students were able to observe, question, reflect, criticize, evaluate and discuss various issues. These represent valuable skills for our future generations!

6 Acknowledgements

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