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Workshop report
Deepening the specificities of scientific inquiry in natural sciences
Wynne Harlen, David Jasmin
Reporter: Susana Borda

WORKSHOP REPORT

In this interactive workshop, Professor Wynne Harlen led our group into a reflection and a discussion on three main questions:

1. What learning experiences are indicators of effective student learning in science?
2. What do teachers have to do to provide students with these learning experiences?
3. What sources of information can be used to evaluate the quality of what teachers are providing?

Firstly, Wynne Harlen went through some of the main characteristics IBSE, which are reminded in the Fibonacci Starting Package "Implementing IBSE". She reminded the group that IBSE is an approach to learning and teaching that aims to ensure that "students truly understand what they are learning and not simply learn to repeat content and information", and that it encompasses a social constructivist view of learning and the use of formative assessment in teaching. She went through the six main principles of IBSE:

- The importance of direct experience
- The ownership by students of the questions and problems they investigate
- The active development of skills, particularly observation
- The opportunities to reason, talk about and communicate through writing their ideas and experiences
- The use of secondary sources complements direct experience
- Science is a cooperative endeavour.

She then presented a list of 17 items (see Annex 1) that, according to the IAP, indicate effective student learning in science. Our group agreed on six items from this list that it considered most essential to inquiry-based science learning:

- Working collaboratively with others, communicating their own ideas and considering others' ideas
- Making predictions based on what they think of find out
- Gathering evidence by observing real events or using other sources

- Talking to each other and the teacher about what they are observing or investigating
- Suggesting ways of testing their own or others' ideas to see if there is evidence to support these ideas
- Pursuing questions which they have identified as their own even if introduced by the teacher

Additionally, the following items were added by workshop participants to the original list :

- Identifying their own pre-ideas
- Exercising scientific attitudes, namely rigour and precision
- Being conscious of the value of their work, now and in the future
- Represent and document their learning process through sketches or drawings, not only through writing
- Making connections between a particular learning experience and previous experiences
- Come up with suggestions for further investigation based on their own research

Some participants also believed that the list could be made shorter by condensing some items that are very similar (i.e. items 2 and 3).

Organized in small working groups, participants then wrote down the actions that they considered the teacher would have to do in order to enable students to actually have the learning experience reported on each item. Annex 2 presents a synthesis of the work done by the participants during the workshop – in other words, participants' characterization of IBSE classroom learning and teaching practices.

Concerning the evaluation of the quality of teaching, three important points were made by Wynne Harlen:

1) In program evaluation, it is important to ask oneself whether or not teachers are using the intended pedagogy (which is the independent variable), and why or why not, before asking whether children are learning (which is the dependent variable).
2) In order to answer this question, there are several possible sources of information:
    - Discuss with teachers concerning their planning, their judgements of success, specific events, etc.
    - Talk with the students
    - Review the teachers' plans
    - Review students' notebooks
    - Observe a class in action
    - Videotape a class in action
3) Indicators, which tell us what the information is about (the questions teachers ask, the help given to students in presenting their findings, etc.) are not enough to conduct an evaluation. It is also important to have criteria (which describe how well these things are done). Establishing

criteria enables judgements about the help that teachers need, or the changes that they need to make, to move towards better provision.

One main question remained open in the workshop, and it was stressed that it would be one of the preoccupations of the Fibonacci Topic Group on Scientific Inquiry: do IBSE learning indicators and teacher actions apply equally in primary and secondary school settings, and in different age groups?

ANNEX 1 : WORKSHOP WORKING DOCUMENT. INITIAL LIST OF INDICATORS OF EFFECTIVE STUDENT LEARNING IN SCIENCE.

Note: This document was distributed to all workshop participants.

Over a period of time, students will be…

1) Gathering evidence by observing real events or using other sources
2) Pursuing questions which they have identified as their own even if introduced by the teacher
3) Raising further questions which can lead to investigations
4) Making predictions based on what they think or find out
5) Talking to each other and the teacher about what they are observing or investigating
6) Expressing themselves using appropriate scientific terms and representations with understanding both in writing and talk
7) Suggesting ways of testing their own or others' ideas to see if there is evidence to support these ideas
8) Taking part in planning investigations with appropriate controls
9) Using measuring instruments and other equipment appropriately and with confidence
10) Attempting to solve problems for themselves
11) Using a variety of sources of information for facts that they need for their investigation
12) Working collaboratively with others, communicating their own ideas and considering others' ideas
13) Assessing the validity and usefulness of different ideas in relation to evidence
14) Applying their learning in real-life contexts
15) Reflecting self-critically about the processes and outcomes of their investigations
16) Recognising their own active role in their learning
17) Showing interest, engagement and enjoyment in developing their understanding.

ANNEX 2 : CHARACTERIZATION OF IBSE CLASSROOM LEARNING AND TEACHING PRACTICES BY WORKSHOP PARTICIPANTS

Note: Items on the left-side column are the same as those in Annex 1, but are ranked in order of importance according to workshop participants. ***(N)*** *indicates extent of agreement among participants concerning item ranking. Total number of workshop participants is 41.*

IBSE LEARNING PRACTICES **Students' experiences when undertaking IBSE. Ranked in order of importance by workshop participants.**	**IBSE TEACHING PRACTICES** **According to workshop participants, teachers' actions needed to give students the experiences identified**
1. Working collaboratively with others, communicating their own ideas and considering others' ideas **(30)**	- Ask questions in the working groups. For example: "Do you agree within the group? Try to argue for your idea…". Ask questions according to pupils' needs or according to the situation in the working group. - Be a moderator, a coach, take part in students' group discussions. Incite students to listen to their colleagues' opinions. - Implement active teaching methods aimed at discussions: either provoked by questions or simple fascinating experiments. There are a lot of such experiments. Teachers should know them and exploit them. - Collect possible ideas and ask for possible explanations to be defined in group work. - Help groups find a common opinion or prediction. - Use concept-cartoons. Ask students "what do you think? Who is right?" - Asking the view of children that are not active.
2. Making predictions based on what they think or find out **(27)**	- Encourage pupils to write down their personal predictions and discuss them. - Allow all children to express themselves through a game, and collect their answers without explaining. - Use a model or animation to demonstrate what is going to be done. Elicit possible things that could happen (what could change, how it could change) and write them on the board. Ask students to be creative, without necessarily giving the right answer: the more ideas, the better. Then, ask them to predict. Let them come back to their predictions after the experiment. Do they want to change their predictions? Why? - Introduce a new anomaly, question or problem connected with the previous research. - Help students express their ideas, encourage them to make predictions. - Ask students about what will happen if… and write it on the board. - Explicitly prompt students to formulate their predictions with regard to the experiments. - All "research" should start with research questions. Learners should give a preliminary answer, what they think will happen. This must be made structural in all IBSE activities. - Use concept-cartoons and discuss. - Collect students' hypotheses, choose a few for discussion or as suggestions for manipulating experimental conditions. Then, in an heuristic way, help students to deepen their understanding of the problem.
3. Gathering evidence by observing real events or using other sources **(22)**	- Discuss with students aspects of the object under investigation which could be observed. Maybe introduce different sized objects, objects which vary in some dimension. Discuss whether or not the observed dimensions are relevant. Make it matter some (but not all) of the times. Start to observe jointly, noting the observations on the blackboard. Slowly move on to self-documentation. - Ask for the evidence that has been planned for in the planning phase. - The teacher has to select a good visualisation, presentation and experiment. - Give the students magazines, newspapers, Internet, etc., and ask them to pick out a real problem that they find interesting. Ask them to describe how the would investigate this problem. - Ask students to describe their observation, repeat their experiments, and check for the reproducibility of the event observed. - Ask students to explain or describe how they are going to gather evidences, and how the will report their observations.

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	- Provide suitable material to observe the "real event". - Propose a subject to be investigated or observed and give students guidance on what is to be observed. - Ask questions and encourage pupils to find the answer via manipulation with empirical material. - Choose clearly observable phenomena and ask students to clearly record their observations. - Be ready to assist students providing scientific methods.
4. Talking to each other and the teacher about what they are observing or investigating **(21)**	- Implementing rules/inquiry language. Remind students to observe, describe and interpret. - Prompt students to discuss the work to be done prior to doing so. - Make small groups of 4-5 students and define roles within the group (secretary, scientific director, communicator…). Within each group, encourage students to discuss their predictions with arguments. One student of each group will explain to the class the results of their investigations and observations. - Give students enough time to prepare their presentations.
5. Suggesting ways of testing their own or others' ideas to see if there is evidence to support these ideas **(21)**	- Moderating discussions. - Every once in a while, students should be asked to carry out their idea and if it fails, they should briefly reflect and try to explain: what did they not consider and why did it matter? - Give value to pupils' predictions by recording them and asking them to prove them. - Ask students to write down their ideas of experiences to be tested. - Incite students to compare information they may have obtained from other sources (other people, books, newspapers, Internet…) with what they learned from the teacher. - Make students find ways to repeat experiments and change parameters in a controlled way. - Prepare an area with a selection of materials. Help students to use these materials.
6. Pursuing questions which they have identified as their own even if introduced by the teacher **(17)**	- Coming up with a question and finding out how relevant it is for students. - Make sure that students understand the question (and, therefore, get puzzled). - Offer lots of different materials in order to stimulate questioning. - After new goal students in groups try to solve the problem and ask new questions. They can introduce their own (group) ideas one by one. - Discuss "anomaly" – phenomenon before starting hands-on activity. - Encourage and provoke students to ask questions. - Help pupils to find the answer by giving materials and the information they need to proceed their inquiry. - Ask a whole class which questions learners ca have on a certain subject. Collect, as time goes by, sets of questions. - Demonstrate a natural process and ask for possible explanations. - Ask students to explain clearly what they want to investigate and to elaborate on what the want to investigate.
7. Taking part in planning investigations with appropriate controls **(16)**	- Ask "how could we find out…" and then proceeding with questions that break down the design into smaller, manageable challenges. - In pairs or groups, incite students to draw a scheme or plan of their ideas to be investigated. - Encourage each student to suggest ways on how to investigate the question. - Give students materials and let them conduct investigations. Discuss different solutions with the whole class and compare them.
8. Raising further questions which can lead to investigations **(14)**	- Let students discuss in groups which are the limits of their investigation, look for how researchers investigate the same problem, and then tell each other in a whole class discussion how the issue can be further investigated. Underline that science is a process where different groups discuss, etc. - Introduce new anomaly, question, problem connected with the previous research. - Give examples of possible questions or create new stimulating situations. - Ask, show phenomena, manipulate, collect observations, raise students' curiosity or discuss students' doubts. Create a stimulating environment.

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9. Applying their learning in real-life contexts **(11)**	- Ask children to recall any observation from their won experience, which can be explained on the basis of the investigation just performed. - Show students news articles, take them to visit industries, mechanic workshops, places where objects are repaired. - Encourage students to look for real-life events that are connected to what they have learned. - Encourage students to compare lab results with real-life observations. - Ask students to recall toys that work with the same principles that they have investigated.
10. Reflecting self-critically about the processes and outcomes of their investigations **(11)**	- Ask students, for example: "what could go wrong when we do the measurement?" - Confront students with the outcomes: are they realistic? Who has done what during the inquiry? What went wrong? What is right? Teachers should plan this in their lessons and not be satisfied with every result. - Sit down with students during experimentation and discuss progress and further steps. - Ask students: "was this a good experiment? How could we improve this experiment?" - Ask students to imagine another way of improving the results of their investigations, or its limits.
11. Assessing the validity and usefulness of different ideas in relation to evidence **(10)**	- Ask students: can we answer the research question based on the evidence that we have gathered? - Incite students to discuss, to doubt, to ask additional questions and test the strength of the evidence they have collected. - Collect evidence in the classroom from all pupils after experimentations.
12. Showing interest, engagement and enjoyment in developing their understanding **(10)**	- Modify his own behavior according to the level of students' engagement (i.e. show his/her enthusiasm, interest, enjoyment if the class is shy, or put the class in order if students are too loud).
13. Expressing themselves using appropriate scientific terms and representations with understanding both in writing and talk **(9)**	- Makes controls about scientific terms. - Helps students reformulate their sentences with scientific terms. Next time, they will use the appropriate terms. - Use active teaching methods aimed at oral and written communication. Assess these methods. This is possible even for traditional problems/exercises. - Ask each student to express what he/she thinks about the problem/question. - Teach mathematical graphics and oral scientific communication.
14. Using a variety of sources of information for facts that they need for their investigation **(9)**	- Give students enough time to surf on the Internet or go to the library, by groups or in pairs.
15. Attempting to solve problems for themselves **(7)**	- Ask students or groups of students to solve problems by creating their own plans, and giving them a lot of time to do this. - Encourage students to come un with individual ideas. There are no "wrong" answers, only incomplete concepts to learn from. - Pre-select information sources for students. Thus, diminish the risk of students being lost within the "information space". - Incite students to discuss collectively their problems they themselves raised.
16. Using measuring instruments and other equipment appropriately and with confidence **(7)**	- Make students familiar with measuring instruments and methods. Train students through repetition. - At a certain age, a step from qualitative to quantitative insight is needed. Instrument are essential then. Teachers should present several measuring methods along with adequate instruments all the time. Measuring is an art. - Give students different easy instruments (meter, chronometer and derivates), each one for each phenomenon.
17. Recognising their own active role in learning **(0)**	