# Assessment of Selected Biological Activity based on Inquiry at Lower Secondary

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This paper is focused on the verification of tools for formative assessment of IBSE activity within the project SAILS. The topic "Plant nutrition – photosynthesis of algae", was piloted at two schools in Košice, Slovakia. Pupils at the age of 12-13 and 15 years old observed colour changes of carbon dioxide indicator caused by carbon dioxide concentration change in the solution of immobilised algae as a result of effect of light intensity on the rate of photosynthesis. We assessed inquiry and reasoning skills. We have focused on key moments in which pupils could make the decision independently and proceeded in the experiment on the basis of their decision. We observed pupil's argumentation, work accuracy, methods of data recording, documentation the experiment and formulation of conclusion. Pupils were very skilled at documenting (own initiative) of experiment using available digital technology (cell phone). At the conclusions they rather expressed the experience of inquiry (colour change of indicator) than the fact that the change was caused by different rate of photosynthesis. It has been found out that younger pupils (12-13 aged) need the assistance when recording and interpreting data. They should have aids in the form of clear tables and graphs to help them realize that exactly the observed and recorded data of variables are important for formulation of conclusion.

## *INTRODUCTION*

Whereas progress into science is based on experimenting it is important to develop practical skills. Opportunities for this are IBSE activities in the educational process of many science disciplines including biology. Students must be able to organise and regulate their own learning, to learn independently and in groups, and to overcome difficulties in the learning process (OECD, 2000). In terms of inquiry cycle biological practical exercises that are part of the thematic plans of all schools in Slovakia, may represent inquiry. Despite the possibilities of inquiry at practical exercises within biology lessons relatively few teachers focus on teaching through inquiry IBSE. Their approach or actually reluctance to innovate education this way justify by lack of tools for assessment, what is ultimately true. For developing of competencies based on acquisition of skills is more effective formative assessment. Therefore it is necessary to create a methodology and tools of assessment and identify key moments in which the student applies active inquiry. This study is aimed to determine the key moments suitable for assessment, and possibilities for formative assessment of inquiry based biology education – IBSE activity "Plant nutrition – photosynthesis of algae".

## *IMPORTANCE OF IBSE AT SCHOOL AND THE WAYS OF ITS ASSESSMENT*

In modern societies, all of life is problem solving. Changes in society, the environment and in technology mean that the content of applicable knowledge evolves rapidly. It is generally agreed that inquiry science include some interactions with the everyday life as "problem solving" or "investigation". Slovakia has long been under OECD average of PISA study in proficiency in problem solving and science skills. We should to create an opportunities to inspire the pupils interested in science, which understanding is the basis for development of science thus form development of their abilities for problem solving in general. Inquiry education in schools gives us the opportunity to achieve this aim.

Inquiry skills are some skills that are really important to scientists. Students can build these skills through science activities in school. In science classrooms, these include problem solving, planning and raising questions, collecting data, reasoning, researching and testing out their ideas. There are many answers to the question "What is scientific inquiry?" as a basic of inquiry based science education. This conception is inspired by scientific diagnosing problems and research procedures. Pre-done knowledge aren´t offered to pupils, they themselves create new knowledge based on the information which they acquired during their research activities and previous experience with that phenomenon in learning process or everyday life.

Inquiry-based learning requires many skills and strategies and a wide range of resources from beyond the school library and classroom (Alberta Learning, 2004). In the framework project 7RP ESTABLISH were designed and implemented an inquiry based activities which were piloted in many countries. In the present project SAILS is preparing teachers for assessment of IBSE activities at school. Learning through inquiry is a process of developing understanding which takes account of the way in which students learn best, that is, through their own physical and mental activity. It is based on recognition that ideas, knowledge and understanding are constructed by students through their own thinking about their experiences.

Also there are possible ways how to assess the inquiry at classroom. There is a difference to assessment of traditional education, in which was long term established summative assessment. Increasingly there is focus on formative approach to assessment. The inquiry model is based on more than 30 years of research from around the world, with thousands of children, adolescents and adults in a variety of inquiry settings (focus on inquiry PDF). There are different types and levels of inquiry-based teaching and learning. Each levels of inquiry published by Wenning (2005) can be in our view deduced from inquiry cycle (Fig. 1).

1) Interactive demonstration represents the active involvement of students in the last two of the six steps of the cycle, the previous teacher carries while leading a constructive dialogue with pupils. The teacher will demonstrate the phenomenon. Students in an interview with him contained context, formulate and present the conclusion and discuss about it.
2) In a guided discovery student's autonomy is extended to the fourth step proceed independently, but according to the instructions. Collect and process data.
3) In a guided inquiry students perform independently the third step: they themselves plan an investigation that will test the assumption.
4) Bounded inquiry is limited only by topic (problem). Students formulate a question of testing, respectively assumption or hypothesis.
5) Open (free) inquiry is the realization the whole inquiry cycle alone, the pupils themselves appear and identify the problem.

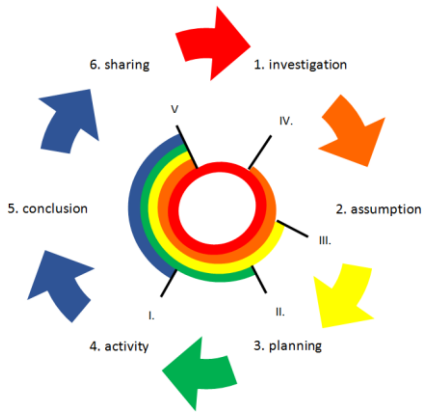


**Figure 1:** Active steps realized by the pupils (1st-6th) inquiry cycle IBSE at the level of inquiry 1-5.

Individual levels and steps of inquiry provide an opportunity for formative assessment of IBSE activity. Assessment used to support day-to-day instruction, called formative assessment, makes use of all the normal activities of a classroom. By Hein and Lee (2000), teacher can ask pupils several times during a unit to systematic recording of results, draw graphs, or provide a complete description of a scientific term. Such student products can inform teachers of what ideas have been understood by individual children and what needs to be done next. The method of solution of some activity or experiment is not immediately obvious. Assessing inquiry science requires that teacher documents student's science skills, such as the ability to observe, measure, and design experiments. For improving of these skills teachers effective feedback to student should to be provided in a timely manner (close to the act of learning production). Study of Nicol and Dick (2007) deals with good quality external feedback. They proposed that quality external feedback to students is information that helps students troubleshoot their own performance and self-correct: that is, it helps students take action to reduce the discrepancy between their intentions and the resulting effects. In an inquiry activity children should discuss, work in groups and

teacher can judge how well students can solve problems, chose methods, which in IBSE aren´t immediately obvious, collect data and make assumptions.

It is clear that formative assessment is essential to the implementation of IBSE. On other hand assessment can be uniquely summative when the assessment stops at the judgement (Taras, 2009). Feedback from teachers is a source against which students can evaluate progress, and check out their own internal constructions of goals, criteria and standards (Nicol and Macfarlane-Dick, 2007).

## *ASSESSMENT OF SELECTED KEY MOMENTS OF IBSE ACTIVITY*

IBSE activity "Plant nutrition – photosynthesis of algae", develops several inquiry steps. In this activity pupils use algae to watch the rate of photosynthesis. First part of the practical involves 'immobilising' the algae making jelly algal balls. Then pupils use them to determine the rate of carbon dioxide absorption, which indicates how fast photosynthesis proceeds. They can detect carbon dioxide absorption using hydrogen-carbonate indicator. The next step is very important to investigate the effect of light intensity on the rate of photosynthesis – pupils have to decide on the details of the quantities and how to vary the light intensity.

Considering the age and lack of experience work in the laboratory pupils did not plan the whole experiment alone. Students performed independently the third step of inquiry: they themselves planned an investigation and then tested the assumption. They applied guided inquiry. They made their own decisions just in three key-moments, and other actions were carried out according to instructions. Pupils worked in groups of three. They prepared a certain amount of algal balls in two steps. First algal cells were shuffled into the alginate solution. Then pupils made the balls by pouring the green mixture into a solution of calcium chloride. This first practical role that pupils enthusiastically mastered was followed by the first independent decision.

### Assessment of Inquiry Plans

1) How to divide prepared balls equally into three experimental containers. First, pupils generated the ideas. They agreed that there are three possible ways: placed in each vessel the same number of balls, placed in each vessel the same amount of jelly balls weighed 3 times the same weight. Each group chose a way that seemed to be the best. They had noted the argument why they decided that way. For example one of the groups, thought that weighing is the fastest way. Others suggested that counting will be the most precise. Another group said that put three teaspoons of algal balls in each dish is the most practical. Others indicated that it will be more precisely to measure volume by measuring cup. They should continue prearranged manner in the experiment by chosen procedure.
2) Another opportunity for planning represented location (layout) of three samples supplemented by standard volume indicator at different distances from the light source. Specific distances in cm were not given in the instructions. Pupils groups should consult, and agree on an appropriate location.
3) Entry of constants and variables were also kept on their own choice. Pupil groups could agree what and how they would enrol after discussions about data which should be recorded (an indication of the amount of algae, volume of added indicator, the distance of samples from the lamp, the time change of the indicator) and the entry form (which can be put into a table and whether some data can be expressed as a graph).

We evaluated skills in planning how to distribute the material into equal parts during implementation (discussion groups) and immediately after the implementation of that step in a discussion with the whole class. The team that chose weighing concluded that it is not true that weighing is the fastest way of dividing. They needed to re-weigh, add and remove material. They agreed, however, that weighting is probably the most accurate of the proposed methods. Those, who dosed balls using a spoon, were quickly done, but they admitted, that this might not be the best way. There were visible differences between the amounts of material in the samples. It was better to measure the volume by a measuring cup. All agreed that counting jelly balls can be quite reliable method. This method was not chosen by any group, the procedure had seemed to be the most time consuming for them.

Layout of samples was evaluated in a discussion after a defined time. At the end of the experiment the pupils sorted on one line samples depending on how far from the lights have been placed. Pupils saw that those of them who thought that the greater distance between the first and the third sample is more apparent on the colour indicator, they were right. Planning layout of samples related to the way of thinking and foresight pupils. They must realize the role of light in photosynthesis. Thus, there must be a sufficient difference in light intensity, which treats on the individual samples.

**Assessment of Data Presentation**

Pupils could choose the form of enrolment themselves. Mostly pupils divided the tasks and just one of them was a writer, who was more an observer, while others realise the experiment. Their output was often based on the writer notes. Pupils themselves made out photo documentation, we didn't hinder them. They used the cell phones spontaneously. They can complete output at home in the form of digital presentation protocol or poster.

We expected that pupils, on the basis of discussion in the introduction, they should enter the weight of the material used in the sample, the amount of added indicator and the time of its action, when writing constants and variables. We supposed that pupils write a simple table into which enter three samples distance in cm from the light and colour of the indicator in each sample. We expected that the conclusion they indicate is that the colour of the indicator changed, because the sample closer to the light, is that where algae consumed more carbon dioxide from the solution.

We expected that pupils tried to organize the data entry in some table or graphs, but nobody chose this way of output presentation. Assessment of this step of inquiry should be realized by using of check list with simple table as a pattern, which they could more to recast.

Some pupils indicated in their output chosen procedure and also in what was its lack and recommendations on how to change it. Others indicated the procedure and lack thereof. Others indicated only the chosen procedure. Although at the beginning we talked with the pupils about the fact that for enrolment data could be used table, no one used this possibility. Their attention is focused on the activities, recording the results was secondary for them. Variables were incorporated in continuous text. It seems that younger pupils need to propose a table in a worksheet, aware of the importance and significance of data tables for clarity of enrolment.

## *EFFECTIVENESS OF FORMATIVE ASSESSMENT OF INQUIRY BASED ACTIVITY*

Feedback, when used as part of a formative assessment system, is a powerful way to improve student achievement. Effective feedback as a result of formative assessment gives to each pupil guidance, how to improve in skills needed for achievement of inquiry goal. In its traditional form, formative assessment has been thought of as providing teachers with more frequent evidence of student's mastery of standards to help teachers make useful instructional decisions. In this way, formative assessment is intended to enhance student learning (Stiggins, 2005). The greatest value in formative assessment lies in teachers and students making use of results to improve real-time teaching and learning at every turn (Chappuis and Chappuis, 2008). Mastery of formative assessment by teacher is assumption for effective inquiry based education. At inquiry lesson formative assessment in IBSE means using questioning to help the development of student's ideas and competences, providing and using of effective feedback and inviting students to assess their work and generate possible steps for improving.

## *CONCLUSION*

The third level of inquiry – guided inquiry was applied in this activity. Pupil didn't investigate a problem and make assumptions so we didn't assess these two first steps of inquiry. Moreover, identification of the problem seems to be difficult. We focused on assessment of the next steps of inquiry. We assessed pupil's skills when they participated in planning an experiment and their activity on course of the experiment. When pupils managed these steps we assessed their ability to collect data and make solid conclusion. In assessment of younger pupils for data collecting skills could be used some check list or another aid. If students managed all three steps (plan, activity, conclusion) we evaluated that they had all assumptions to share their results on good level with others. It was the assessment of the last step of inquiry cycle. We were able to assess only some of the key moments of IBSE activity because there are still not enough tools and methods for assessment, which could be like guidance for teacher during the inquiry education.

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