Embedding Formative Assessment in Inquiry-Based Learning

Simay Koksalan
Marmara University, Turkey

Feral Ogan-Bekiroglu
Marmara University, Turkey

Introduction

In recent years, the education system has changed drastically in all over the world. The main ideas underlying this need for change are sometimes related to how to create a more effective learning environment, and sometimes to measure and evaluate students' learning outcome. New learning approaches that have observable positive effect, and the alternative measurement and evaluation methods that are discussed take place in the educational field. Besides, inquiry-based learning and formative assessment are among the prominent topics in this field. Inquiry-based learning with formative assessment provides students with the ability to acquire new information easily, solve new problems, use creativity and critical thinking skills in designing new approaches to existing problems, rather than simply equipping them with stereotyped knowledge and skills. It is very important to be able make changes in the right way in order to train students who keep up with the current world understanding and to clarify the blind spots in the education system.

Inquiry-based learning has been part of innovative science teaching over the last decade (Grob, Holmeier & Labudde, 2017). The recent call for reform made it clear that not only did reform of science teaching, but also that assessment methods should be changed to support a new curriculum in the way that emphasizing the creation of meaningful understanding in students rather than directing them to memorize science content (Briscoe & Wells, 2001). Inquiry-based learning is incomplete when applied alone. One of the points that lacks is about the assessment method to be used in learning. In the innovative understanding of science teaching, inquiry-based learning and assessment methods that should be used in this learning created question marks for educators.

On the other side, there are research findings that formative assessment may be the most important factor in increasing academic achievement of all students, especially low-performing students (Black & Wiliam, 1998). Students need feedback to be aware of when, where and how to use the information they have learned. Moreover, formative assessment is well suited to inquiry-based learning which aims to develop students' scientific understanding through direct interaction with real situations and materials (Harlen, Brand & Brown, 2003). It is vital for the education system and the teaching to be done that how inquiry-based learning and formative assessment are applied to learning and the results obtained after the application.

Inquiry-Based Learning and Formative Assessment

"If a single word had to be chosen to describe the goals of science educators during the 30-year period that began in the late 1950s, it would have to be INQUIRY." (DeBoer, 1991). Inquiry-based learning (IBL) has a long history since Socrates. John Dewey, an American educational reformer in the first half of the twentieth century, pointed out that traditional education, which is authoritarian and rigid, and a predetermined approach to knowledge are not sufficient to understand students' real experiences (Haury, 1993). Educator Joseph Schwab (1960, 1966) was effective in taking this view into science education. In a science course with inquiry-based learning, students formulate and answer their own questions through their own discoveries. Instead of assuming that there is a single answer to the problems of different students, inquiry-based learning allows individuals to solve them in different ways by taking advantage of their strengths (Haury, 1993). Students gain a deeper understanding when they discover what they ask, discuss and learn. When students discover the principles, they learn not only by memorizing them from any textbook, but also by understanding what is happening, how it is, and what is important. In fact, students need gradual inquiry to reach their research skills, understanding and where they can conduct their own investigations from start to finish. On this basis, there are many levels of inquiry that students can advance to and they have a deeper scientific thinking as the process progresses . Looking at the literature, Schwab treated the levels of inquiry-based learning in the same way (Abrams, Southerland & Silva, 2007). Four levels (confirmation, structured, guided, and open) were identified to be useful in classifying inquiry levels (Table 1). In the Level 0, confirmatory inquiry, students are given questions and methods and the results are known in advance. This stage is useful when the teacher's aim is to strengthen an already introduced idea. Its aim is to provide students with the experience of questioning or to provide students with a specific research skill, such as data collection and recording (Banchi & Bell, 2008). In the Level 1, structured inquiry, according to Colburn (2000), teachers provide students with procedures and materials as well as a practical problem for research, but do not inform them of the expected results. In the Level 2, guided inquiry, the teacher provides only the material and problem required for the research. Students develop their own procedures to solve the problem (Colburn, 2000). Guided inquiry provides opportunities for students to take more responsibility during the lesson (Lederman, 2009). In the Level 3, guided inquiry, this approach is similar to guided inquiry as well as formulating students' own problems to investigate. Open inquiry is in many ways the same as doing science (Colburn, 2000).

Table 1. *Schwab's Inquiry Levels*

	Source of the question	Data collection methods	Interpretations of results
Level 0 (Confirmation)	Given by teacher	Given by teacher	Given by teacher
Level 1 (Structured)	Given by teacher	Given by teacher	Open to student
Level 2 (Guided)	Given by teacher	Open to student	Open to student
Level 3 (Open)	Open to student	Open to student	Open to student

"Formative assessment is a process used by teachers and students during instruction that provides feedback to adjust ongoing teaching and learning to improve students' achievement of intended instructional outcomes." (McManus, 2008). Formative assessment is done to give feedback to the student and teacher about how well the subject has been taught and learned during teaching. The purpose of the formative assessment is to determine whether the students have reached their intended capacity and what adjustments should be made in teaching. Timely feedback to students on their conceptual learning levels and skills is a requirement of effective teaching, giving students problems to think about (Ogan-Bekiroglu, 2004). According to Yorke (2003), formative assessments may be "planned" and "unplanned". Planned formative assessments can be defined as assessments performed by referring to the assessment framework of a particular curriculum. It includes the student's necessary activities (what they need to do the work) and the evaluator's activities (evaluating the work and providing feedback for the student to learn). Unplanned formative assessments are those that occur during events but are not specifically envisaged in curriculum design. This type includes instant feedback on students' participation in a learning activity and comments on material drafts for inclusion in portfolios.

Black and Wiliam (1998) discovered that improved formative assessment, including self-assessment, was effective in improving the performance of students at the lowest level of performance. Formative assessment helps students understand the standards expected of them. When expressing expected standards, only curriculum objectives or learning expressions are often insufficient to convey the richness of that meaning.

Formative assessment can be conceptualized as consisting of five key strategies (Black & William, 2009; Clarke, 2001):

1. Clarifying and sharing learning intentions and criteria for success;

2. Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding;

3. Providing feedback that moves learners forward;

4. Activating students as instructional resources for one another; and

5. Activating students as the owners of their own learning.

<div align="center">**Integrating Formative Assessment into Inquiry-Based Learning**</div>

Inquiry-based learning method was developed against traditional teaching methods which are based on students' memorization of the given information and whose failure is noticed (Bruner, 1961). The main specialty of this learning is to take care of the students' questions in the learning environment. In the inquiry-based learning method, students follow the same path as scientists while doing scientific research. National Research Council (NRC) (1996) identified the characteristics of the inquiry-based learning method as follows. These features;

- Be acquainted with scientific questions,

- Prioritizing the evidence that will explain or improve these questions,

- Students formulate explanations from the evidence for questions,

- Students' explanations reflect particularly scientific understanding evaluation in the light of alternative explanations,

- Students communicate and justify their explanations are suggested,

- Students plan and manage the research.

In general, when the literature is examined, inquiry includes; open, immerse, explore, identify, gather, create, share and evaluation steps. According to NRC (2000), assessment for inquiry-based learning determines whether students can produce and explain their questions at the same time, develop possible explanations, whether they can design queries and use the data as evidence to support or reject their own explanations.

On the other hand, one of the effective ways to encourage students' learning is considered to be the use of formative assessment. Formative assessment has the purpose of assisting learning, and is also called "assessment for learning" by the Black et al. (2004). This assessment includes the steps which are that where learners and their teachers are searching for and interpreting evidence, where they are in learning, and how they should proceed in the best way to learn. Formative assessments can support improvements in instructional quality and that assessments are needed to both defining the task and assessing accurately what is learned in inquiry-based learning (Barron & Darling-Hammond, 2010).

The feedback given at the end of the instructions is thought to be late interventions for

students to learn. It is believed that continuous feedback, which is the main element of formative assessment, will continue and assist students in inquiry process. The principles of inquiry-based learning and formative assessment are in harmony with each other as shown in the Figure 1.
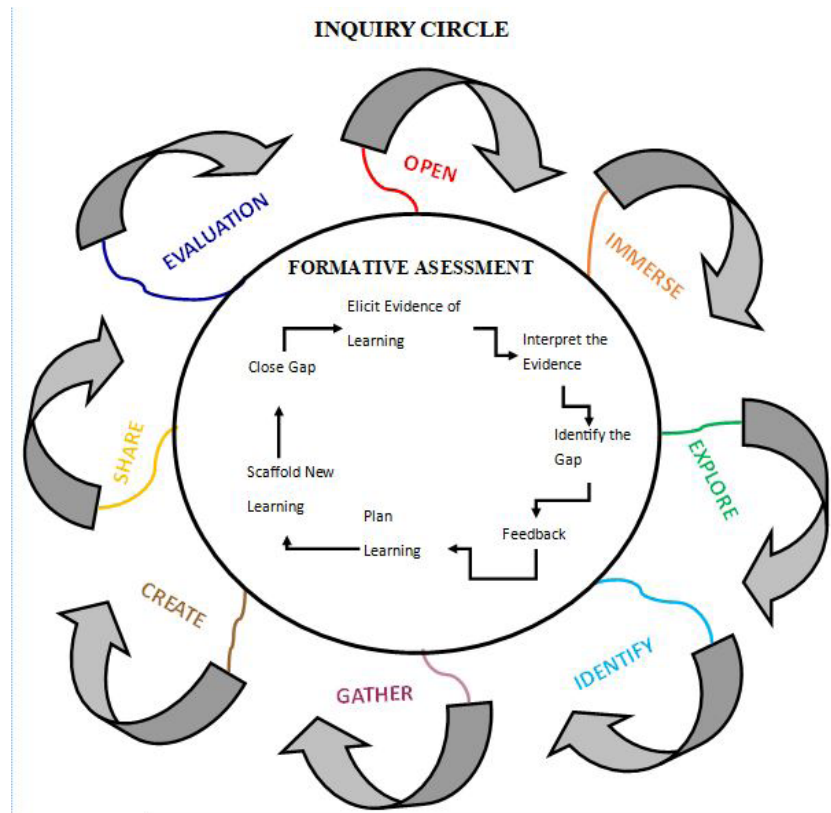

Figure 1. Relationship Between Inquiry Circle and Formative Assessment

Each color used in the diagram represents a different stage in the inquiry cycle. As is seen in the Figure 1 above, when talking about the relationship between inquiry-based instruction and formative assessment, it is seen that formative assessment can take place at every stage of inquiry-based learning. The inquiry cycle begins with the open phase; then immerse, explore, identify, gather, create, share and evaluation respectively. However, it is not possible to limit the inquiry cycle to these stages only. In some cases, the steps may be reduced and sometimes more detailed.

In an inquiry-based learning where formative assessment is not used, the assessment occurs at the end. It is not enough for students to make evaluations as the last stage. Measurement of students in the process has great importance for both themselves and their teachers to realize the stage of their learning and to make the necessary arrangements on time. For this reason, formative assessment is embedded in each stage of the inquiry. The formative assessment begins with revealing the evidence of learning and takes place in various ways, such as asking a question in some cases, letting the student comment on a relevant case, doing self-assessment or preparing research paper. If the evidence is sufficient, the next step is to proceed. If the evidence

obtained from the student is interpreted and defined as deficiency, then feedback is provided. In this case, both the student and the teacher have an idea of the current level of learning. If necessary, the teacher re-plans or changes learning. In some cases, the teacher defines new tasks to build new learning in the student. At the end of these processes, the aim is to eliminate the lack of students' knowledge.

A lesson plan template (Table 2) was prepared for learning, in which basic characteristics of the inquiry class, the components of inquiry-based learning, the stages in guided inquiry-based learning and formative assessment were taken into consideration. The original framework of lesson plan template was designed by Kuhlthau, Maniotes and Caspari (2012), and it was rearranged by the researcher by integrating formative assessments.

This lesson plan includes formative assessments in all steps (open, immerse, explore, identify, gather, create and share) that students follow. Therefore, evaluation step which is normally the last step of the inquiry circle, is not included in the lesson plan separately.

The purposes of the formative assessments (given in Table 2) in this inquiry-based learning template are;

- Open Step; to reveal whether students arouse curiosity or not

- Immerse Step; to measure whether students can make connections between subjects or not

- Explore Step; to realize how much students can get into the subject

- Identify Step; to measure whether students can form a research question or not

- Gather Step; to measure whether the students can gather the right information about the subject and how deep they can go

- Create Step; to measure students' ways of going to the results, their final results and objectives

- Gather Step; to measure how students acquire and transfer information in the process and how they compare their ideas with other ideas

Table 2. A Lesson Plan Template for Formative Assessment in Inquiry-Based Learning Method

Steps	Definition
OPEN	Invitation to Inquiry, open minds, stimulate curiosity **F. A.:** It is revealed whether the students are curious or not with formative assessment
IMMERSE	Build background knowledge, connect to content, discover interesting ideas **F. A.:** It is measured whether students are able to make connections between subjects with formative assessment
EXPLORE	Explore interesting ideas, look around, dip in **F. A.:** It is measured whether students are involved in research with formative assessment
IDENTIFY	Pause and ponder, identify inquiry question, decide direction **F. A.:** Whether the students can formulate a research question and how they follow a path is measured with formative assessment
GATHER	Gather important information, go broad, go deep **F. A.:** It is measured whether the students can gather the correct information on the subject and how deep they are with formative assessment
CREATE	Reflect on learning, go beyond facts to make meaning, create to communicate **F. A.:** Students' ways of reaching the result, their results and achievements are measured with formative assessment
SHARE	Learn from each other, share learning, tell your story **F. A.:** Students' ways of acquiring and transferring information in the process, and comparing their ideas with other ideas are measured with formative assessment

*F. A.: Formative Assessment

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