The Significance of Inquiry-based Learning of IB programme from the Perspective of Active Learning

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Abstract
International Baccalaureate (IB) educational programmes are known to emphasize a range of pedagogical aspects. This includes elements such as conceptual understanding, contextualized teaching and learning, and its approaches to learning (ATL). It is also known to implement inquiry-based learning by establishing a statement of inquiry that integrates concepts and contexts in each unit design [1]. From the perspective of active learning strategies, this research analyzes science classes by quantitatively analyzing unit designs, and classes for inquiry-based learning based on IB methods. We quantified the effects using the Reformed Teaching Observation Protocol (RTOP) [2], which is widely used in science and mathematics educational research in the United States of America. This tool measures the extent to which learner-centered, collaborative lessons are developed to promote deep conceptual understanding. 5 categories (class design and practice, subject content, instructional techniques, relationships between learners, relationships between learners and instructors), are analyzed using RTOP's 5-point method. In Japan, many high schools are still considered to have a passive approach to learning, and – despite the growing existence of schools that are trying to better design inquiry-based lessons – often remain teacher-led. Therefore, we designed three types of lessons: passive lessons, teacher-led inquiry-based lessons, and (as is considered ideal in IB education) student-led lessons. Basing our evaluation around active learning strategies, we implemented these three lesson-types in the same unit and compared them with the RTOP indicator. The difference between the three classes was not only identified by RTOP, but also by students' level of understanding. Based on our analysis we propose plans for improving classes, while also discussing similarities and differences in the design of IB and RTOP lessons. Results from this study support the idea that emphasis on conceptual understanding, contextualized instruction, along with teachers playing greater roles as facilitators, are key requirements to help better realize independent learning.

Keywords: *IB, RTOP, Active learning, Lesson study*

1. Introduction
In Japan, with the revision of the Courses of Study, there is a need to improve classes from the three perspectives of active learning described below.

1. Whether the learning process of acquisition, utilization, and exploration realizes a process of deep learning with problem discovery and solution in mind.
2. Whether the process of interactive learning, in which students expand and deepen their own thinking through collaboration with others and interaction with the outside world, is realized.
3. Whether or not the process of independent learning, in which students work persistently with a clear outlook, reflect on their own learning activities, and connect them to the next step, is realized.

This is due to the fact that students are expected not only to acquire knowledge and skills in lecture-based classes, but also to develop qualities and abilities that are difficult to develop through lecture-based classes alone. In other words, the emphasis is on "what will the students be able to do?

On the other hand, the International Baccalaureate, an international educational program, focuses on conceptual learning and views classroom improvement as follows. What is of paramount importance in the pre-university stage is not what is learned but learning how to learn … What matters is not the absorption and regurgitation either of fact or pre-digested interpretations of facts, but the development of powers of the mind or ways of thinking which can be applied to new situations and new presentations of facts as they arise. And it recommends the following five approaches to teaching[4]:

1. inquiry-based teaching.
2. teaching with an emphasis on conceptual understanding
3. teaching that is developed in local and global contexts
4. teaching that emphasizes effective teamwork and collaboration
5. differentiated teaching to meet the needs of all learners.
6. teaching that incorporates assessment.

The author has been conducting lesson research at an International Baccalaureate (IB) authorized school in Japan. In this study, by quantitative analysis using RTOP, the unit design and classes based on the IB method are analyzed from the viewpoint of active learning, and a viewpoint for class improvement is proposed.

2. Comparison of three lessons

Using the RTOP indicators as a reference, three lessons with the same learning content were developed and compared. The learning content is molar concentration, and we designed three types of lessons: passive lessons（Table 1）, teacher-led inquiry-based lessons（Table 2）, and (as is considered ideal in IB education) student-led lessons（Table 3）.

Table 1 Passive lessons

Process	Learning activities	Points to keep in mind when teaching
Introduction	Confirm the lesson theme. "What is molar concentration and mass percentage concentration?" Write on the board the definitions and formulas of molar concentration and mass percentage concentration.	The teacher gives a one-sided explanation of what has already been learned. Students fill in the worksheet.
Development	Assignment Calculate how many grams of sucrose are required to prepare 100 mL of 0.3 mol/L sucrose solution and 100 g of 0.3 % sucrose solution, each. ・Work on your own assignment. ・Checking answers Write the process of calculation on the board and check the results.	Challenging activities for learners, but no justification for the way they are done.
End of lesson	Explain how to prepare 100 mL of 0.3 mol/L aqueous sucrose solution and 100 g of 0.3% aqueous sucrose solution, showing the experimental apparatus.	Teacher-led, teacher's own questions Tell students that they will use a scalpel flask to accurately measure the volume of the solution.

Table 2 Teacher-led inquiry-based lesson

Process	Learning activities	Points to keep in mind when teaching

Introduction	Inquiry Question 1 How can we prepare 100 mL of a 0.3 mol/L sucrose solution and 100 g of a 0.3 % sucrose solution? ・Discuss in groups. They try to find the amount of sucrose and water needed for each. Some groups consider the experimental apparatus. ・Ask some groups to explain.	The teacher asks the learners questions to confirm what they have already learned. Learners communicate their ideas through interaction with each other and examine their ideas in multiple ways. There is some interaction and concept building between learners, but the teacher does not give the correct answer.
Development	Inquiry Question 2 What laboratory equipment should be used to prepare 100 mL of a 0.3 mol/L sucrose solution and 100 g of a 0.3 % sucrose solution? Select the appropriate apparatus for each experiment. Prepare solutions.	
End of lesson	Explain the method of preparing 100 mL of 0.3 mol/L sucrose solution and 100 g of 0.3 % sucrose solution by showing the laboratory equipment.	Understand the meaning of each operation by comparing it with your own operation.

Table 3 Student-led lessons (as is considered ideal in IB education)

Process	Learning activities	Points to keep in mind when teaching
Introduction	Inquiry Question 1 How is "concentration" used in the real world? ・Remind students of the various situations. Example.) What is the true meaning of 100% fruit juice, caffeine free, etc.? As a measure against COVID-19, measure CO_2 concentration and use it as a guide for ventilation. Smartwatch to measure blood oxygen level	Learners explain phenomena by themselves using various means of expression Focus on units Understand that each concentration is used in situations that correspond to its definition. To have learners discuss with each other and confirm what they have already learned. The teacher should help the learners build concepts and understanding through their interactions.
Development	Inquiry Question 2 How does "quantifying of concentration" affect us? ・For the purpose of deepening, I would like to ask students about the significance of "quantification" and "quantification" rather than the sense of comparison, such	The relationship between scientific concepts and phenomena seen in everyday life is fully discussed.

	as thick or thin, high or low.	
End of lesson	Inquiry Question 3 The concentrations used in chemistry include "molar concentration" and "mass % concentration". 1) What is the difference between 0.3 mol/L and 0.3 %? 2) Which is a thicker solution, 0.3 mol/L or 0.3 %? 3) In what situations are molar concentration and mass percentage concentration used respectively? ・For each question, repeat the process of thinking in groups and sharing with the whole group.	It would be ideal if the students could think about the definition in question 1), compare the mass of solutes in question 2), and think about the concept of concentration in question 3). The teacher plays the role of listening to the learners, helping them to find their own answers, rather than giving them instructions. The teacher plays the role of listening to the learners, helping them to find their own answers rather than giving them instructions.

3. Analysis of the lesson

After each of the three classes, the following surveys were administered to the students who attended the classes. The method used was the six-point method.

Table 4 Comparison of class surveys

	Passive lessons /N=28	Teacher-led inquiry-based lesson /N=9	Student-led lessons (as is considered ideal in IB education)/N=16
This class was an enjoyable experience for me.	**2.64**	**3.78**	**4.38**
It was difficult for me to understand the content of this class.	**2.75**	**2.22**	**3.38**
What I learned in this class is chemistry.	**4.18**	**4.67**	**4.38**
What I learned in this class is that chemistry and other disciplines	**3.11**	**4.00**	**4.25**
In order to understand the usefulness of what I have learned in this class, all I have to do is to do the examples and exercises.	**4.18**	**3.56**	**3.88**
To understand the usefulness of what I have learned in this class, all I have to do is to apply it to my daily life.	**2.86**	**3.89**	**4.19**
If I cannot answer a question or solve a problem on my own in this class, what I expect from my teacher is a correct answer or solution.	**3.07**	**3.44**	**2.88**
If I can't answer a question in this class, or can't solve a problem on my own, what I expect from my teacher is advice on how to get to the right answer.	**4.61**	**4.56**	**5.38**
The mathematical expressions used in this lesson will help you find numerical answers to problems	**4.11**	**4.44**	**4.38**
The mathematical expressions used in this lesson help to relate concepts in a meaningful way.	**3.18**	**4.00**	**4.50**

In a passive lesson, many students expect to practice calculating concentrations and want to be taught by the teacher rather than trying to solve problems on their own. On the other hand, in teacher-led or learner-led inquiry-based lesson, when faced with a problem, they seek advice rather than seeking the answer. More students in the exploratory classes find it difficult to understand the content, but they want to solve the problems by themselves.

4. Conclusion

Conceptual learning in the IB requires teacher- or student-led inquiry-based learning. This creates opportunities for learners to learn from each other and for deeper learning that connects what is learned to the real world. It is necessary to change the mindset of teachers that conceptual understanding and collaboration among learners will lead to deeper understanding, rather than teaching the content of science learning.

References

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