

On study and research responsibilities: a case in Japanese upper secondary school

Sur les responsabilités d'étude et de recherche: un cas au lycée japonais

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Abstract

This presentation aims to identify some students' roles on a study and research path conducted in a Japanese upper secondary high school. Especially, we focus on responsibilities for questioning and answering in their inquiry. For this purpose, we describe the students' inquiry using the tree diagram of questions Q and answers A . Then, we analyze what kind of students' roles emerged in their activity and discuss why that responsibilities could appear. As a result, we identify two interesting points of their study and research responsibilities: 1) On producing an initial question; 2) On producing temporary answers.

Keywords: Study and research path; topogenesis of knowledge; graph theory

Résumé

Cette présentation vise à identifier les rôles de certains étudiants sur un parcours d'étude et de recherche mené dans un lycée japonais du deuxième cycle du secondaire. Surtout, nous nous concentrons sur les responsabilités en matière de questionnement et de réponse dans leur investigation. À cette fin, nous décrivons l'investigation des élèves en utilisant le diagramme d'arbre des questions Q et réponses R . Ensuite, nous analysons le type de rôles des élèves qui émergent dans leur activité et discutons pourquoi ces responsabilités pourraient apparaître. En conséquence, nous identifions deux points intéressants de leurs responsabilités d'étude et de recherché : 1) En produisant une question initiale ; 2) En produisant des réponses temporaires.

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Mots-clés: Parcours d'étude et de recherche, Topogenèse des connaissances, la théorie des graphes.

Resumen. Esta presentación tiene como objetivo identificar los roles de algunos estudiantes en un estudio y una ruta de investigación llevada a cabo en una escuela secundaria superior japonesa. Especialmente, nos centramos en las responsabilidades para cuestionar y responder en su consulta. Para este propósito, describimos la consulta de los estudiantes usando el diagrama de árbol de cuestiones Q y respuestas R . Luego, analizamos qué tipo de roles de los estudiantes surgieron en su actividad y discutimos por qué podrían aparecer esas responsabilidades. Como resultado, identificamos dos puntos interesantes de su estudio y responsabilidades de investigación: 1) Al producir una cuestión inicial; 2) Al producir respuestas temporales.

Palabras-clave: Recorrido de estudio e investigación, Topogénesis del conocimiento, Teoría de grafos.

On study and research responsibilities: a case in Japanese upper secondary school

In this presentation, we report a plan and some results of our ongoing study about students' and teachers' roles in inquiry-based teaching and learning situations. The realization of inquiry-based education is an important issue in not only didactic research of mathematics but also mathematics education practice. In Japan, mathematics and more general curricula emphasize the necessity of inquiry-based pedagogy. Following this educational demand, each high school tries to realize students' autonomous investigation as much as possible. Our research is involved in this kind of didactic endeavor. We are studying the nature and possibility of the *study and research path* (SRP) at a specific course in a Japanese high school, where the first author teaches mathematics.

Our ongoing research especially focuses on the distribution of different kinds of responsibility and its evolution, that is, *topogenesis of knowledge* (cf. Chevallard & Ladage, 2008), in SRP. The SRP has a radically different didactic contract as that of ordinary classroom conducted by traditional teaching formats: transmission, problem-solving and so on (cf. Bosch & Winsløw, 2015). Thus, the topogenesis of knowledge in SRP is probably different from that of the formats. Our research questions are as follows:

- What differences are there between a SRP in our case and the “ideal” SRP, about distributions of responsibilities?
- Why do such differences emerge?

Main theoretical tool

We use the tree diagram of questions Q and answers A on SRP together with information about main producers of them (cf. Winsløw et al., 2013). In the diagram, any node is some kind of Q or A , and has some kind of color for describing main actor at a considered node. In this paper, we use only two colors: black and white. The black indicates the teacher and the white indicates the student (see Figure 1). And we distinguish three types of answers:

ready-made answers A^{\diamond} , temporary answers A_j , and final answer A^{\heartsuit} (cf. Barquero & Bosch, 2015). Let us use the diagram for describing inquiry process.

Context of our design research

Our study is conducted under constraints of a Japanese high school system where the first author is involved. This school is one of attached schools of Hiroshima University and its students' achievement is generally high. The school is setting an original course called *Kadai-kenkyū* (project study) which aims to educate students' scientific attitude and capacity. At the period focused in our case study (from May, 2017 to September, 2018), 80 students of "Science Class" at eleven and twelve grades participate in this course. Our research target is 40 eleven grade students within them. They make some groups with 3-6 members following their interest and friendship, and each group decides their research topics of natural science including mathematics. Then, each group constructs a fundamental question which will be investigated for one year and a half. Each group includes one supervisor, it is a *didactic system*. Didactic times are 90 minutes per week.

The group supervised by the first author consists of 4 eleven grade students. Their interests for science did not accord initially. But they have been good friends before then and the student being good at mathematics invited the others. Then, they decided to inquire mathematical topics.

Description of Q/A-tree and main actors in there

In this section, we describe temporary process of ongoing study and research by the group mentioned at previous section. This reports the process of SRP during 8 weeks. The theme of the group is the cyclicity in graph theory which is not included in mathematics school curriculum. Unicursal graph is one of the most classic topics in this theory. The method for identifying unicursality of a graph is well known for many Japanese students, but that of

multicursality is little recognized. Furthermore, proof of the theorem justifying that method is unknown for almost all of the students. The group focused on this problem and tried to inquire the conditions of the bicursality.

Before starting the description of the SRP, we briefly explain the inquiry process of the students. First, they started to identify what kinds of graphs are bicursal. That is, they tried to find the necessary and sufficient conditions for being bicursal. Second, they referred to some websites and books in order to search a mathematical and accurate description about unicursal graph. In general, Eulerian graph and semi-Eulerian graph are well known as unicursal graphs. The book which the students read deals with the unicursality of Eulerian graph. So, they tried to understand the claim and that proof. Then they applied the method of proving to the proof of unicursality of semi-Eulerian graph. The detail of their SRP is as follows.

Q0: What kind of graph is bicursal?

Q1: What does “bicursal” mean mathematically?

Q1.1: To begin with, what does “unicursal” mean mathematically?

$A_{1.1}^{\diamond}$: A graph is unicursal if and only if the graph is Eulerian or semi-Eulerian.

Q1.1.1: What is a Eulerian / semi-Eulerian graph?

$A_{1.1.1}^{\diamond}$: A vertex of a graph is even (resp. odd) if and only if its degree is even (resp. odd) and a graph is Eulerian if and only if the graph has only even vertices. A graph is semi-Eulerian if and only if the graph has just two odd vertices.

Q1.1.2: Why is the Eulerian graph unicursal? (What should we show to prove it mathematically? Or what is the explicit definition of “unicursality”?)

$A_{1.1.2}^{\diamond}$: We should show there exists a closed trail $T \subset G$ such that $E(T) = E(G)$ ($E(G)$ represents the edge set of a graph G)

Q1.1.2.1: What is a trail?

$A_{1.1.2.1}^\diamond$: A walk without repeated edges.

$Q_{1.1.3}$: How can we prove that semi-Eulerian graphs are unicursal?

$A_{1.1.3.1}$: We can obtain an Eulerian trail of a semi-Eulerian graph G if G can be constructed from a Eulerian graph.

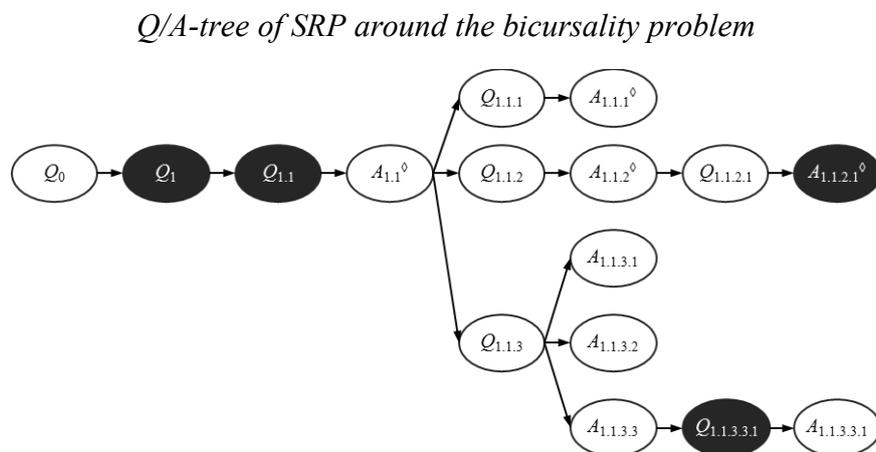
$A_{1.1.3.2}$: For a given semi-Eulerian graph, we can obtain a Eulerian graph by integrating the two odd vertices and regarding them as one vertex.

$A_{1.1.3.3}$: For a given semi-Eulerian graph, we can obtain a Eulerian graph by attaching an edge which connects the two odd vertices.

$Q_{1.1.3.3.1}$: Can we find any relationship between Eulerian trails of the obtained Eulerian graph and that of the original semi-Eulerian graph?

$A_{1.1.3.3.1}$: If there exists a Eulerian trail of the obtained Eulerian graph, which has the attached edge at the end, we can obtain a Eulerian trail of the original semi-Eulerian graph by extracting the end edge.

Figure 1.



Discussion

There are two interesting phenomena in this case. The first interesting point is that the initial question does not come from the teacher but from the students, that is to say, students have the *role of producing an initial question*, while initial questions are predetermined by the

teacher in many cases of SRP. In this sense, the SRP in our case is closer to scientist inquiry. Why is it possible although it is in the “didactic” context? We conjecture that it comes from a special didactic clause involved in the didactic system of the project study in this school. In this school, each group of the Science Class is required to establish its own research question or task at the beginning of the inquiry. In order to do this, the students 1) look for interesting scientific topics from websites and books, 2) refer to themes that their senior carried out in the project study, and 3) consult teachers. Then, each group chooses a research field and establishes a research question or task. In this sense, the emergence of the initial question from the students was not *adidactic*, that is, due to the rule within the project study.

The second interesting point is that the *role of producing temporary answers* is occupied by students, that is, this is a role with full responsibility or a *topos* of students, although the responsibility of producing questions is shared by students and teachers except about the initial question. The emergence of this *topos* is a common character of this SRP organization and other teaching approaches. This is superficially natural phenomenon in any didactic situation. However, if we consider some Ph.D. program as a typical SRP, then we can notice that this is unnatural in authentic inquiry-based teaching and learning. In the program, supervisors often give their temporary answers to various questions, and then discuss with their students similarities and differences between their temporary answers and their students’ answers. Such a dialogue probably has important value for constructing students’ own final answers, that is, their doctoral theses and professionalities as a researcher. Nonetheless, the SRP in the project study includes no teacher’s temporary answer. We think that it is because of a remembrance of old didactic format of “master and underling” (cf. Chevallard, 2015), which is an institutional constraint. In fact, other parts of teaching organization in this school (e.g., normal mathematics courses) are conducted together with a didactic clause in traditional school pedagogies: a teacher questions and students answer.

As a future task, we will analyze this SRP in more detail. We are trying to identify *topoi* and their evolutions in the students' group. In the target group, each student probably has its own *topos*. For example, we could observe that some roles are not played cooperatively but with high responsibilities for a person: taking the leadership, deciding a direction of the activity, asking a naïve question, summarizing results of the research, and so on.

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