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Tottori University

Study and Research Paths
for InMside

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Background

For Inclusive Mathematics for Sustainability in a Digital Economy,

✴ students need more mathematical competencies, however;

- qualitatively or quantitatively?
- what should be roles/functions of mathematics for students?
- what topics/contents in mathematics could be important for students?
- otherwise, should we change the way of teaching and learning of mathematics (*didactique des mathématiques*)?

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Idealisation

★ Students should become able to inquire sustainably toward the real world problems using both mathematics and *other diverse knowledge*,

- however, can students get it through current classroom practices, especially in mathematics?
- if not, what would be lacking, and how could it be understood?
  - *some theoretical framework will be useful for didactic and research practices*

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Study and Research Paths [SRP]

The long historical dominance in most school systems of the transcendentist relation to knowledge has imposed to this day what I have called the paradigm of visiting works. A (mathematical) work is "visited" by a class under the supervision of the teacher as if it were a monument, even a masterpiece, that, however impudently, we are expected to revere and bow to. This leads to what I have called the "monumentalization" of the curriculum. Now when, to the contrary, we adopt the inherentist stance, things change almost completely.

The first historical step in this direction was taken a number of decades ago when the French "modern" didacticians, following in the wake of Guy Brousseau's pioneering work (1997), set to tackle the general basic problem of didactics: Given a work w, find a question Q the study of which will, if not generate, at least leads one to come across w, regarded as a key resource to arrive at an answer A to Q. Such was the first systematic and effective effort to "demonumentalize" the mathematics curriculum. Acting on the basis of Brousseau's theory of didactic situations, another step was then taken by ATD, in which the notion of "study and research activity" (SRA) was developed. This notion was soon reworked to give birth to the notion of "study and research path" (SRP) in which the question Q, which at the start seemed to be a mere foil to the work w, soon assumed greater significance.

(Chevallard, 2016/*in press*)

SRP for teachers education [SRP-TE]

Recent research in the frame of the Anthropological Theory of the Didactic (ATD) states the need of basing the professional development programmes of secondary school teachers on certain problematic questions that arise from teachers' professional practice (Chevallard & Cirade 2009, Ruiz-Olarría 2015). Notions and analysis methods from mathematics education research can thus be introduced as tools to approach these professional questions, rather than as pre-established knowledge to be learnt (Chevallard, 2015). It also gives educators and teachers the opportunity to link these tools to school realities and, through the feedback obtained, to raise new research questions to be developed further.

These assumptions are embodied in the methodology of what we call study and research paths for teachers education (SRP-TE). An SRP-TE is an inquiry-based educational device that combines a practical and a theoretical questioning of school mathematical activities and provides teachers with epistemological and didactic tools to analyse and reconstruct these activities in the classroom (Barquero et al., 2015).

(Bosch, et al., 2016)

SRP by Herbartian Scheme

$$[S(X, Y, Q) \rightharpoonup M] \hookrightarrow A^{\heartsuit}$$

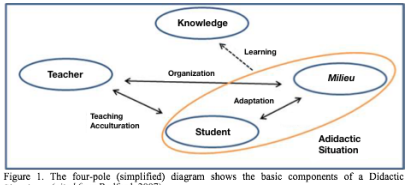


Figure 1. The four-pole (simplified) diagram shows the basic components of a Didactic Situation. (*cited from* Radford, 2007)

$$M = \{A_1^{\diamondsuit}, A_2^{\diamondsuit}, \ldots, A_m^{\diamondsuit}, \ldots, W_{m+1}, W_{m+2}, \ldots, W_n, Q_{n+1}, Q_{n+2}, \ldots, Q_p, D_{p+1}, D_{p+2}, \ldots, D_q\}$$

$$[S(X, Y, Q) \rightharpoonup \{A_i^{\diamondsuit}, W_j, Q_k, D_l\}] \hookrightarrow A^{\heartsuit}$$

X: student(s)

Y: teacher(s)/assistant(s)

Q: initial question

$A\diamondsuit_i$: existing answer(s)

W_j: existing work(s) for understanding $A\diamondsuit$

Q_k: personal question(s)

D_l: data

$A^{\heartsuit}$: final answer

Types of inquiry (Bosch & Winsløw, 2015; Otaki, 2017)

SRP

« Herbartian » $[S(X, Y, Q) \rightharpoonup \{A_i^{\Diamond}, W_j, Q_k, D_l\}] \hookrightarrow A^{\heartsuit}$

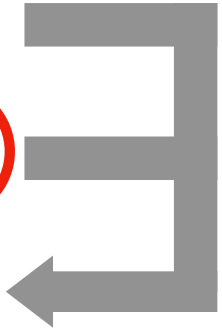
« **Herbartian** » means attitude of scientists to ask and confront questions. Here, it also include « **procognitive** » attitude to try to get answers from anywhere, and « **exoteric** » attitude to learn as much knowledge as necessary for inquiring questions.

« pre-Herbartian » $[S(X, Y, \mathcal{Q}) \rightharpoonup \{A_i^{\Diamond}, W_j, Q_k, D_l\}] \hookrightarrow A^{\heartsuit}$

« retrocognitive » $[S(X, Y, Q) \rightharpoonup \{\mathcal{A}_i^{\Diamond}, W_j, Q_k, D_l\}] \hookrightarrow A^{\heartsuit}$

« esoteric » $[S(X, Y, Q) \rightharpoonup \{A_i^{\Diamond}, W_j, Q_k, D_l\}] \hookrightarrow A_y^{\heartsuit}$

« micro » $[S(X, Y, Q) \rightharpoonup \{A_i^{\Diamond}, W_j, \mathcal{Q}_k, D_l\}] \hookrightarrow A_y^{\heartsuit}$

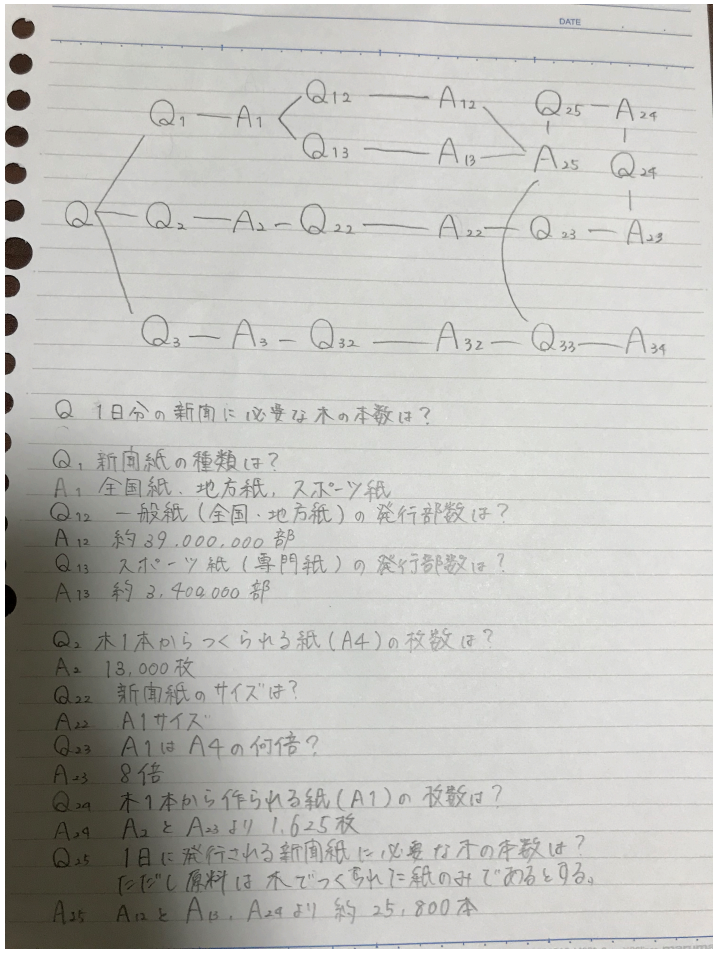


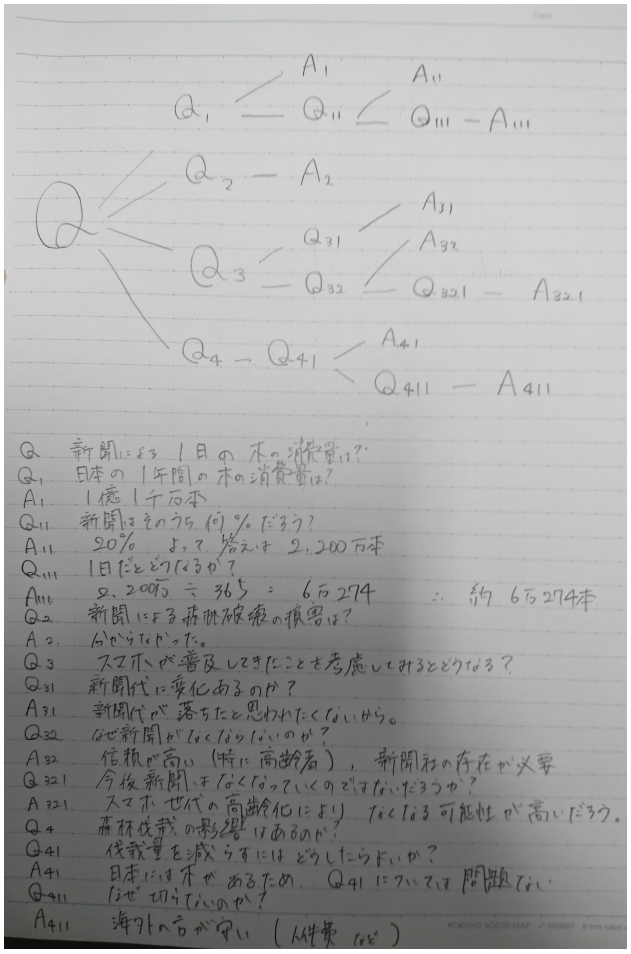
Example of *implementing* SRP

1st grade university students group practices

Task: About how many trees are needed each day to provide newspapers for your country?

(from PRIMAS)





students' reports

« SRP-TE »

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Example of *developing* SRP

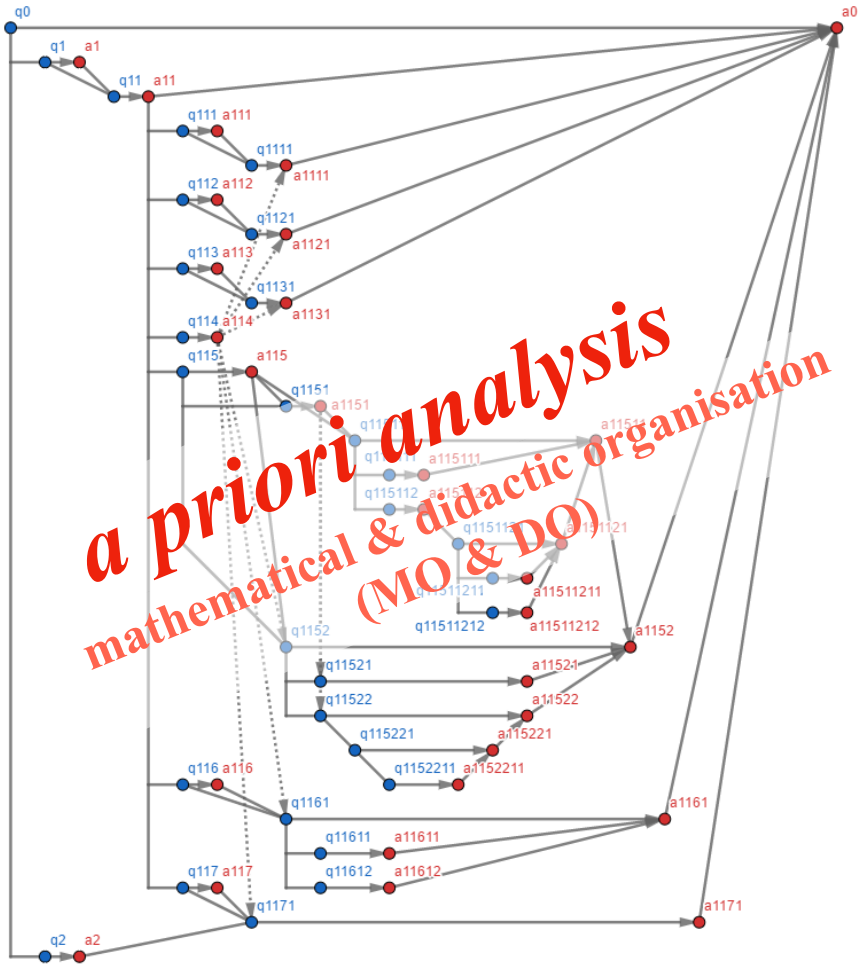
3rd grade university students group practice

students developed finally

Task: Develop a new SRP

Q_0: *What is the water footprint of bananas imported by Japan in a year?*

Q&A map made by students



A♥

$$\sum_e WF(e, Japan) = \sum_e \frac{p \cdot c}{r} \frac{ET(e)}{YLD(e)} TRD(e, Japan) = 340{,}553{,}729{,}832(\text{kg})$$

$$WF(e,i) = \frac{p \cdot c}{r} \frac{ET(e)}{YLD(e)} TRD(e,i)$$

some of milieu

	1月	2月	3月	4月	5月	6月	7月	8月	9月	10月	11月	12月	平均
台湾	103.5	180	189.5	198.3	233.9	322.6	251.1	349.1	372.4	163.6	98	72	211.2
ベトナム	20.6	32.6	53	98.5	210.7	235.5	279.1	279.1	222.9	146.4	56.3	10.2	137.1
タイ	15.1	18.3	39.3	86.6	245.8	162	171.4	207.9	349.2	302.2	47.9	7.4	137.8
フィリピン	36.6	29.4	40.6	62.1	146.5	298.5	352	394.5	263.3	235.2	163.5	94.1	176.2
インドネシア	362	285.8	207.2	123.4	113.2	60.8	38	57	47.2	117.9	125.8	323.6	155.2
メキシコ	7.6	7.2	13	67.1	118.9	268.3	276.9	201.1	141.8	71.2	5.1	11.8	99.2
グアテマラ	3.2	3.1	18.4	14.6	109.6	242.2	185.7	175.3	244.4	112.1	15.4	5.4	94.1
コスタリカ	7.6	14.2	21.8	77.5	271.2	251.4	176.4	240.6	339.2	338	146.4	34.7	159.9
コロンビア	2.1	2.7	2.6	21.1	117.9	100.3	122.8	141.5	161.3	241.7	157.1	41.5	92.7
エクアドル	124	168.8	146.3	105.8	92.1	43.7	28.1	15.6	24.8	16.7	3.6	41.8	67.6
ペルー	——	——	——	——	——	——	——	——	——	——	——	——	——
オーストラリア	335.7	453.9	363.7	213	88.6	41.8	30.2	29.9	33.2	48.5	111.4	180.5	160.9

For the next didactic and research practice...

- ✓ How can SRP as authentic inquiry be embedded in current or future curriculum? What are *conditions* and *constraints* for that ('ecology' of SRP in the curriculum)? Actually, SRP has not been realized in current Japanese curriculum and classrooms.

  - ◉ *Actually, SRP has not been realized in current Japanese curriculum and classrooms (educational system).*

- ✓ What kind of initial question could be generative and how to provide it?

- ✓ What skills are required for teachers to implement SRP authentically? Do we need different teacher education programs than current one?

- ✓ What kind of competency(-ies) and attitudes can students acquire through SRP? Is it sustainable over their future?

- ✓ ...