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Effects of expert teachers' collaboration on their conceptualisations and practices towards inquiry based methods in science teaching.*

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Key words : teacher collaboration, inquiry based methods, secondary school, teacher education, teacher professional development.

Abstract: This paper aims to investigate teacher collaboration through observations and interviews with 6 new science teachers [NSTs]. It aims to identify the effects of debates amongst NSTs about specific teaching problems (i.e. new science teachers exchange about the gain and loss of inquiry based methods). The effects concern NSTs' conceptualisations and practices about IBST implementation. The study tackles two questions: At what level NSTs are able to implement IBST within their class-room? Does the interactions through the teacher education specific session change the NSTs' conceptualisations and practices? The first section drawn the research's theoretical framework: it refers to vocational research which explore collective work from the activity theory model. The second make explicit the methodology: a mean to elicit teachers' knowledge and their repertoire of actions is presented. The third presents the main results: under certain conditions, debates amongst teachers and teachers educators create a common system of knowledge and practices.

Teacher collaboration is a key question amongst educational research. This paper aims to investigate this question through observations and interviews with 6 new science teachers [NSTs]. This paper's first section drawn the theoretical framework of this study; the second make explicit the methodology; then we will present the main results and outline some conclusions.

1. Theoretical framework

The individual aspects of teachers' activities are well known. Nevertheless, few studies aim to understand the interactive processes which underpin teacher collective work [TCW] and which contribute to change practitioners' conceptualisations and practices (Grangeat & Gray, 2008). Nevertheless, with respect to vocational fields, these questions are well known since the 90s, through the ergonomics or activity theory frameworks (Schmidt, 1991). These studies produced some findings which could be helpful for understanding the factors which influence teacher collective work .

1.1. Three collective work features

A first result leads to identify three collective work features. The first associates an increasing form (several teachers who teach the same subject) with a collaborative function (these persons act with similar goals and methods): within this feature, the difficulty consists to ensure the coherency, the similarity, amongst the actions of the different actors (Tiberghien, 1994). The second associates a completive form (teachers from different subjects act together) with a co-operative function (teachers deal different tasks to accomplish a same goal). Here, the difficulty is to maintain both the specificity of each actor and their mutual support (Hansen, 2008). The third associates a co-active form (actors work within the same space and time) with a debative function (they confront their ideas). The challenge is the respect of each point of view and the helpfulness of the common resources which result from the debate (Tillema & Orland-Barak, 2006). This

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paper focuses on this debative function and aims to understand its effects on NSTs' conceptualisations and practices.

1.2. Collective work effects

A second result highlights the collective work effects. Research shows how informal interactions transform the way in which professionals think about their work: professionals extend the range of elements which are caught in the situation in order to steer the activities at work. This extent occurs when actors could interact either through specific training sessions -aiming to confront methods about a specific professional problem- or through projects accomplished with partners (Engeström, 2001). This paper addresses interactions amongst NSTs which are organized during five specific sessions -called seminar of professional practices analysis (SPPA)- based on the creation of socio-cognitive conflict amongst NSTs. These debates are about pupils' motivation towards science subjects and specifically the way inquiry based science teaching [IBST] methods allow teachers to improve pupils' responsibility, to take care of their specificity and to make explicit the knowledge and the competence which had been taught through IBST session.

1.3. Research question

This paper aims to identify the effects of debates amongst new science teachers [NSTs] about specific teaching problems (i.e. new science teachers exchange about the gain and loss of inquiry based methods). The effects concern NSTs' conceptualisations and practices about IBST implementation. The study tackles two questions: At what level NSTs are able to implement IBST within their class-room? Does interactions which are generated by the TE specific session (SPPA) change the NSTs' conceptualisations and practices?

2. Methodology

The data are collected through videotaped IBST sessions and interviews with each NST about the video. Each lesson and interview are transcribed. Six NSTs intended to the inquiry (2 mathematics, 2 physics and 2 biology teachers). The activity system of each NST is elaborated from these transcriptions.

2.1. Basic components of the activity system

Four elements define professional knowledge (Grangeat, 2008, 2009):

- *Goal*: the teachers' purpose which is held individually or collectively (e.g. to maintain the learners' attention...).
- *Clue*: the piece of information picked out from the teaching situation, which is seen as relevant by teachers, and which activates a specific teaching strategy (e.g. when some students begin to chat...)
- *Repertoire of actions*: set of the teaching strategies which are triggered by the clue and orientated by the goal (e.g. so I organised a peer-work session...)
- *Reference knowledge*: the set of individual or collective knowledge which enable one situation to be matched to another, taking into account similarities and singularities, in order to define and justify a teaching strategy (e.g. since varying teaching often renews students' attention, thus I accustom students to learn by themselves through peer-work).

These elements compose a teacher professional knowledge which is called "teaching process-knowledge" for it addresses teaching as a long term process and not as a punctual action. The set of teaching process-knowledge which is built by each professional compose the activity system of this person (Engeström, 2000). This activity system is organised according to the main dimensions of the activity .

2.2. Dimensions of the activity system of new science teacher towards IBST

The activity which is addressed by this paper refers to inquiry based science teaching (IBST). Following the mid-term results of the S-TEAM project¹ IBST is built on six dimensions which represent a continuum:

- The origin of *questioning* which spur the inquiry: from teacher only to pupils' group only.
- The nature of the *problem* : from an open-ended problem introducing a new chapter to the existence of a research problem whose answer is not obvious, even for the teacher.
- The learners' level of *responsibility* for steering the inquiry: from following a standardized procedure to ensuring the control of a personal “hands on” process, including self-assessment.
- The consideration of pupils' *diversity* (cognitive, affective, social, gender, disability): from an unique way to conduct the class-room during inquiry to different ways and resources made available for the pupil's by the teacher.
- The role of *argumentation*: from presentation of the results of each pupils' group to comparison of each rationale.
- The level of *explanation* about what is learned during the inquiry : from implicit to explicit teaching about knowledge and meta-knowledge.

Each teacher, and specifically each NST, cannot be always on the top level of each dimension. Nevertheless, we think that debates could help NST -which, in 2010 in France, are very new teachers, quite student teachers- to overcome the first stage of each dimension of the IBST model.

3. Results

This study addresses three dimensions of the IBST model: responsibility, diversity, and explanation. These dimensions represent the content of the socio-cognitive debates within the SPPA.

3.1. Improving pupils responsibility towards inquiry

On the two first levels of this dimension teacher steer the inquiry. On the two upper levels, pupils are allowed to self-regulate the inquiry.

Level 1: Implementing IBST within the classroom. All the NSTs (6/6) involved in the study reach this level at least. Their activity system are generally built on 2 goals amongst [within brackets the number of NSTs who indicated each goal]:

- Allowing pupils to learn together [3].
- Indicating clearly to the pupils what they have to do [3].
- Enabling pupils to ask question to themselves and to propose some answers [2].

Level 2: Enabling pupils to conceive many solutions. This level is reached by 5/6 NST who generally follow 3 goals:

- Directing pupils' activity towards the expected inquiry process [3].
- Enabling pupils to achieve the task [2].
- Answering to pupils' questions [2].

¹ <https://www.ntnu.no/wiki/display/steam/SCIENCE-TEACHER+EDUCATION+ADVANCED+METHODS>

Level 3: Enabling pupils to be responsible of the inquiry process. Half part of the NST (3/6) reach this level; they follow 2 goals:

- Managing the use of laboratory material by the pupils [2].
- Maintaining active the object of the current inquiry within the pupils' memory [1].

Level 4: Enabling pupils' self-assessment. No NST reach this level which we observed within experienced science teachers practices.

3.2. Taking care of pupils' specific needs and diversity

On the two first levels teachers address generally to the whole class-room. On the two upper, teaching strategies are based on pupils team work.

Level 1: Coping with the behaviour of some pupils in order to make them more active. All the NST (6/6) involved in the study reach this level at least. They follow 2 goals amongst:

- Gaining pupils' attention and speaking to them [4].
- Coping with a disturbed pupil's behaviour [3].
- Allowing pupils to discuss and exchange [2].
- Helping a pupil who is encountering difficulties [2].
- Choosing the class-room with which the IBST will be implemented [2].

Level 2: Adapting the task to maintain pupils' involvement. Half part of the NST (3/6) quote teaching knowledge which belong to this level; they follow 2 goals:

- Coping with advanced pupils [2].
- Allocating more time to pupils to accomplish the task [1].

Level 3 : Verifying the understanding of each pupils team. All the NST (6/6) involved in the study reach this level; they follow 3 goals in mean:

- Choosing the pupils' team which need teacher's help [6].
- Creating the pupils' teams [4].
- Helping a pupils' team who is encountering difficulties [3].

Level 4: Adapting the teaching strategies to specific pupils. Only 1/6 NST reaches the top level of this dimension. The NST action aims to include a disabled pupil.

3.3. Making explicit what is tough through IBST

The two first level consist on clarifying teacher expectations. The two upper levels aim to spur pupils' metacognitive reflection.

Level 1: Making explicit teacher's goal for the current session. Our methodology cannot allow us to access this point for the interview addressed the 20 last minutes of the session.

Level 2: Making explicit what is been achieved during the session. One of the NST reports no knowledge about this dimension; the other (5/6) reach this level but they not overcome it. They follow 2 goals:

- Making explicit what is expected to be learned during the session [3].

- Keeping track of the results in order to anticipate the next session [2].
- Enabling pupils to master the scientific methodology [2].

4. Conclusion: new teachers as experts?

4.1. At what level NSTs are able to implement IBST within their class-room?

IBST can have different meanings thus we align ourselves with the S-TEAM and Mind the Gap² projects, which describe IBST as including:

- authentic and problem based learning activities where there may not be a correct answer;
- a proportion of experimental procedures, experiments and "hands on" activities, including searching for information;
- self regulated learning sequences where student autonomy is emphasised;
- discursive argumentation and communication with peers ("talking science").

Within this paper we studied only the third part of this definition which we completed by a specific focus on explanation for it is a strong component of self-regulated learning.

The results show that the 6 NSTs are able to implement within their class-rooms some teaching strategies which are relevant for the three dimensions of this study: responsibility (6/6), diversity (6/6), explanation (5/6). They are able to reach the upper levels of two of three of these dimensions: the results highlight a weakness with respect to the ability to make explicit what is learned through IBST.

Consequently, after the SPPA sessions, NSTs are able to implement IBST session in which pupils responsibility is emphasised and in which they pay attention to pupil's diverse needs; in some extent, they make explicit their expectation for and what is learned through IBST session. Thus, in some extent, such new teachers could be called "expert" teachers.

4.2. Does debates amongst NSTs' alter their conceptualisation and practices?

Within our theoretical framework, teacher knowledge should come both from interactions amongst colleagues and from teacher education or training. We had found that kind of results with experienced teachers (Grangeat, 2008; Grangeat & Gray, 2007). Nevertheless, surprisingly, this hypothesis seems to be irrelevant to NSTs' case. Through observations and interviews, they report few interactions which could improve their practices: few colleagues and partners are quoted (a mentor, a person who is responsible of the laboratory, and another who help a disabled pupil are mentioned once); teacher education is only quoted in a very generic way (teacher education institute is mentioned as a whole which had enabled NST to implement IBST). Thus, we could conclude that NSTs act in a strongly individual way and that teacher education cannot change their conceptualisations and practices. It could be a very strange result!

Deepening the study, we compared the NSTs' teaching process-knowledge (goals, clue, repertoire of actions, reference knowledge) with the material which was dealt by teacher educators during the SPPA. We

²<http://www.uv.uio.no/english/research/projects/mindingthegap/about/index.html>

found a strong coherency amongst NSTs' teaching process-knowledge and knowledge which was explicitly discussed and taught during the SPPA. These similarities consist on :

- Supporting each pupil towards overcoming complex and challenging problems.
- Paying attention to pupils solutions which aim to resolve the problem.
- Helping pupils to find out a solution to resolve the problem.
- Providing feed-backs about pupils progresses towards overcoming the problem.
- Creating heterogeneous teams amongst pupils in which each person could contribute.
- Creating equitable opportunities for all kind of pupils.
- Asking to shift amongst different ways for writing procedures and results (draw, diagram, text).
- Writing the mid-term results.
- Discussing about methodology.

Consequently, through implicit and no direct ways, the socio-cognitive debates which were organized during the SPPA seem to contribute to the change of the NSTs' conceptualisations and practices about IBST.

4.3. Perspectives

These results need further studies in order to confirm the contribution of SPPA with respect to the three dimensions which were studied by this paper. They need also to extend the study toward the other dimensions of the model: the origin of the questioning (teacher vs pupils vs authentic problem from actual life); the nature of the problem (open-ended problem vs problem with no correct answer); role of argumentation (presentation of the right answer vs debates about methodology and results). Finally, further studies need to focus on experienced teachers.

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