On the diffusion of professional praxeologies at university level: the case of investigation workshops.

Jean-Pierre Bourgade

Difficulties of the profession and dissemination as catalysers for the construction of professional praxeologies

Jean-Pierre Bourgade
Aix-Marseille Université, EA 4671 ADEF, ENS de Lyon (Aix-Marseille, France)jean-pierre.bourgade@univ-amu.fr

The introduction of didactic devices such as investigation workshops at university level reveals some difficulties related to missing professional praxeologies. Indeed, the paradigm of the visit of works is dominant in those institutions where a 'pedagogy of teachers' is widespread: investigation workshops require the mastery of a 'pedagogy of investigation', which is based on different professional praxeologies. The aim of this work is to present a didactic analysis of the exploration of a professional type of tasks related to the design of generating questions for such a workshop. We chiefly underline the parts played by the encounter with difficulties of the profession and the processes of dissemination of praxeologies: these two types of situations prove to be catalysers of the construction of praxeologies, in particular in the elaboration of the logos *of professional praxeologies.*

Keywords: Anthropological Theory of the Didactic, Generating Questions, Investigation Workshops, Problems of the profession, Professional Praxeologies.

INTRODUCTION

Investigation workshops have been introduced by Yves Chevallard (2011, see also Marietti 2009) at the Collège du Vieux-Port, in Marseille, at high school level (students aged 13) and were based on previous works in the frame of the Anthropological Theory of the Didactic (ATD). This was not only a new type of didactic device but also a laboratory for investigations on the professional praxeologies required when a teacher works in the frame of a new didactic paradigm (Chevallard 2013) of *questioning the world*. This paradigm is opposed to the paradigm of the *visit of works*: currently at school in France, students are required to study barely motivated (mathematical) works, which they *visit* just as tourists visit works of art or monuments, that is artificially, since it is not their own questioning that led to this visit but rather a formerly and firmly established program of visit (established by the tour operator in one case, by the ministry of education in the other case). On the other hand, a new paradigm of study emerges with difficulty, in which what is under consideration at school no more is a collection of yet established works, that is answers without questions, but rather *questions needing answers*. The aim of the study is then to elaborate collectively an answer to a question, without prejudging which works might be crossed in the course. In this sense, an investigation workshop leads to the development of a study and research path (SRP), which differs from *praxeologically finalised SRP* (Chevallard 2011), and the management of such a *praxeologically open SRP* raises different professional difficulties, especially in relation with the fact that the 'teacher' no longer knows up to what point, nor in

which direction, the investigation has to be led: he does not play the role of a ‘director of the study’, rather that of an ‘aid to the study’.

The ‘Investigations on the Internet’ workshopsat the Collège du Vieux-Port were based on the study of short or medium range questions (four questions were studied in 18 hours the first year). Investigation workshops have also been introduced at University level (students of engineering sciences, aged 18) at *la prépa des INP* in Toulouse. This institution is a preparatory class that leads to engineering schools after two years of intense training in sciences and humanities. Teaching is generally organised following the visit of works paradigm and pedagogy is on the whole*pedagogy of teacher*. As Marietti (2009) mentions it, “today, the transition from the paradigm of the visit of works and from a pedagogy of teacher to a ‘questioning’ paradigm served by an adequate pedagogy of investigation constitutes an open problem” and an important challenge not only is to train teachers in pedagogy of investigation, but already to provide the profession with the identification of praxeological needs and the construction of professional praxeologies to answer these needs.

In this communication, we address the following question: to what extent is the elaboration of a professional praxeological equipment dependent on professional difficulties on the one hand, and on the dissemination of this equipment on the other hand? The author of these lines initiated and supported during two years the implementation of an investigation workshop at *la prépa des INP*. In an institution where no investigation workshop had ever existed previously, the author had to realise a certain number of professional types of tasks related to the design and implementation of the workshop; then, after changing of institution, he had to pass onto his colleaguesthe praxeological equipment needed for the realisation of these types of tasks. In this communication we proceed to give a didactic analysis of the construction of part of this praxeological equipment; we mainly focus on a specific type of tasks related to the formulation of a generating question and try to identify, in the history of the workshop, the realisation of several didactic moments (first encounter, exploration, building of the technological-theoretical block). In a general fashion, the construction of a professional technique by the subject of an institution does not necessitate the productionof a very elaborate *logos* regarding this technique. While, in classrooms, the teacher designs didactic situations where an epistemological obstacle makes it necessary to elaborate further the technique and, consequently, to discuss it, thereby enriching the *logos* on the technique, in a professional context, only a-didactic situations are expected to generate elaborate *logos*. The analysis in terms of didactic moments enables us to identify two catalysers of the *logos* production in the building process of a professional praxeology: professional difficulties and dissemination issues. Finally, the construction of a praxeology also benefits from the *a posteriori* analysis such as the analysis presented in this communication, which can be read as an evaluation and development of the praxeological equipment built up to now.

HOW TO ASK A QUESTION? FIRST ENCOUNTER AND EXPLORATION

We briefly remind the reader with the praxeological model (Chevallard 2007) introduced in the ATD, according to the which any human action can be modelled as the realisation in a given institution of a certain type of tasks *T*, using a technique τ that can be justified in the institution under consideration by means of a certain discourse on the technique, a technology θ, which can in turn be grounded on a theory Θ. The quadruplet [*T*/τ/θ/Θ] is called a *praxeology*. The study of a given praxeology can be described by the identification of at most six didactic moments (Artaud 2011): the moment of first encounter with the type of tasks and of its identification, the exploratory moment (or moment of the emergence of the technique), the technological-theoretical moment, the praxeological-work moment, the moment of institutionalisation and the moment of the evaluation of the praxeology. In this communication, we will seek to identify both the praxeology under construction for the realisation of a certain type of tasks, but also to make the analysis of the process of study of this praxeology in terms of didactic moments. This will enable us to clarify the parts played by professional difficulties and dissemination issues in the elaboration of a praxeology, especially in the construction of its technological-theoretical block.

The introduction of an investigation workshop at *la prépa des INP* was a lengthy process for the author of this communication (hereinafter designated by the letter *y*); at first *y* consider that one of the aims of the workshop was to[1] "promote the emergence of a mathematical knowledge in a functional context of application" (FRR). By that time, *y* had an indirect acquaintance with the design and implementation of study and research paths (SRP), mainly by reading scientific papers dedicated to these devices. While the management of praxeologically finalised SRP has been considered with accuracy (see Bosch 2010, Chevallard 2011, Ruiz-Munzón 2010 for instance), a guess is that the praxeological equipment related to the pedagogy of investigation also requires components for the *design* of a SRP. In particular, the formulation of a generating question is a problem of the profession, which is generally barely addressed, at least as such and in an explicit way. In the case of praxeologically finalised SRP, a praxeological model of reference (PMR) is built, which indicates the possible paths that can be followed in the study of a given mathematical work (see *e.g.* Ruiz-Munzón 2010 for algebra as a model for arithmetics). As such, it also partially governs the design of the generating question and we can assume that the design of the question is performed in a dialectical process with the construction of the PMR: the design of the question is generally related to the mathematical praxeologies at stake.

In an investigation workshop, the students are asked a question, but the 'teacher' has no clue regarding the works that will be encountered in the process of the

[1] Unless otherwise stated, the quotations are drawn from a funding request report (FRR) and from the author's logbook (LB).

investigation. This can seem to conflict with the idea of aiming at the 'emergence of a [*given*] mathematical knowledge': as a matter of fact, the questions were first selected in order to reassure *y* in an institutional context where the paradigm of the visit of works is dominant. Under these constraints, *y* had to design a generating question for a SRP that would (hopefully) lead to the encounter with mathematical works but would, at the same time, remain praxeologically open. This is a realisation of the moment of first encounter and of identification of the type of tasks:

T_Q: "Design a generating question for an investigation workshop"

The moment of exploration of this type of tasks was realised in collaboration with a high-school teacher at first, then with a didactician, and progressively led to following technical component[2]: to design a generating question, you have to choose a question which ensures the encounter with mathematical works; though, you must not study the question yourself. Technological components were very limited at that stage since *y* did not have to justify to anyone but himself –and this personal justification boiled down to the fact that studying the question is forbidden in order to avoid the selection of the works that will be studied (which would mean designing a praxeologically finalised SRP).

Using this technique, *y* had selected two questions: the first question was provided by the high-school mathematics teacher who had asked it after reading an article in a mathematics journal for teachers; *y* had elaborated a second question after an investigation based on the reading of a biographical article on Leonhard Euler. In the opinion of *y* at this time, both questions had the advantage of ensuring the encounter with some specific mathematical praxeologies (linear spaces, matrices, eigenvalues, etc.).

A few days before the initiation of the workshop, the two selected questions were:

Q_1: "Some photo editing software can sharpen blurry photos. How do they do it?"

and "There are numerous constraints on the building of a bridge. In particular, the bridge is required to support heavy loads. How is it possible to foresee the maximum weight a bridge can withstand?" (LB) Nevertheless, after a working session with a didactician, the second question was abandoned in favour of the following:

Q_2: "Some mobile phones do not enter into standby until the user stops looking at them. How is it possible?"

Obviously, the didactician had something in mind while proposing this question to replace the question about bridges: *y* understood it as a way of proposing a sharper question, which would facilitate the starting of the workshop by focusing on the

[2] As our task here is to analyse the influence of professional difficulties and dissemination processes on the emergence of the praxeological equipment of *y*, we do not proceed to evaluate this equipment; in particular, we do not enter into a discussion of the validity of the emerging techniques.

students' interests. Also, this new question was not designed in order to insure the emergence of mathematical praxeologies –and even less, *chosen* mathematical praxeologies. This episode was a further realisation of the exploratory moment and led to a modification of the technique: the question had to be chosen 'sharp' and independently of any *a priori* knowledge regarding the sort of mathematical works that would be encountered in the study of the question.The technology was still very limited since it only included the fact that a sharp question would enhance the students' motivation to work.

PROFESSIONAL DIFFICULTIES AS A DRIVING FORCE FOR PRAXEOLOGICAL CONSTRUCTION

Surprisingly enough for *y*, the exploration of this type of tasks was constantly renewed overtwo years. Indeed, *y*expected $T_Q$to have a paramount importance at the start of the workshop, but not necessarily once the workshop was launched.

Managing without leading

At the beginning, students were interested or even *seduced*by the workshop: the freedom given them to investigate in any direction and in a large autonomy was appealing. Nevertheless, several students soon confronted *y*with a reluctance to accept parts of the didactic contract of the workshop (*e.g.*"Continue your investigations as far as you may"); some claimed to have found a satisfactory answer at a very early stage (after one session): "Five minutes after the beginning of the [second] session, two students come to *y* and claim that their team has 'found the answer'." To deal with this problem, *y* asked several questions with the effect that the students concluded that their answer was actually "crappy" (LB). This early incident was only the first of a long series that reached its climax on the eve of Christmas holidays when a team refused to work during all the session, only to end with a provocative speech directed to *y*, blaminghimfor not giving help and refusing to give precisions regarding the sort of answers that were expected. During the second session (out of 15 one-and-a-half-hour sessions), a girl had already complained: "What is it about? Do we have to program a phone? Do we have to understand engineers' programs?" (LB). A boy of the same team was upset by the fact that "we will never know whether the answer is satisfactory" (LB). We can model the previous incidents as follows. The workshop requires that *y* realises the following type of tasks:

T_{MW}: "Manage a group of students in the frame of an investigation workshop"

By the answers he gives to a reluctant team, *y* gives a hint of the kind of technique he has elaborated: not to give a direct answer (yes or no) to the question "is our answer satisfactory?", rather ask questions about the elements of the submitted answer in order to allow the students to identify weaknesses in their proposition. Though it seemingly leaves an important *topos* to the students, this technique, however, raises a problem: letting the team set their own stopping criterion gives no means to tackle the problem raised by teams that believe they have a satisfactory answer and that their

criterion for satisfactoriness is satisfactory. Letting the students choose the stopping criterion can lead them to minimal criterions. There remained to seek a solution, which would not rely on a return towards the 'pedagogy of teacher' by allowing *y* to impose his own criterion since this would conflict with the idea of an *open* SRP and, more specifically, with the goals of the investigation workshop: this workshop was indeed designed as a device for the diffusion of didactic praxeologies such as investigation techniques, etc. Therefore, choosing a stopping criterion can be considered as an essential part of the praxeological equipment that students have to elaborate and make theirs in the course of the workshop.

In search of a third way

A first analysis of the situation led *y* to conclude that there were actually two ways of managing the workshop: either the study aid *y* imposes a stopping criterion, or he leaves it to the students to select their own stopping criterion. The first way was soon rejected by *y* for the above-mentioned reasons.The second way of dealing with the stopping criterion difficulty (to leave it to the student) was first considered ideal by *y*, buthe had no idea how to avoid the production of minimal criterions or, on the contrary, the production of 'satisfactory' (from the 'teacher's' viewpoint) criteria for non satisfactory (from *y*'s viewpoint) reasons: benevolent students could follow implicit stopping criteria matched to the didactic contract ('in *classes préparatoires*, it is expected that the student goes as far as possible', etc.) – though maximal, such a criterion would not emerge for functional reasons, but rather for ecological reasons, which *y* considered was a flaw.During the first year, *y* did not really change his vision of this difficulty of the profession. No sooner than in the month of June did he note that: "asking a question that would lead to a *production* [*would*] avoid the difficulty due to the absence of a stopping criterion" (LB). This is the first sign of the existence of a possible third way to address the difficulty met in realising T_{MW}.

A new *raison d'être* for T_Q

It must be stressed that up to that moment, *y* had understood the difficulty met in the management of the workshop as relative only to his management praxeologies. Only at that time does he consider the possibility that the design of the generating question may have an influence on the stopping criterion issue. This is a realisation of both the exploratory moment and the moment of the construction of the technological-theoretical block: while the technique slightly evolves ("asking a question that would lead to a *production*"), the technology now includes a new *raison d'être* for T_Q: the design of a generating question must take into account the fact that the question itself may be helpful to tackle the difficulty of the stopping criterion[3].

[3]The realisation of the type of tasks T_Q is subject to many other constraints; we choose to focus here on the relation it has with T_{MW} for several reasons, among which is the fact that the exploration of T_Q described herein is closely articulated with the confrontation with a difficulty in the realisation of T_{MW}.

Enhancing the technological-theoretical block

In an attempt to explore further T_Q and improve the technique under construction, *y* came across a distinction between two types of questions, which had been made by Chevallard in his *Séminaire* (Chevallard 2010): technical and technological questions. The difference lies in the use of distinct interrogative pronouns –or on the possibility to reformulate questions using one of the two pronouns, *how* and *why*. A *how*-question is a technical question in which it is expected that the person describe a technique commonly used in a given institution to realise the task referred to in the question. A *why*-question leads to an explanation (technology, in the sense of the ATD) of the use in a certain institution of the technique referred to in the question.Questions Q_1 and Q_2 were first analysed by *y* as being technological questions: though apparently *how*-questions, they pulled the students towards the necessity to explain *why* such or such technique was used, or *why* such or such device actually worked. To put it another way, *y* thought at first that the problem met in the managing of the group was originated in the fact that the questions asked for *explanations* (technologies) and that the students were provided with no *a priori* criterion for the kind of admissible explanations. Indeed, many teams proposed explanations of a divulgation type –leaving all technicalities unstated.

One could argue, though, that both questions are technical: Q_1 asks "how do they do it?", while Q_2 asks "how is it possible?". Answering the first question is to give a description of a technique used "to do it" in a given institution. To answer the second question, it is necessary to explain *why* a certain technique actually works ("how is it possible?" read as "why is it possible"); yet, to explain *why* something works, it is first necessary to show *how* it works, unless the "how" be given in the question – which was not the case here. The interpretation by *y* of his difficulties was therefore not entirely satisfactory. Nevertheless, it is a milestone in the process of exploration of T_Q: the identification of the link between T_Q and T_{MW} indicates a certain direction for the elaboration of a technique for the realisation of T_Q, while the previous explanation (the questions were "technological"), though incorrect, is a technological element of the praxeology under construction. Finally, let us point that this thinking on the relations between T_Q and T_{MW}also gave a hint about a part of a technique to realise T_{MW}: managing an investigation workshop can be difficult, but a good realisation of T_Q can make the job easier.

DISSEMINATION AS A DRIVING FORCE FOR *LOGOS* CONSTRUCTION

After two years, *y* left *la prépa des INP* and a new team of teachers took the responsibility of the investigation workshop: a teacher of English (y_1), a mathematics teacher (y_2) and a physics teacher (y_3). None of them was acquainted with didactics of mathematics, with the ATD or with pedagogy of investigation –though the three of them had already had an important thinking on their professional (pedagogical) techniques. We will now shortly report on the process of formulating two questions for the workshop as it can be observed in *y*'s logbook and in the e-mails exchanged with the y_i's.

Exploration of T_Q by the y_i's…

First, expectedly, y_2 had designed questions related to mathematics (or that would rapidly reach mathematical problems): *y* has consequently swept aside these first questions by clarifyingthe aims of the workshop to y_2(we find here the first elements of the technique elaborated by *y* in the first year of the workshop). After some days, a new question arises:

> "How to detect counterfeit artworks?"
>
> Comments by y_2: "Problem: can the question asked to the students result in a catalogue of existing techniques […]? […] Up to what point should we investigate to make sure that the question provides a field of investigation neither too wide nor too closed […], without investigating for them?" (Common logbook of $y_{1, 2, 3}$, 9/13/2015)

The comments made by $y_2$show that part of the technology for T_Q has been acquired by the y_i's since they recognise the potential influence of the generating question on the ways the students might answer it. Here is a comment formulated by *y*:

> "I think we should find a wording that would allow the students to enter into an investigation that would not finish rapidly in a catalogue of existing answers. […] The question […] should be converted to a 'could you do…'-question." (e-mail to y_i's, 9/11/2015).

Here appears the following technological component: "the generating question must be designed in such a way that the investigation will not result in a catalogue of existing answers". The technique is based on this element: designing a "could you do"-question is, at that time, supposed to avoid the encyclopaedic menace. However, this technology does not seem to convince the y_i'swho propose to *y*yet another generating question:

> "To meet energy needs of humanity, how can we use human beings themselves to produce dailya useable energy?" (e-mail, $y_{1, 2, 3}$ to *y*, 10/1/2015)

The questionis'sharp' in its reference to the energetic problem, and also independent of chosen mathematical praxeologies: it matches with the first requirements identified by *y* for a "correct" realisation of T_Q. Nonetheless, itis *not* a"could you do"-question – though we observe an attempt to "make technical" the questions by introducing interrogative pronoun "how"; in response,*y* proposes the following wording:

> "To meet energy needs of humanity, it can be contemplated to use energy produced by human beings themselves. Could you suggest a device that would allow covering the needs in energy of the amphitheatre of *la prépa* using only (or mainly) the energy produced by its users?" (e-mail to $y_{1,2,3}$)

…enhancement of the technological-theoretical block by *y*

Here, *y* produces a "could you do"-question. Nevertheless, the technology of this technique is not well shared with y_i's since, in his message, *y* only gives the question and provides no rationales for the modifications he made. The technology of the

technique proposed by *y* at this stage was essentially this: if the question is asked at the level of the teaching institution, students will *have* to study it until an effective result is obtained (a more efficient heating of the amphitheatre, *e.g.*). This modification of the technology can be understood as the effect of the reaction of the *milieu* constituted by the y_i's: the inadequacy of their propositions (though they formally match the requirement of producing 'technical' questions, that is *how*-questions in the sense of Chevallard 2010) forced *y* to question further the reasons why these propositions did not satisfy him. In the following weeks, *y* proceeded to read again (Chevallard 2010) and came across the following comment:

> "When [the institution] is elided [in the question], it is as if it was unique and as if there also existed a technique, also unique and therefore implicitly universal, which would give an answer to the initial question. This is a language effect that represses and hides the institutional relativity of praxeologies."

The evocation of the institution '*la prépa des INP*' in the rewriting of the generating question by *y* can be read as an attempt to make explicit the institution in which the answer must be produced or, to put it more precisely, in which the constructed praxeologies will be used (and, therefore, have to be usable). This new technological component could only be elaborated in the confrontation with competitive rationales produced by the y_i's, such as: "Thanks for the [question], I feel [it is] indeed *more precise* with your modifications" (e-mail from y_1 to *y*, 10/8/2015, my emphasis). The justification by the 'precision' of the question did not match with the intentions of *y*,who had to elaborate further on his own justifications for his techniques (another realisation of the technological-theoretical moment).

CONCLUSION

As he or she takes the responsibility of the realisation of a new (for him or her, or for the institution) type of tasks in a given institution, a subject of this institution generally first encounters the type of tasks and goes on to elaborate a technique to deal with it. The justification of the technique is usually left at a low level of clarification, unless a peculiar *difficulty* makes it necessary to further explore the type of tasks and to analyse the reasons why the previous technique failed to work. However, it is only when the subject of the institution has to disseminate the praxeology under construction towards other subjects of this institution that the construction of a *logos* reaches its highest level: tackling with their difficulties necessitates the explication of previously semi-unconscious choices, etc. Notably, this collective process is the illustration of the conversion of a *difficulty* of the profession into a genuine *problem* of the profession in the sense that an instance takes the responsibility to study it and formulate a (partial) answer (Chevallard et Cirade, 2010).

In the case under consideration in this communication, one step further was taken in the process of submission of the paper since the referees comments led *y* to relate the praxeology evoked in this paper with other techniques used *e.g.* by Ruiz-Munzón

(2010) in her realisation of T_Q: in her work, the choice was made to consider the class as a *consultancy service* with the objective to answer (real or imaginary) companies' demands. The common point with the praxeology presented here probably lies in the inclusion in the question of a precise institution –which amounts to include in the question some clues regarding the 'stopping criterion', living it to the students to build after the situation presented in the question a satisfactory criterion. The choice made by *y*was characterised by a close relation between the demanding institution (*la prépa des INP*) and the answering institution (an investigation workshop at *la prépa des INP*), which can be read as an autarkic version of the 'consultancy service' fiction.

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