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Didactic Transposition: From theoretical notion to research programme

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Abstract. The term *didactic transposition* refers to the deconstruction and reconstruction of science knowledge, values or practices in order to make them teachable. In this paper, I present the theoretical framework that has grown around this notion. I use examples from different levels of science education and different subjects to illustrate how science is transformed in any teaching undertaking, and how that transformation influences the way science is experienced and appropriated by learners. The chosen examples also illustrate the development of the notion of didactic transposition from a descriptive framework to the more normative construct of today (the Anthropological Theory of Didactics or ATD), where it converges with other comparable frameworks, e.g. the Model of Educational Reconstruction.

Key words: didactic transposition, transformation of knowledge

What is didactic transposition?

The word *didactic* exists in many languages, but does not have the same meaning everywhere. In the British Merriam Webster online dictionary, one finds the adjective ‘didactic’ to describe something that is designed or intended to teach people something. Furthermore, it is often used in a negative sense, to describe someone or something that tries to teach something (such as proper or moral behaviour) in a way that is annoying or unwanted. Indeed, in Webster’s New World dictionary, ‘didactic’ means too much inclined to teach others; boring or pedantic and moralistic.

In this presentation however, I refer to the word ‘didactic’ in its continental European sense. In Germany, for example, the noun ‘didaktik’ concerns the analytical process of transforming human knowledge, such as domain specific knowledge, into knowledge for education (Duit, Gropengießer, Kattmann, Komorek, & Parchmann, 2012). Similarly in French, the noun ‘didactique’ refers to the science that takes the teaching of disciplined knowledge as its subject. The phenomena that are relevant to the didactique of a science are those that pertain to its dissemination (Artigue & Winsløw, 2010; Clément, 2000). In the following, I use the adjective ‘didactic’ to refer to the processes that have to do with creating knowledge for teaching or dissemination, and I use the noun ‘didactics’ to describe the science of teaching specific bodies of knowledge.

This clarification, in turn, prompts the question: What is meant by the term ‘knowledge’? Here, I use the term in the sense of the *knowledge, values and*

*practices that comprise a science discipline, e.g. chemistry or physics (cf. Clément, 2006). I see knowledge as a result of human endeavour. In other words, knowledge is not a fixed or ‘true’ entity, but rather, it is produced, changed, and sometimes eliminated by the humans that use it. In fact, an ecological metaphor may be used to describe the way knowledge circulates in human society. According to this metaphor, knowledge becomes adapted to *institutions* much as plants become adapted to their environment. This means that ‘transplantation’ of knowledge from one institution (or ecology) to another is sometimes possible, sometimes difficult, but never trivial (Winsløw, 2014).*

This transplantation of knowledge between institutions, and the subsequent and necessary adaptation of that knowledge to the new conditions in each institution, is exactly what is meant by the term ‘didactic transposition’ (Chevallard, 1991). Consider Figure 1. Here, an object of knowledge is translocated between contexts, and undergoes substantial trans-formation (or adaptation) along the way, finally becoming the knowledge acquired by learners.

The process of didactic transposition takes place whenever somebody intends to disseminate or teach disciplinary knowledge to somebody else. Thus, didactic transposition takes place in relation to formal schooling situations, but it can also take place in other situations such as in the media, at the work place, or in relation to science centres and museums (Clément, 2000)

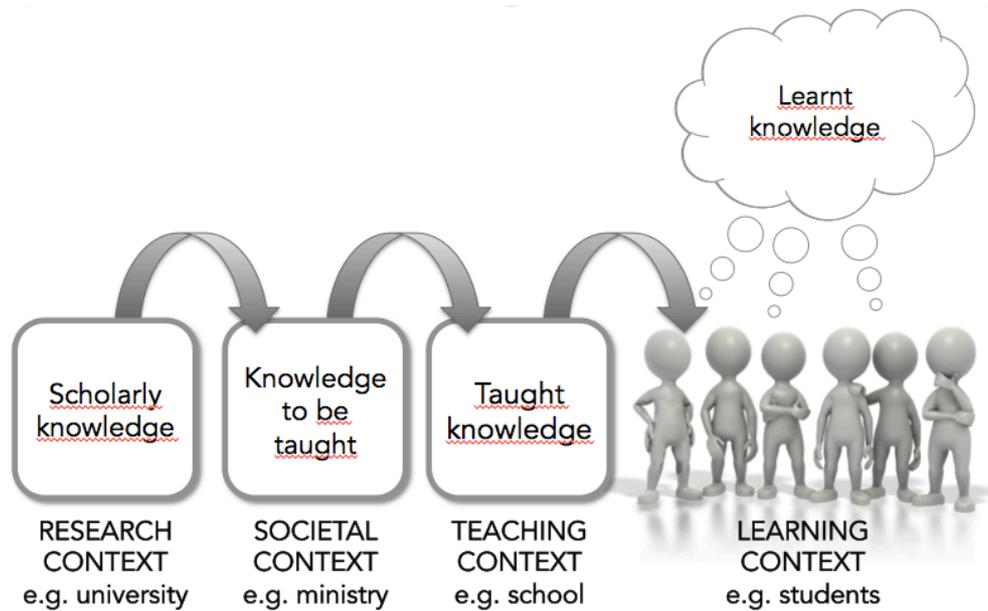


Figure 1. *Didactic transposition: An object of scholarly knowledge is produced, typically in a research context. It is then selected and rearranged in a societal context to become part of the knowledge to be taught, for example as part of an official curriculum. It is then again translocated and transformed into the knowledge actually taught in a teaching context, e.g. a classroom. Finally, it is acquired by learners, becoming learnt knowledge.*

As mentioned in the preceding, the process of didactic transposition entails the successive adaptation of an object of knowledge to the institutions or ‘ecologies’ it is transplanted to. These adaptations may include reorganisation, substitution, simplification, enrichment, and modality changes. Consider the following example from palaeontology: In the early 1900s the Burgess Shale, a fossil deposit, was discovered in the Canadian Rocky Mountains. One fossil, *Sidneyia inexpectans*, was very common, but there was significant doubt as to how to classify it, since all the discovered fossils were flattened between their armoured back and their armoured underside. Because fossils are essentially two-dimensional, the features required for the definitive classification of this animal (a marine arthropod) were concealed between the flattened, fossilised armour of the fossil’s back and that of its underside. In particular, details of the animal’s gills and legs were necessary for its classification.

However, palaeontologist David Bruton was able to carefully separate the layers of the fossils, and discovered that the three-dimensional structure of the animal was somewhat intact between the flattened layers of its armour. He subsequently managed to reconstruct the details of *Sidneyia*’s morphological structure, which were subsequently published in a scientific monograph (Figure 2).

Several points may be made regarding the case of *Sidneyia inexpectans*. First of all, it represents an instance of didactic transposition in the dissemination of knowledge from researcher to researcher, because David Bruton published his illustration in a peer reviewed scientific periodical.

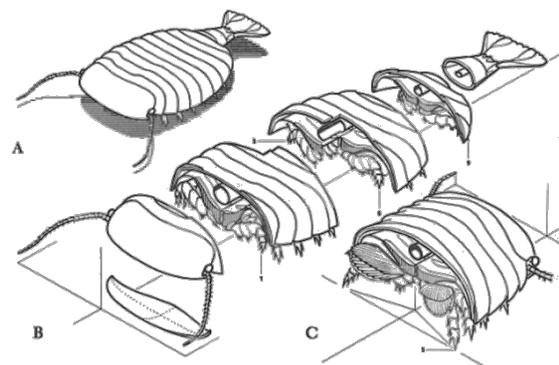


Figure 2. *The morphological structure of *Sidneyia inexpectans*, a marine arthropod, reconstructed from essentially two-dimensional fossils by David Bruton (1981). Significant features of its gills and legs are seen in this illustration that are not visible in any of the discovered fossils.*

For the purpose of convincing his fellow researchers of his correct classification of *Sidneyia*, the features that were significant to its

classification but not visible on the fossilised animal (the structure of the legs and gills) were clearly illustrated in the monograph (Figure 2). The illustration of *Sidneyia* is thus what is called a *didactic object*, an object created for the purposes of dissemination but which has no counterpart in the real world. Indeed, there are no living exemplars of *Sidneyia inexpectans*.

Second, the case of *Sidneyia* illustrates how an object of knowledge may change modalities. Originally, the scholarly knowledge about *Sidneyia* resided mainly in the two-dimensional fossils themselves. However, that knowledge was subsequently transposed into illustrations of its three-dimensional structure, entailing a modality change from a two-dimensional object to a representation of a three-dimensional structure.

As mentioned in the preceding, scientific *values* and *practices* are subject to didactic transposition in the same way as scientific *knowledge*. Consider another example, this time of the didactic transposition of a palaeontological practice: Fossils are important to palaeontologists because they can make inferences about extinct animals based on the clues embodied in the fossils. In the example shown in Figure 3, a hands-on museum exhibit invites visitors to assemble the bones of an Iguanodon's foot - an activity that has been transposed from the practice of a real palaeontologist to become the practice of the museum visitor.



Figure 3. A hands-on exhibit in the Palaeontology Lab at the Royal Belgian Institute of Natural Sciences in Brussels. Casts of fossilized Iguanodon foot bones can be fit together by visitors using the outline on the table. Photo by M. Achiam.

In this case, of course, the palaeontological practice has been simplified in the process of didactic transposition. The visitor does not encounter the real conditions of a fossil dig, nor

are they faced with missing or potentially confusing bones from other sources. In other words, the palaeontological activity has been adapted to the ecology of a museum exhibition, more specifically the discovery pedagogy typical of hands-on activities.

In summary, didactic transposition refers to the transformation and translocation of scientific or disciplinary knowledge carried out in order to make it teachable and learnable by its target audience. In the words of Guy Brousseau, 'didactic transposition [...] is at the same time inevitable, necessary and, in a sense, regrettable. It must be kept under surveillance' (Brousseau, 1997/2002, p. 21). Didactic transposition is *inevitable* and *necessary* because we cannot just transmit scholarly knowledge directly into the minds of learners; rather we must first transform it into a teachable and learnable form. This is because the contexts of scientists in which scholarly knowledge is constructed are clearly not similar to the contexts of learners in school or other educational situations (Fensham, 2002). However, didactic transposition is *regrettable* because any transformation of knowledge runs the risk of introducing oversimplifications or even mistakes. Therefore, Brousseau reminds us, we must keep it under surveillance. In the following, we will delve a little deeper into the implications of such surveillance.

Emancipation of the researcher

Becoming aware of the process of didactic transposition means becoming aware that the scholarly knowledge produced in research contexts is different from the knowledge to be taught in educational contexts. This means that we, as researchers of didactic phenomena, must free ourselves from the viewpoint of the educational institution with respect to the knowledge in question (Chevallard & Bosch, 2013). As an example, consider the following case of introductory thermodynamics, published by Christiansen and Rump (2008):

Christiansen and Rump investigated three courses on Introductory Thermodynamics given by three different departments at the Technical University of Denmark (DTU). Specifically, they were interested in the elements of thermodynamics knowledge that were shared by the three courses, and that appeared in the textbooks for the courses as well as in interviews with the course teachers. In other words, they studied the 'taught knowledge' of didactic transposition (Figure 1).

The authors used the *technical matrix* in the study as a way to systematically account for the various disciplinary components of thermodynamics (Hendricks, Jakobsen, & Pedersen, 2000). Briefly, the technical matrix describes a discipline in terms of its characteristic objects, methods, values, theory structures, exemplars, and epistemic and ontological assumptions.

In their study, Christiansen and Rump compared the technical matrices of the three courses given by the respective departments of Physics, Chemical Engineering, and Mechanical Engineering. In spite of all three courses being about introductory thermodynamics, the researchers found vast differences in the content of the courses. A particularly striking example is the way the three course teachers described the basic thermodynamics notion of an engine:

You have a hot reservoir (at temperature T_H) and a cold reservoir (T_L), and some sort of 'contraption' which receives heat from the warm reservoir and delivers to the cold reservoir, while performing a work (W) (course teacher from the Department of Physics; see Figure 4).

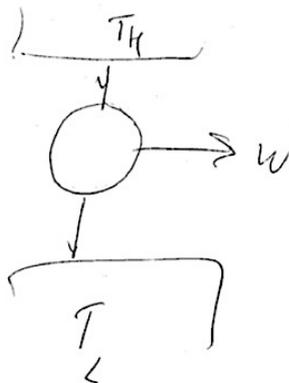


Figure 4. Drawing made by the teacher from the Department of Physics to illustrate an engine.

From a pedagogical perspective it is important for the students, in addition to understanding the Carnot cycle, to see examples of cycles that are physically realisable (course teacher from the Department of Chemical Engineering).

An engine could be a steam turbine... and that means a collection of components that operate a thermo-dynamical power cycle... The mechanical components needed for a power cycle to take place in the real world (course teacher from the Department of Mechanical Engineering).

Although I cannot give sufficient detail here to do it justice, the study by Christiansen and Rump demonstrates the *institutional relativity of knowledge*, or how there 'is no such thing as an eternal, context-free notion or technique, the matter taught being always shaped by institutional forces that may vary from place to place and time to time' (Chevallard & Bosch, 2013, p. 3). Clearly, the teacher from the Physics Department sees an engine as a much more abstract entity than, for example, the teacher from the Department of Mechanical Engineering, who emphasises the real world in his explanation. These differences accrue from the different institutional backgrounds of the teachers and the taught courses, respectively (Christiansen & Rump, 2008).

For us, as didactics researchers, this means that we should never take for granted the organization of any taught discipline as if it were the only one possible. Instead, we should view the structure of taught disciplines against a backdrop of the various structures that are *possible*, considering also the scholarly knowledge (Chevallard & Bosch, 2013). The study by Christiansen and Rump gives us glimpses of three different possible organisations of introductory thermodynamics; the consideration of such alternative organisations (or adaptations of knowledge to different ecologies) is an important part of the researcher's necessary emancipation or detachment from any given institutional viewpoint. It is not that these institutional viewpoints are wrong (nor are they 'true' or necessarily correct), they are simply answers to specific institutional requirements, and must therefore be considered in any analysis of didactic phenomena (Bosch & Gascón, 2006).

Enlargement of the unit of analysis

It follows from the preceding discussion that a second important implication of didactic transposition is the necessary enlargement of the unit of analysis in didactics research. In the words of Chevallard and Bosch (2013, p. 3):

Besides studying students' learning processes and how to improve them through new teaching strategies, the notion of didactic transposition points at the object of the learning and teaching itself, the "subject matter", as well as its possible different ways of living—its diverse ecologies—in the institutions involved in the transposition process.

To exemplify the necessity of enlarging the unit of analysis, consider the following study carried out

by Clément (2007) in which the concept of the cell is studied in biology textbooks for French secondary school. Specifically, Clément studies the depictions of animal and plant cells in select textbooks and in the resulting drawings of students. In terms of Figure 1, Clément compares the 'knowledge to be taught' with the 'learnt knowledge'.

Typically, the biology textbooks featured illustrations of juxtaposed animal and plant cells. The cells were prototypical in that they combined the features of a variety of animal and plant cells, respectively, without corresponding to any individual real animal or plant cell types (Clément, 2007). In other words, the illustrations were *didactic objects* as discussed previously.

However, Clément identified a potential problem with these didactic objects: The prototypical plant cell was always depicted adjacent to other cells, and with a hard cellulose cell wall, whereas the animal cell was depicted as isolated, with a flexible cell membrane (Figure 5).

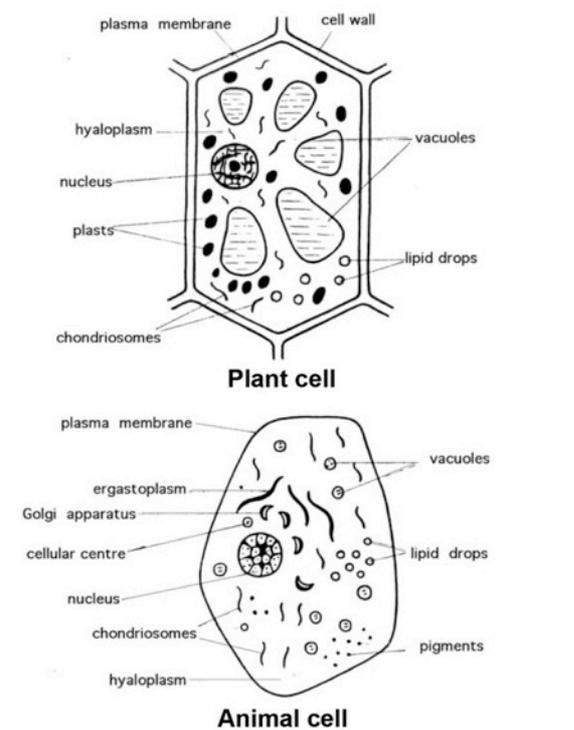


Figure 5. Illustration of an animal and a plant cell from a biology textbook. From Clément (2007).

Clément hypothesised that these illustrations could have the consequence that the students who used the textbooks developed a number of conceptions about animal and plant cells, namely that:

- All **animal** cells have the same morphology and structure as the animal cell in the book
- All **plant** cells have the same morphology and structure as the plant cell in the book
- The main differences between animal and plant cells are their shape and the presence or absence of links with adjacent cells.

And indeed, this seemed to be the outcome, judging from the drawings made by students of animal and plant cells (Figure 6). This is problematic because both animal and plant cells can occur in isolation and juxtaposed to other cells, respectively, and not all plant cells have hard cell walls. In other words, the illustrations of cells were inconsistent with the scholarly knowledge, and could potentially lead to *didactic obstacles* (Clément, 2007)

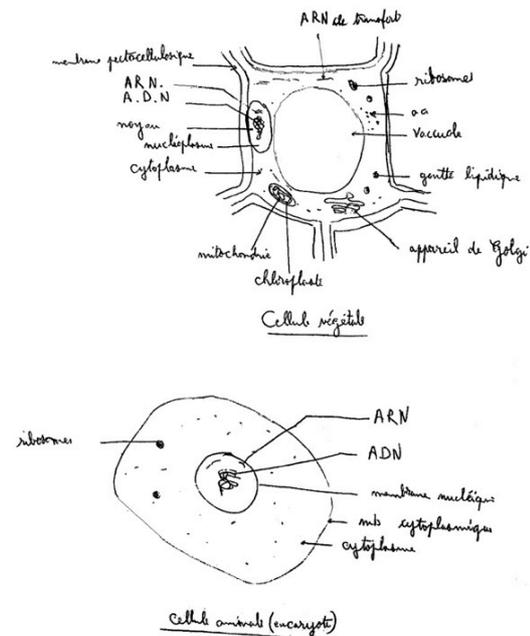


Figure 6. Typical student drawing of an animal and a plant cell. From Clément (2007).

The question asked by Clément was then: Why do the prototypical illustrations of animal and plant cells persist, when they are clearly at odds with the scholarly knowledge? To answer this question, Clément enlarged the unit of analysis. In effect, he stepped outside the institutions involved in the teaching process - the scholarly context as well as the text book context - to create his own epistemology by asking at each step of the transposition: What is the reason for the persistence of these prototypical cells? (Figure 7).

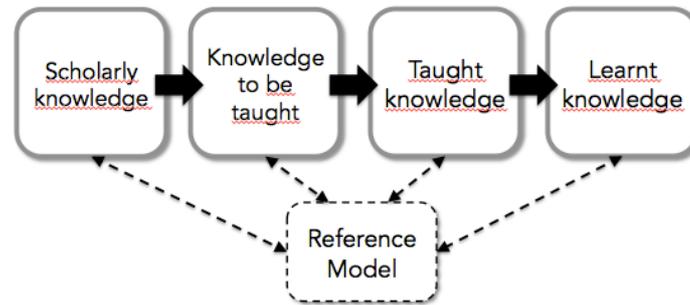


Figure 7. *Didactic transposition and the external position of the didactics researcher, described by the 'reference model'. The reference model constitutes the researcher's methodological proposal for the analysis, and must consider all the steps of the transposition.*

In his analysis, Clément (2007) was able to identify the reason for the persistence of the prototypical cell illustrations at each step of the transposition. It is perhaps not surprising that the learners (the students) acquire a persistent notion of animal and plant cell morphology; they are motivated by passing their exams, and observable differences between the two types of cells shown in their textbooks become exemplary for these learners.

With respect to the taught knowledge (cf. Figure 7), Clément found that in secondary school laboratory exercises, it is very common to use onion epidermis cells and human mouth epithelium cells as plant and animal cells for observation exercises, as these cells are quite easy to come by, to observe, and to identify. Clément thus shows how the persistence of the prototypical animal and plant cells in the taught knowledge is based on the necessity of having the practical and pedagogical means to teach the cell concept.

Finally, Clément analysed the scholarly knowledge, inquiring about the reasons for the persistence of the prototypical animal and plant cells here. He was determined that the historical division between academic departments of Botany and those of Zoology created a tension between such departments regarding who had the right to define a cell. Thus, the distinction between plant and animal cells that persists in biology textbooks and teaching activities today is based on this historical tension between fields of research. This finding is corroborated by the fact that the duality of prototypical cells is gradually disappearing as molecular biology is restructuring the organisation of research laboratories and erasing the distinction between animal and plant cells (Clément, 2007).

The study by Clément demonstrates how it is necessary for us, as didactics researchers, to not only enlarge our unit of analysis to encompass the processes and institutions involved in creating taught knowledge from scholarly knowledge, but also to take an important step outside the didactic system under investigation. Clément implicitly does this in his study, inquiring about the persistence of the cell prototypes from a standpoint outside the institutions he is studying, but Chevallard and Bosch (2013) go one step further, recommending a quite explicitly stated *reference model* for the purposes of this inquiry.

How should such a reference model be constructed? There is no simple answer to this question, because there is no single point of reference from which to observe the phenomena occurring in the different institutions involved in the teaching process (Chevallard & Bosch, 2013) Researchers should build their own reference models with respect the bodies of knowledge involved in the reality they wish to approach (Barbé, Bosch, Espinoza, & Gascón, 2005).

In summary, accepting the notion of didactic transposition obliges us to expand our unit of analysis. The bodies of knowledge that are produced and re-produced in research and education contexts are answers to particular needs and formulated according to specific conditions. Therefore, our point of reference for this analysis cannot be the scholarly knowledge – this is the reference point of educational institutions, but not of researchers who consider these institutions as an object of study. Instead, we must formulate our own reference model that takes into account all the steps of didactic transposition.

A research programme evolves

The final point I wish to make here is in regard to the present-day status of the research surrounding the notion of didactic transposition. The body of knowledge related to didactic transposition has grown in the last decades, and the increasing realization among didactic transposition scholars¹ that the production and diffusion of scientific knowledge in society is fundamentally *anthropological* or human-based in nature, has gradually led to the coalescence of a research programme called the Anthropological Theory of Didactics (ATD). Within this programme, the perspective on knowledge has gradually changed: Rather than seeing scientific knowledge as being valuable in its own right, ATD sees knowledge as always an *answer to a question*. In the words of Chevallard,

Knowledge must sacrifice itself, including its possible subsequent uses, from the moment it no longer appears as something that allows answering certain questions, solving certain problems (Chevallard, 2004).

To reflect this perspective, ATD has recently seen the development of new ways of modelling knowledge as answers to questions or *praxeologies* rather than as tried and true facts to be memorised. This development in ATD thus parallels the thinking behind other contemporary frameworks or ideas, e.g. inquiry-based science education, although the anthropological approach in ATD seems to have a much stronger epistemic focus.

Another parallel development, undertaken by German didactics researchers (most notably Reinders Duit) is that surrounding the Model of Educational Reconstruction (MER). The reasoning behind MER has many similarities with that of ATD, in that MER also considers science content for teaching as something that

...has to undergo certain reconstruction processes. The science content structure has to be transformed into a content structure for instruction. The two structures are fundamentally different (Duit et al., 2012).

In summary, the notion of didactic transposition started out as a theoretical concept to describe and

understand the development of taught knowledge. In the last decades, it has gradually grown and developed into a more normative framework for analysing and even designing teaching/learning situations. In this sense, it parallels several other contemporary theoretical frameworks such as the Model of Educational Reconstruction and Inquiry-Based Science Education frameworks.

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¹ Most notably professors Yves Chevallard, Marianna Bosch, Carl Winsløw, and Pierre Clément, although there are many others.

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