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Micro-analyses of students' productions in physics reveal misunderstandings not misconceptions

Alaric Kohler & Anne-Nelly Perret-Clermont

Abstract of 100-250 words

Sommer et al. (2010) invite researchers to examine children's productions from a theoretical stand that centers on understanding the meaning of what children are doing in their context here and now, rather than on the distance between their productions and normative external references and categorizations. Such investigations have the potential to reveal psychological processes and issues, which remain otherwise invisible to researchers.

To this end, the present study investigates data collected in a 12 weeks field study of 17 years old students studying Newton's laws. Analyses are carried out for specific moments, selected with a critical incidents technique, when high school students are not meeting the cognitive expectations of their physics teacher. Are these discrepancies due to misconceptions that would be putting them at odd, or to other processes involved?

We will present examples of students trying to grasp new concepts or answering tests in which it is clear that they are not relying on conceptions prior to learning, but trying to reason with/on the linguistic productions, signs and images that are constitutive of the *teaching*. We will point to similarities between the difficulties encountered by the students and the misunderstandings Newton encountered in his time. We will conclude suggesting that Newtonian physics at school is a very complex object of discourse, with specific pitfalls and challenges, and that teaching may be more efficiently improved if students' mistakes are studied as *situations of misunderstanding* rather than as resulting from immature preconceptions.

Keywords

- Secondary education
- Knowledge creation
- Physical science
- Social interaction

Interest Group (menu déroulant web)

SIG 10 Social Interaction in Learning and Instruction

Domain (menu déroulant web)

Learning and Social Interaction Learning

Extended summary of 600-1000 words (including references)

Sommer, Pramling Samulsson & Hundeide, in their 2010 book "Child Perspectives and Children's Perspectives in Theory and Practice" invite researchers to examine children's productions from a theoretical stand that focuses on understanding the meaning of what children are doing in their context here and now, rather than on the distance between their productions and some normative external references and categorizations. The authors show that a general "child perspective" benefits from a more particular reconstruction of *children's perspectives*, for each child and relatively to her activity, situation and context. Such investigations have the potential to reveal psychological processes and issues, which remain otherwise invisible to researchers.

To this end, the present study investigates moments when high school students are not meeting the cognitive expectations of their physics teacher. Are these discrepancies due to misconceptions that would be putting them at odd, or are other processes involved?

Data was collected in a 12 weeks field study of 17 years old students studying Newton's laws, with the collaboration of a teacher who agreed to discuss his expectations and provide help to document his own and his students' work. All the lessons and exercises were recorded (audio and video), and relevant material (textbooks, handouts, students writings, etc.) were collected. The teacher provided a written report of his own intents and of what he observed during the teaching. A researcher was present all along the teaching process and interviewed the teacher on occasions, yet leaving him free to teach his own way.

Seven critical incidents were chosen for in-depth micro-analysis on the basis of failed communication connected to discrepancies in teacher's and students' meaning making. Attention was focused on identifying the various *points of view* involved in the communicative situation. These micro-analyses were inspired notably by Inhelder et al. (1992)'s studies of micro-genesis, Tiberghien's focus on micro grain of analysis, *facets of knowledge* and distinction between *taught knowledge* and *knowledge-to-be-taught* (Tiberghien, 1997), and Grize's *logico-discursive operations* (Grize (1996).) These allowed for a description of natural language *in use*, and a comparison between knowledge as it is presented to an audience and knowledge as it is apprehended or reconstructed by the students.

These fine-grained descriptions have made clear that misunderstandings were taking place at the crossroads of different *perspectives*: Newton's mathematical perspective on the physical world, the teacher's goals in teaching Newton's laws, and the students' attempts to succeed in a particular type of exercise, sometimes despite their overall feeling of missing the point. The specific perspective of the textbooks authors was also present in the situation through discursive traces that students and teacher were reinterpreting in their own ways in the context of the school activity that they were performing. Even the designers of the computer software were silently present among the multiple (and often ambiguous or contradictory) perspectives that students were exposed to.

We will present some examples that illustrate how students are not so much applying (or enacting) their own conceptions prior to learning, when they are performing at school or trying to grasp new concepts, but are also reasoning on (most often ambiguous) linguistic productions, signs and images that are constitutive of the *teaching*. Hence, we argue that what is often considered "misconceptions" in the literature, actually catches another phenomena: it is, at least partly, the result of students trying to meet (contradictory) expectations and to imitate (partly implicit) models of reasoning., Students can be observed trying to imitate and understand (reproduce and reconstruct) the discourse provided by teachers, textbooks, tasks instructions, computer software as if it was one unique and coherent discourse. In fact it is a polyphony of discourses, and they sometimes clash.

We will conclude by suggesting that Newtonian physics at school is a very complex object of discourse and that is it is quite normal that students as well as teachers often run into *situations of misunderstanding* (Author 2020). For instructional practice, the results of this research highlight the importance of addressing such situations *as* misunderstanding rather than *as* misconceptions, avoiding therefore to cast all the responsibility on students. Communicating knowledge in physics is particularly complex: It requires the coordination of various semiotic means (everyday language, mathematical symbols and diagrams, sketches and drawings, etc.), of various points of view to different audiences (teacher to students, student to students in group work, etc.) and the coordination of various perspectives elaborated throughout the history of science (supposed to be the epistemological core of the teaching). On this last point, we will report some striking similarities between situations of misunderstanding observed during this research and misunderstandings Newton encountered in his own historical time, while discussing with contemporary scholars or when reading predecessors like Galileo. In fact, the historian Koyré (1968) shows that Newton could not always make himself understood, even by his close interlocutors.

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Micro-analyses of students' productions in physics reveal misunderstandings not misconceptions

Alaric Kohler & Anne-Nelly Perret-Clermont

Conference talk – see also the extended summary

Introduction

[slides 1-4] *Welcome*
Why approaching physics with more complexity while already so demanding? Precisely to move from the (false) impression of *difficulty* to a (true) sense of its *complexity*...

[slide 5] Sommer et al. (2010) invite researchers to examine children's productions:

- From a *theoretical* stand that centers on understanding the meaning of what children are doing in their context here and now, rather than on the distance between their productions and normative external references and categorizations;

- And with a methodological approach based on *semiotic micro-analyses* of students' productions.

These investigations consider students' productions as *situated responses and initiatives within very precise socio-material-historical context,* have the potential to reveal psychological processes and issues, which remain otherwise invisible to researchers.

[slide 6] To this end, the present study investigates *critical moments,* as global situations in which students are not meeting the cognitive expectations of the teacher. We will refrain from considering students having *individually* erroneous conceptions in physics, in these moments; Instead, these *critical moments* are the starting point of a *detailed inquiry* about the situation of (mis)understanding, including the use of French and math language, signs, images. Based on the constructivist and interactionist idea that these are constitutive of the teaching and of the learning, such inquiry allows us to address, for each situation *singularly*, the following questions: - *Are these discrepancies between teacher's expectations and students' answer due to their misconceptions, or are other processes involved?*

Methodology

[slide 7] Data was collected in a 12 weeks field study of 17 years old students studying Newton's laws. All the lessons and exercises were recorded (audio and video), and relevant material (textbooks, handouts, students writings, etc.) were collected. The teacher provided a written report of his own intents and of what he observed during the teaching. A researcher was present all along the teaching process and interviewed the teacher, yet leaving him free to teach his own way. Seven critical incidents were chosen for in-depth micro-analysis on the basis of failed communication connected to discrepancies in teacher's and students' meaning making. Attention was focused on identifying the various *points of view* involved in the communicative situation. References for the method of analysis are in the abstract.

[slide 8] We will now present some examples that illustrate how students are not so much applying (or enacting) their own conceptions prior to learning, when they are performing at school or trying to grasp new concepts, but are also reasoning on (most often ambiguous) linguistic productions, signs and images that are constitutive of the *teaching*.

Examples

[slide 9] Here you can see a question, known in literature for triggering misconceptions, i.e. wrong ideas that students hold individually about the physical world. The example of students' answers provided here are illustrating the expected misconception, according to which students would associate with a greater weight a faster acceleration or speed when the ball falls. This misconception is sometimes described as the causal relation, in the mind of the student, between *weight,* on one side, and *speed* (or *higher velocity*), on the other side.

Yet, the interpretation of the students' answer I provided here, only considers a small part of their wording. The fact that students are generally using as few words as possible brings an additional challenge to the researcher. In the three answers reproduced on the slide, we can nevertheless observe that there are quite different from one another if red fully and carefully.

[slide 10] This is one of the main reason that make me take distance with the explanation in terms of *misconception*. Can we consider Barbara's answer, providing three sentences, as enacting the same “conception” than Julian, who just write “iron ball”? This assumption is often made in cognitive psychology, without further discussion. But we will prefer to consider that each answer are potentially different, indicating a specific *pathway of thinking*. In this way, not only can we observe more diversity, but also discover that students actively adapt their thinking to the question.

[slide 11] Let us try with the heavy and light ball falling to the ground. The expected answer, written in the mathematical language in use in this class, would suggest a constant acceleration of all objects falling freely at the surface of Earth. Yet, such “constant” acceleration is merely resulting from a mathematical simplification of the fraction, when dismissing the influence of friction forces.

[slide 12] If we look at the development of the equation including a friction force – e.g. *air* – such simplification is not allowed in mathematical rules. Of course, the actual *effect* of air on the speed of the fall of the two balls, here calculated with realistic values, is very small: a million part of a second. Yet, in order to *know that,* one must make such a calculation. This is were the point of view of the teacher, and the point of view of the student, are diverging: The teacher has made such calculation once at least before deciding to neglect friction – as for example during his studies in physics – while students could not. So how could they decide that the friction force should be neglected?

What first appeared a “misconception” turns out to be, for some students at least, the discrepancy between two different *points of view* on the question : From the first point of view, the teacher is considering the scale of the influence exerted by friction force on falling objects, while from the second point of view, students start from the teacher's discourse *that something is constant,* to take various decisions for solving the problem. In other words, the reasoning take another pathway for these students, for the mere fact it is the first time they attempt to solve it: Not knowing the mathematical result about the influence of the friction force on the balls velocity, they cannot follow the rationality of the teacher.

[slide 13] The friction is not the only point leading students to a diversity of pathways of thinking on this question. We have observed that the repetition, in the teacher discourse, on this "constant" acceleration of falling object constitute*s a discursive element of the milieu to which students* are actively trying to adapt themselves, which has led some to assimilate the idea of |constancy| associating it with *force* rather than *acceleration*. Depending how much they have understood the mathematical relations between force and acceleration in Newtonian physics besides grasping this element of discourse, leads to two different pathways of thinking represented here on the slide. Interestingly, the strangest of the two is a better reasoning in respect to Newton's laws, since it concludes that the heaviest ball will first touch the ground if the gravitational forces exerted on the two balls would have equal intensity. The first pathway of thinking, also it provides an answer appearing superficially correct, is no more than a discursive repetition of the teacher's words, without any operation made by students on the basis of Newton's laws.

[slide 14] To move the investigation as far as history of science, provides a clue the misunderstanding these students are entangled in, has more to do with the way Physics, as a science, has been put into language and forms, than with their own "conceptions", lack of conception or even intelligence, if anyone would doubt they have their good share of it. Indeed, Newton himself falls into an analogous misunderstanding when reading Galileo, one of his predecessor in Physics. Nobody would attribute to Newton misconceptions in Physics, and even less a lack of intelligence. Yet, this is what we do, as psychologists, when we overlook the process of communication, dismissing the potential consequences of adopting different points of view on the problem.

[slide 15] Of course, students adopting a different point of view on the problem may be simply considered by the teacher as *answering to the wrong question*, so to speak. Precisely in these cases, however, we have a chance to observe that students' difficulties have little to do with conceptions in physics. Here you have Julian's answer that recall the expected knowledge for the first question I presented, with the two balls falling. Only, for a horizontal movement such as the two chariots here, the reasoning should be quite different. Yet, she seems to believe that she has to rely, in order to answer such type of questions, on the knowledge learned on the occasion of falling objects. From the point of view of the student, *knowledge* seems to be the mere repetition of the right reply to a same type of questions; Only, she has made her category of question somehow too broad, including both vertical and horizontal movements. This is specific to a point of view shared by students. For an expert in Physics, *knowledge* is not associating a reply to a question, but rather using Newton's laws – in this case at least – in a reasoning for providing a suitable model for predicting the movement of the represented chariots.

Can we say Julian has a misconception about the physical world? I would rather say she has a wrong conception about what she's supposed to be doing at school... a misconception about education. More likely, she has no conception at all about the problem, and only just tries to "be right" within the discursive space: It is a game of language.

[slides 16-18 optional] To illustrate this last point, here are a few examples of how much semiotic details matter in the way students construct their point of view on the tasks.

Results and conclusion

[slides 19-20] Hence, we argue that what is often considered “misconceptions” in the literature, actually catches several other phenomena: It is, at least partly, the result of students trying to meet (contradictory) expectations and to imitate (partly implicit) models of reasoning, or even elements of discourse. Students can be observed trying to imitate and understand (reproduce and reconstruct) the discourse provided by teachers, textbooks, tasks instructions, computer software as if it was one unique and coherent discourse. In fact it is a *polyphony of discourses*, and they sometimes clash with one another.

[slides 21] For instructional practice, the results of this research highlight the importance of addressing such situations *as* misunderstanding rather than *as* misconceptions, avoiding therefore to cast all the responsibility on students. Communicating knowledge in physics is particularly complex: It requires the coordination of various semiotic means (everyday language, mathematical symbols and diagrams, sketches and drawings, etc.), of various points of view to different audiences (teacher to students, student to students in group work, etc.) and the coordination of various perspectives elaborated throughout the history of science (supposed to be the epistemological core of the teaching). On this last point, we have seen some striking similarities between situations of misunderstanding observed during this research and misunderstandings Newton encountered in his own historical time, while discussing with contemporary scholars or when reading predecessors like Galileo. In fact, the historian Koyré (1968) shows that Newton could not always make himself understood, even by his close interlocutors.

[slides 22] We will conclude by suggesting that Newtonian physics at school is a very complex object of discourse and that is it is quite normal that students as well as teachers often run into *situations of misunderstanding* (If you would enjoy learning more about this research, you can access online to the complete PhD: Kohler, 2020).

[slides 23 displayed during discussion]

Micro-analyses of students' productions in physics reveal **misunderstandings not misconceptions**

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Presentation at the 19th biennal EARLI Online Conference for Research on Learning and Instruction.

Presentation

From Misconceptions to Misunderstandings

Empirical Examples

Conclusion For Today

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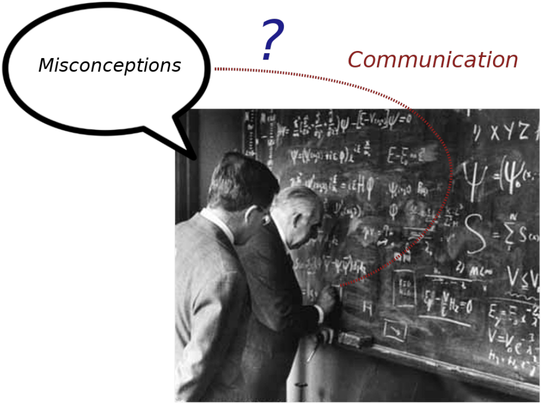
Introduction

From Misconceptions to Misunderstandings

What about communication, semiotics, etc.?



Niels Bohr at the blackboard (web image).

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Micro-analyses of various points of view

Sommer et al. (2010) invite us to examine children's productions :

- centering on the meaning - for the child - of what she is doing here and now ;
- with a methodological approach based on semiotic micro-analyses.

We believe that this has the potential to reveal psychological processes and issues, which remain otherwise invisible to researchers.

From *critical moments* ... to *situations of (mis)understanding*

- We pay attention at moments when students are not meeting the cognitive expectations of the teacher

  With a *critical incidents technique* (e.g. Flanagan, 1954) and based on Tiberghien (1997)'s distinction between *taught knowledge* and *knowledge-to-be-taught*.

- We start from these moments to analyse each situation singularly
  - What are the various *points of view* involved?

    (based on micro-genesis studies such as : Inhelder et al., 1992)
  - How students actively try to assimilate and reason on and with linguistic production, signs, image and material objects?

    (based on logico-discursive operations of Grize, 1996)

- Allowing to respond to the research question for each situation :
  - Are these discrepancies due to students' misconception of physical phenomena, or do they emerge from communication processes?

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Data Collection

Data (audio and video recording and field notes) were collected during an intensive 12 weeks field study in a Swiss high school with 17 year-old students studying Newton's laws.

The teacher collaborated :

- providing a written report of his own intents and of what he observed during the teaching.
- participating in regular interviews,
- teaching his own way, free to use (or not) the ressources provided by the researcher.

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Empirical Examples

An inquiry on the various perspectives

Here are a tennis and an iron ball ("pétanque"), of identical shape :

Which one will touch the ground first if I drop them from the same height ?

A few students' answers

Julian :	"	iron ball"
Ernest :	"the	iron ball because it is heavier"
Barbara :	"the	iron ball because it is heavier. It goes towards the gravitational force. Since the tennis ball is lighter, is being stopped during its trajectory."

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From misconceptions to *pathways of thinking*

"iron ball" as a mistake (in reference to normative expectations)

- Misconception, erroneous answers... (diSessa, 2006; Carey, 2009);
- The "cognitive–situative divide" (Vosniadou, 2007) in conceptual change theories : The need to look at sociocultural processes.

Each answer as a peculiar *pathway of thinking* about the item

- The conformity judgment only takes the point of view of the researcher : What about the point of view of the student?
- Can we consider all answers giving "iron ball" the same conception?

To allow observation of misunderstandings (Kohler, 2015) requires :

- A description of natural language in use;
- A comparison between
  - — knowledge as it is presented to an audience (by teacher, textbook, etc.)
  - — and knowledge as it is apprehended or reconstructed (by the students).

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The expected knowledge

Without friction forces

$$\overrightarrow{F}_g = G \cdot \frac{m \cdot M}{r^2} \qquad \overrightarrow{F}_g = 9.81 \cdot m$$

$$\overrightarrow{F}_{nette} = m \cdot \overrightarrow{a} \qquad \overrightarrow{a} = \frac{\overrightarrow{F_{nette}}}{m} = \frac{9.81 \cdot m}{m} = 9.81$$

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More than the expected knowledge

Without friction forces

$$\vec{F}_g = G \cdot \frac{m \cdot M}{r^2} \qquad \vec{F}_g = 9.81 \cdot m$$

$$\vec{F}_{nette} = m \cdot \vec{a} \qquad \vec{a} = \frac{\vec{F}_{nette}}{m} = \frac{9.81 \cdot \cancel{m}}{\cancel{m}} = 9.81$$

With an air friction force

$$\vec{F}_{nette} = \vec{F}_g - \vec{F}_f$$

$$\vec{a} = \frac{\vec{F}_{nette}}{m} = \frac{(\vec{F}_g - \vec{F}_f)}{m} = \frac{(9.81 \cdot m) - (\vec{F}_f)}{m} = 9.81 - \frac{\vec{F}_f}{m}$$

a millionth of second

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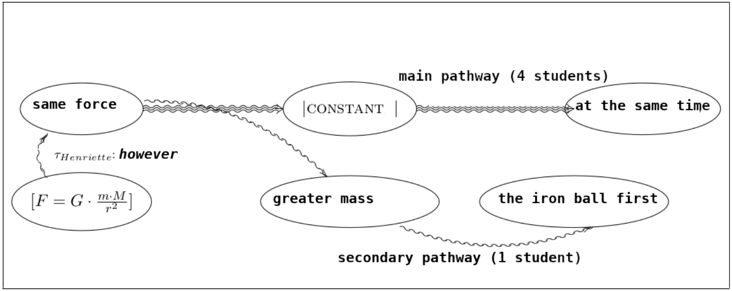
Two pathways of thinkings from students

Various assimilations from the teacher's discourse about a |constant|

→ "same acceleration";

→ "same force".



Source : (Kohler, 2020, p.426).

One student operates with the difference of mass after interpreting the |constant| as a "same force"...

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A similar situation of misunderstanding for Newton

Galileo writes : “planets fall with gravity egal and uniform...”

Koyré reconstructs two possible meanings :

1. The acceleration due to gravity is equal everywhere in space regardless of distances, mass, etc. : it is a universal constant.

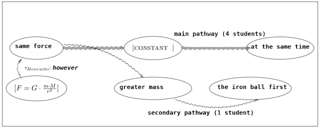
2. The velocity with which objects (including plantes) “fall” is the same, be it constant or not (see the example above for a fall at identical velocity and yet a gravity force of various intensity exerted on each ball).

Koyré shows that

the historical meaning of Galileo is version 01 ;

Newton yet understand version 02.

Version 02 requires to take into consideration the difference of mass like the student below...



"Nous allons revenir à la théorie de Galilée mentionnée par Newton à propos du "passage de Platon". Si les planètes "descendent avec des gravités uniformes et égales, ainsi que le suppose Galilée", nous dit Newton, elles ne peuvent pas toutes partir du même endroit. Nous l'admettons volontiers. Il nous reste, cependant, à préciser le sens de l'expression : "descendent avec des gravités uniformes et égales". En effet, cette formule peut vouloir dire des choses assez différentes ; notamment : a) selon Galilée, l'action du la gravité est partout uniforme et constante et, par conséquent, les corps - tous les corps, grands et petits, lourds et légers - tombent toujours avec la même vitesse et ce où qu'ils soient placés, près ou loin de la Terre (ou, en l'occurrence, du Soleil) ; en d'autres termes, que l'accélération *due à la gravité* est une constante universelle ayant la même valeur partout dans le système solaire ; ou bien, b) selon Galilée, tous les corps, et donc aussi toutes les planètes, "tombent" avec la même vitesse, qu'elle soit constante ou non, et, par conséquent, si elles partent du même endroit et tombent ensemble en traversant les mêmes espaces, elles ont aux mêmes "hauteurs" par rapport au Soleil des vitesses égales, sans que cette assertion implique la constance de l'accélération qui pourrait varier avec la distance, comme la force d'attraction, et même en fonction de celle-ci.

Quelle interprétation devons-nous donner à la formule newtonienne ? C'est-à-dire : quel sens a-t-elle dans l'esprit de Newton ? ce n'est pas là une question oiseuse. En effet, a) représente la théorie galiléenne de la chute dans sa vérité historique ; b) au contraire, une adaptation - mésinterprétation - postérieure ; a) implique une connaissance directe et précise de l'œuvre de galilée ; b) ne l'implique aucunement. Or, il semble clair que c'est le sens b) que lui donne Newton...

Source : (Koyré, 1968, p. 253).

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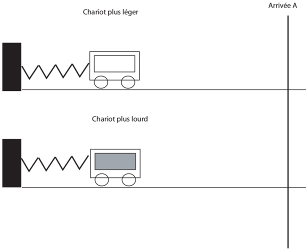
The right discursive answer for the wrong question...



Deux chariots de masses différentes, mobiles sur un plan horizontal, sont abandonnés à l'action de deux lanceurs identiques (ressorts déformés de la même manière).

Lorsqu'on lâche le ressort, lequel des deux chariot arrive-t-il le premier au point d'arrivée A?

Two wagons of different masses, mobile on an horizontal plane, are abandonned to the action of two identical launchers (springs unshaped the same way).

When releasing the springs, which of the two wagons reach first the arrival line A?

A student's answer

Julian Both wagons reach the arrival at the same time, because the forces do not change, but stay alike. Only the mass change but it does not act on the forces.

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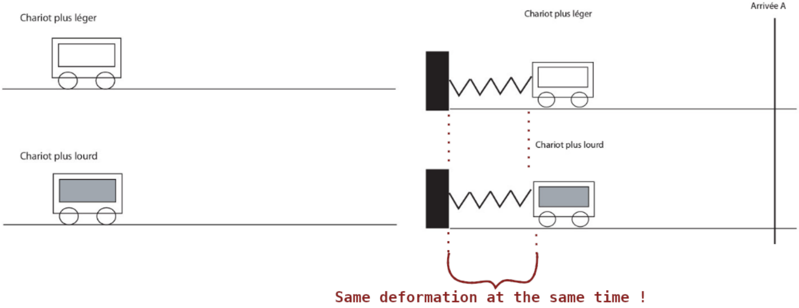
Students’ choices proceed from details

First and second version of the question



Alternative students’ answers

Laurie	Both reach the arrival at the same time. The heavier wagon goes less fast than the lighter but the heavier accelerate more quickly than the lighter.
Yves	The heavy wagon, since its important mass increases its acceleration.

Students either discuss the moment where the wagon is launched (11/23), its trajectory (9/23) or both (3/23).

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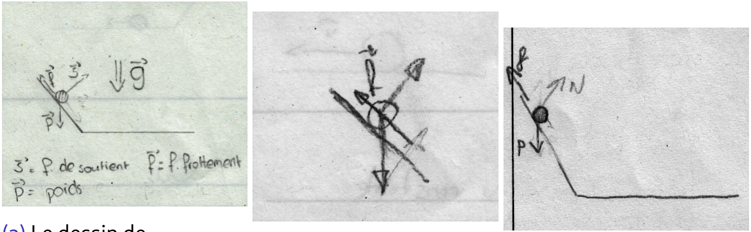
The importance of semiotics



(a) Le dessin de Cassandra, Julianne, Laurie et Ferdinand

(b) Le dessin de Ernest, Ophélie et Victor

(c) Le dessin de Yves

Figure – Dessins des forces des élèves à l'exercice 4A avec une flèche effacée dans le sens du mouvement (la *vis inertia* de Newton).

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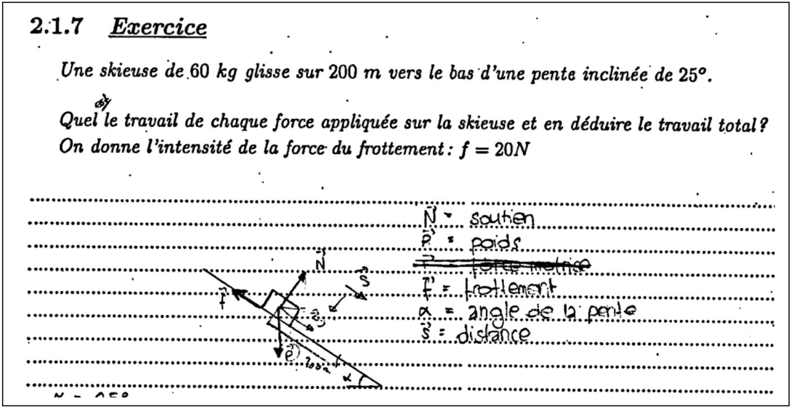
The importance of semiotics

A skier represented by a rectangle...

- *the wagon commonly used in physics !*



2.1.7 *Exercice*

Une skieuse de 60 kg glisse sur 200 m vers le bas d'une pente inclinée de 25°.

Quel le travail de chaque force appliquée sur la skieuse et en déduire le travail total ?
On donne l'intensité de la force du frottement : $f = 20N$

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Conclusion For Today

Empirical observations

- students are not so much applying their own preconceptions
- but trying to grasp new concepts
- to reason on (most often ambiguous) linguistic productions, signs and images, *as provided by the teaching material and context*.

Students do not only use their previous knowledge : they adapt to the *milieu*.

- The assimilation - accommodation dialectical process can be extended to the adaptation of students to *a discursive milieu* :
  - this research has shown great diversity in the pathways of thinking of students, starting from the same (complex) ensemble of discourse, graphs, etc. ;
  - we have developed a methodology to describe an analyse such adaptation.
- Such approach is moving the focus from the conformity of students' answers with a model ("right" or "wrong") to the *choices* and *change operated* by students on the teaching discourse.
- This research supports the importance of shifting from a monological to a dialogical perspective on children's and students' argumentation (Perret-Clermont et al., 2019) : There is a polyphony of discourses.

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Message to take home

It matters to address such situations *as* misunderstanding rather than *as* misconceptions

- avoiding therefore to cast all the responsibility on students ;
- allowing to improve the communication between teachers and students.

The hypothesis of *situation of misunderstanding* at school made in sociology (Bourdieu et al., 1965) stands on the socio-constructivist and interactionist idea extended to communication processes (Perret-Clermont, 1992; Weil-Barais & Lemeignan, 1990).

This idea is supported by the empirical results of this study :

- The situated action of students with precise socio-material components and context are constitutive of their learning of physics, and can be studied singularly at the level of a *situation* (for a definition, see Dewey, 1938/1993), with a basic unit of analysis at the level of the *word-meaning* (Vygotski, 1934/1997; Tiberghien, 1997; Grize, 1996).
- See Kohler (2020) for more references.

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To Go Further

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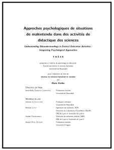
Approches psychologiques de situations de malentendu dans des activités de didactique des sciences

Understanding Misunderstandings in Science Education Activities : Integrating Psychological Approaches

THÈSE

Alaric Kohler

Directrice de thèse

Membres du jury

Kohler, A. (2020). *Approches psychologiques de situations de malentendu dans des activités de didactique des sciences*. Thèse de doctorat présentée à la Faculté des lettres et sciences humaines de l'Université de Neuchâtel. https://libra.unine.ch/Publications/Alaric_Kohler/44936.

Short article [in English] **available for direct download** :

Kohler, A. (2015). Elements of Natural Logic for the Study of Unnoticed Misunderstanding in a Communicative Approach to Learning Argumentum. Journal of the Seminar of Discursive Logic, Argumentation Theory and Rhetoric, 13, 80-96. https://www.fssp.uaic.ro/argumentum/Argumentum%20No%2013%20issue%202.htm.

Thank you for your attention!

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