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The notion of time from a didactics' point of view. Conceptions of 5 to 7-years-old students about time perception

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Abstract

The enigmatic question of time, essentially of a physical, psychological and social nature, occupied human since becoming aware of his existence and of the surrounding environment. Young students' conceptions may be a starting point for improving their understanding of the world. This research is interested in very young students who are in full "construction" of the concept of time. Conceptions related to time notion play a decisive role throughout learning procedure and are often incompatible with the scientific model. Conceptions' analysis is a tool for the advancement of a proximal development zone in which a first conceptual system can be built by students. We refer to the area of current or potential success of young students concerning the understanding of time notion. This paper presents findings on 5 to 7-year-old students' conceptions about the inverse relationship between time and speed.

Keywords

conceptions, students 5 to 7 years old, time, speed, methodology, qualitative analysis

Résumé

La question énigmatique du temps, de nature essentiellement physique, psychologique et sociale, a occupé l'individu à partir du moment où il a pris conscience de son existence et de l'environnement qui l'entoure. Les conceptions des jeunes élèves constituent le point de départ pour améliorer leur compréhension du monde. La présente recherche s'intéresse à de très jeunes élèves qui sont en pleine construction du concept de temps. Ces conceptions relatives à la notion de temps jouent un rôle décisif dans l'apprentissage et sont souvent incompatibles avec le modèle scientifique. Leur analyse est un outil d'aménagement d'une zone proximale de développement au sein de laquelle un premier système conceptuel peut être construit par les élèves. Le présent article expose nos premiers résultats obtenus concernant les conceptions d'élèves de 5 à 7 ans sur la relation inverse entre le temps et la vitesse.

Mots-clés

conceptions, élèves de 5 à 7 ans, temps, vitesse, méthodologie, analyse qualitative

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I INTRODUCTION

Our current research project, concerning Precursor Models and Time Measurement Teaching, aims to enhance the understanding of how the application of the Precursor Model Concept in Science Teaching and Learning may help children overcome comprehension difficulties. Our study concerns Early Years Science Education and Science in Primary School, especially French students aged from 5 to 7 years old. There is a general agreement that, children's initiation to Science Education should start as early as possible (Eshach & Fried, 2005; Klaar, 2016). PISA 2012 results, highlight the benefits students get form attending preschool in terms of future school performance (Eurydice, 2014). Children's comprehension of natural phenomena is developed through everyday life's experience (Eshach & Fried, 2005; Sikder & Fleer, 2015). Various authors argue that, spontaneous children's representations are a starting point of instruction to improve pupil's understanding (Siry & Kremer, 2011; Boilevin, 2013). We are interested in identifying the conceptions of 5 to 7-year-old students about time characteristics. By taking into account the difficulties encountered by students on the notions of grandeur and measurement (Munier, Chesnais & Molvinger, 2014), and in particular on the concept of time measurement (Piaget, 1981; Levin, 1992; Samartzi, 2008; Ravanis & Kaliampos, 2018), we make the assumption that students encounter difficulties on the notion of duration, of succession as well as on the notion of speed in relation to time. Through the analysis of students' conceptions, we aim to determine the elements that hinder the understanding of time measurement. These obstacles can be taken into account for the construction of a didactic engineering under the objective of teaching time measurement.

II THEORITICAL FRAMEWORK

The enigmatic question of time, essentially of a physical, psychological and social nature, has occupied human since becoming aware of his existence and of the influence of the surrounding environment. Different distinctions have been proposed for time aspects. Individual time (biological and psychological), collective time (religious, political), time in physics. To approach our object of study, we retain a distinction concerning time: objective time and subjective time. Subjective or psychological time brings together various feelings we have of time flow. It is about perception and intuition of individual personal experiences (Tartas, 2009). Objective time is socially shared and recognized. It can be declined in cultural or social objective time and in objective time in physics. School time is considered to be an aspect of social time (Masy, 2013). Social time, also called conventional time, groups the constructions of human to be able to identify and regulate his existence (Fraise, 1979). This time corresponds to the time measurement systems specific to each culture (De Coster, 2004). Time in physics obeys to logo-mathematical relations, this is time defined by Newton.

As part of our research, we are interested in the notion of time measurement, which is perceived here in concordance with the official prescriptions of the French national education curricula for students of primary school, including kindergarten and elementary school students. For this reason, time measurement finds its bases in the scientific model underlying the theory of mechanics non-relativistic classic physics (Matthews, 2015) as well as in the psychological aspects of time (Piaget, 1981; Droit-Volet & Meck, 2007; Samatzi, 2011; Rattat & Tartas, 2017), explored throughout primary school. In this perspective, time is considered as the indefinite continuous progress of existence and events that occur in an irreversible succession from the past through the present to the future (Matthews, 2015). From the epistemological point of view, we refer to the measurement of a grandeur. Two main streams exist related to grandeurs and measurement: operationalism and realism (Perdijon, 2012). From the point of view of the operationalism, grandeur is strongly related to measurement and makes no sense in the absence of measurement. From the point of view of the realism, grandeur exists, regardless to measurement. Munier and Passelaigue (2012) emphasize the need of introduction of epistemological knowledge and elements of metrology in teaching to enable students give meaning to the concepts of grandeur and measure. We identify a strong presence of the realistic aspect in French curricula of the first cycle of learning, (Xirouchaki, 2017). At this level, curricula emphasize on the construction of the time concept in student's mind as a grandeur. Thus, we identify the gradual introduction of the operationalist aspect in the curricula at the beginning of the second cycle of learning concerning students 6 to 8 years old (Ibid).

We refer to the notion of duration, succession, and to the notion of speed related to time. Duration refers to a time interval. The estimation of a duration may depend on a number of changes perceived and memorized at the time of the estimation (Fraise, 1979). A duration is felt each time that a need generates a desire which, to be satisfied, an interval of time unfolds (Zakopoulou, 2000). The capacity to estimate a duration and the personal working memory capacity related to the speed of information processing have a reciprocal influence relationship (Droit-Volet, 2016; Montemayor, 2017). The succession of events corresponds to the temporal consciousness (Samartzi, 2003). The perception of changes, of the successive phases of an event, lead to the primitive awareness of the concepts "before" and "after" (Zakopoulou, 2000). The understanding of these concepts is essential for the temporal consciousness to be structured, in terms of past, present and future. The temporal consciousness is a key component of the general consciousness and determines largely the level of general consciousness (Samatzi, 2003). We also refer to the notion of the perception of speed in relation to time perception. Piaget (1981) explains that the relationship between time and speed is a key element in the temporal structuring of children. This relationship consists on the fact that a fast movement corresponds to a short interval of time. Using a language suitable for students from 5 to 7 years, we would say that "faster" corresponds to "less time", what Piaget (1981) describes as the inverse relationship between time and speed. Considering the elements explained above, we are interested in the conceptions of students on the notion of duration, succession, and speed related to time by assuming the existence of obstacles concerning these notions.

We now discuss elements of explication for the terms: conception, obstacle, and didactic engineering. Conception (often referred to as representation), is described as students' implicit ideas about scientific concepts (Bachelard, 1967; Astolfi & Devalay, 1989; Giordan & Vecchi, 1994; Ravanis, 2010). Obstacle, is described as the boundaries that constitute the domain of children' experience (Martinand, 1986, Astolfi & Peterfalvi, 1993, Ravanis, 2010). These obstacles may concern the word polysemy, children's psychogenetic levels, children's attitudes, or explanations (Ravanis, 2010; Xirouchaki 2017). The identification of obstacles leads to setting objectives for a learning intervention applying a didactic engineering. To learn, students have to be actively involved in a didactical situation (Sensevy, 2011; Bachtold, 2012). The precursor model is described as an intermediate mental schema between students' conceptions and a scientific explanation (Lemeignan & Weil-Barais, 1994). This procedure can be facilitated by the action of the teacher as a mediator (Fleer & March, 2009, Delserieys, Jégou, Boilevin & Ravanis, 2017). The term mediator describes an intermediary between the world of knowledge, scientific practice and students (Weil-Barais & Resta-Schweitzer, 2008). The proposal of a didactic engineering, including the conception, the realization, and the analysis of teaching sequences (Artigue, 1988), could help students overcome the obstacles they encounter in measuring time. In our current research, we are interested in the first phase of a didactic engineering (Artigue, 1988), which is called preliminary analysis. This analysis contains the cognitive analysis of students' conceptions.

III RESEARCH OBJECTIVES

New French curricula pay attention to time measurement teaching. Curricula examination of the first cycle of learning, concerning students 3 to 5 years old, reveals that one of the main objectives is the construction of time landmarks and duration awareness. According to curricula of the second cycle of learning, concerning students 6 to 8 years old, students learn to question time more accurately, by applying a first scientific and thoughtful approach.

The development of temporal landmarks is considered as a transversal skill, essential to the cognitive structuring of students. Everyday teacher practice reveals that among students in the same class, regardless of grade level, differences are noticed in student's performance in both perception and time measurement activities. Difficulties encountered by students related to time measurement question us. Etienne Klein (2007) claims that to be situated in time, to be today in time, is to have a story, a past, a present and a future. It is in the present that we are and feel, yet it seems that it escapes us. Based on information cited above, we consider that time measurement teaching presents a social and cultural issue.

From didactics' point of view, the emergence of students' conceptions is a process advocated by the majority of constructivist theories in science education (see Baviskar et al., 2009). Driver and Easley (1978) emphasize the importance of taking students' conceptions into account by comparing them to the accepted scientific knowledge. In this context, conceptions are characterized as "alternatives, built by students" (Driver & Easley 1978, 64 and 79). Bachtold (2012) considers student conceptions as an essential ingredient in science education. Conceptions have a double importance (Ibid). On the one hand, conceptions should be taken into account for the didactic transposition of scientific knowledge. Didactic transposition refers to knowledge reorganization and reformulation in order to be assimilated by students. On the other hand, the very recognition of the existence of the initial conceptions of students arriving in class may lead to a revision of the science teaching strategy. In particular, teaching process can consider conceptions as a starting point. Posner & al (1982) state that for students' conceptions to be understood, they have to become explicit. In this context, these conceptions must be expressed in one way or another, orally or through a schema. diSessa (2017), claims that students' conceptions examination can lead to innovating teaching ideas which can motivate students' interest about learning science.

We formulate our research questions under the following terms:

- What are the conceptions of 5 to 7 years old students about the measurement of time, concerning the notion of duration, succession and speed in relation to time?
- What obstacles do students encounter about perception of duration, speed and succession notions related to time?

IV METHODOLOGICAL FRAMEWORK

To identify students' conceptions of the concept of time measurement, we propose situations that allow students express their initial ideas about time measurement. We now present methodologist tools set up for a student sample for conceptions of the notion of the inverse relationship between time and speed. The methodological framework applied is inspired by research existing in both didactics and psychology. The collection of data obtained pass through open discussions between the student and the researcher. These discussions take place through an individual semi-structured interview, as we present to the student an experimental support. The discussion takes place around the questions transcribed in advance on our interview guide. The interviews last about five minutes, they are filmed and take place in a room specially designed for this purpose inside the schools. This way of data collection, allows us to collect the ideas, responses and reactions of each student individually, without being influenced by other students. 63 subjects (33 boys, 30 girls) aged 5 to 7 years participated in this data collection. The population comes from 5 classes of different primary schools, urban and rural, of the department of Ille and Vilaine in France. Participants are children from mixed socio-cultural categories as the students questioned come from public schools of this region. The choice of sample collection from the same department is done in order to eliminate the social time perception variable (De Coster, 2004). As previously explained, time is not lived or organized in the same way according to cultures (Troadec, 2007). The subjects of our sample have not previously received a didactic intervention organized on the understanding of the notion being treated. Collection of our data is carried out using digital equipment, a dictaphone and a camera on stand with microphone. The interviews are subsequently transcribed. The use of video allows us to identify communicative gestures (DeLoache, 2004), for students aged 5 to 7 who may not express themselves verbally. In this study we focus on the external systems of representation (Ibid) mimetics and language, by keeping a video trace.

Students are confronted to a problem situation. We will refer to the etymological explanation of the word problem, from the epistemological point of view, as indicated by Boilevin (2005). (The word problem, is formed by the prefix "pro" which means “in front” and the radical "ballin" which means "to throw". The essential idea is that of a difficulty, an intellectual challenge, for example - that we throw "βαλλω" in front of "προ" the student). We design our experimental support, in the form of a water clock. By using this support, we create our problem situation with the objective of identifying its resolution procedure (Boilevin, 2005), as developed by the student. We aim to understand the student's reasoning, identify his or her initial idea and the potential obstacle that exists behind it. In the modern cognitive psychological context, the study of the notion of time is usually related to the ability of problem resolution (Samartzi, 2011). This is the main ability that reflects the thought directed towards a goal (Ibid).

The water clock is presented by a water tank which flows downward through a Y-tube. The two branches of the Y have exactly the same flow (quite low but steady) and are controlled by a single tap handle, so that they will always begin to flow simultaneously and stop simultaneously. We then branch under the two branches from the Y two small jars of different shapes and equal volumes (A) and (B) and the experiment begins. We ask the following questions to the student: "Which of these jars will be filled more quickly? "Will it take a longer time for the one jar to fill up or less time than for the other jar? ". We turn the tap and let the jars fill up. We continue with the questions: "Which jar has been filled more quickly? », « Did it take a longer or less time than for the other? ". We hypothesize that 5- to 7-year-olds students think that the fastest water movement, in their opinion, is the one that corresponds to a longer time. To emit this hypothesis, we are inspired by the research of Piaget (1981), but also from the epistemological perspective of the Knowledge in Pieces (CpM), (diSessa, 2017) which refers to students' prior conceptions and the role of these in the emergence of competence.

Figure 1: the water clock

This theoretical and empirical framework deals within the framework of the "conceptual change" (Vosniadou, 2013) and proposes a method of qualitative analysis of students' conceptions on especially difficult notions (diSessa, 1993). The "conceptual ecology" of students before they receive a teaching has to be finely analysed (Ibid), considering one by one the intuitions to understand learning. Students have a multitude of disorganized "intuitions", activated and effective in very specific contexts which are called phenomenological primitives, (noted as "p-prims" as follows), (Smith, diSessa & Rochelle, 1993)."P-prims" can be mental structures used without justification or related to causal relationships with a low level of interpretation (Ibid). These are elements of intuitive knowledge that constitute for subjects their "sense of mechanism". This way of thinking leads young students to consider certain facts as obvious, some as plausible, some as improbable and provide their real or imaginary explanations. For example: "an increased effort generates greater results", "the greatest is the stronger"(diSessa, 1993). By taking into account research cited above, we make the assumption that students from 5 to 7 years old, participating in our interviews, can express themselves in a way similar to the following one: "the jar (x) is filled more quickly, it will take more time to fill". The CpM methodology takes into account students' different ways of thinking and a various vocabulary, which allows us to deal with the richness and diversity of student responses.

We also establish a grid of categorization of possible student responses prior to the interview (Ravanis & Boilevin, 2009) to better manage the possible heterogeneity of the students' reactions during our analysis. We expect three classes of responses to which we add the case of a possible lack of response. The first class concerns the satisfactory response of a scientific point of view, which corresponds to the correct, immediate solution of the problem proposed. The second class concerns the intermediate response, which includes some ideas that fit the intended knowledge. The student will provide answers sometimes accurate, sometimes false. S/he will momentarily understand the inverse relationship "faster = less time", but may not be able to generalize this report. The third class concerns the insufficient answer. In this case, the student anticipates that the smallest (the one that seems to be the smallest) of the two jars (A) and (B) will be filled the faster. S/he imagines that the fastest water movement (in his/her opinion) is the one that corresponds to a longer time. We also contribute a class in the absence of an answer. We also constructed a class for the absence of an answer. In this case, the child gives no answer or starts to answer and do not finish his sentence or remain undecided.

V RESULTS

We now present the results of our study concerning the notion of the inverse relationship between time and speed by giving some examples of the student responses. We are interested in students' ideas expressed before realising the experiment. The analysis of the ideas expressed by the students allows us to infer their conceptions about the inverse relationship between time and speed. In the case of satisfactory answers, the student says that the jar which will be filled the fastest is the one for which it will take less time to be filled. We present the example of the answer of the subject 9, to the first and the second question asked: "the jar (A) will be filled faster than the jar (B), it will take less time to fill the jar (A) ". In the case of intermediate answers, the student understands momentarily the inverse relationship "faster = less time". We present the example of the answer of the subject 25, to the first and the second question asked: "the jar (A), not the jar (B) will be filled as quickly as possible, the jar (B) will take more time, oh no I think that the jar (A) will take longer to fill". In the case of insufficient answers, the student anticipates that one of two jars (A) and (B) will be the fastest to be filled and says that the one who is going to be the faster to be filled, will take longer. We give the example of the answer of the subject 26: "the jar (A) will be the first to be filled, it will take more time to fill the jar (A).

The results obtained during the analysis indicate that a large proportion of the students provide an insufficient answer. More specifically, 19% of students do not give any opinion on the question asked. 56% of students present an insufficient opinion. 22% of them give an intermediate response whereas only 3% give a satisfactory answer. Taking into account the large number of insufficient responses added to the rate of no response, we can conclude that one of the main barriers to understanding the notion of time perception among students of the ages examined is the misunderstanding of the inverse relationship between time and speed.

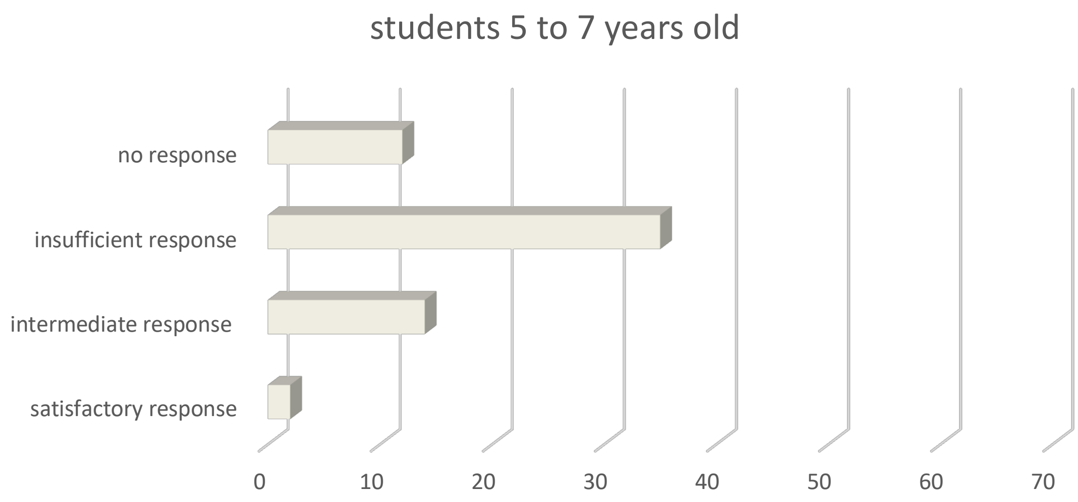

Figure 2: students' responses

VI DISCUSSION

The study presented in this paper provides an answer to one of our initial questions regarding 5 to 7-year-old students' conceptions of the inverse relationship between time and speed. We make the choice to perform interviews with students aged 5 to 7 from different schools in the department of

Ille et Vilaine wishing to limit the variant of social time (De Coster, 2004). We focus on the collection of students' conceptions of time perception. We refer to time measurement from the point of view of classic non-relativistic physics (Matthews,2015). The experimental support that we propose, in a form that we call "water clock", allows us to approach time as a grandeur (Munier and Passelaigue, 2012) from a realistic point of view (Perdijon, 2012) in concordance with the official curricula of the national education for students 5 to 7 years old (Xirouchaki, 2017). This experimental setup allows us to identify students' conceptions (Bachelard, 1967, Astolfi & Devalay, 1989, Giordan & Vecchi, 1994, Ravanis, 2010) on the inverse relationship between time and speed by eliminating as much as possible the influence of stimuli from other registers, the presence of a colour or an odour for instance. By using this support, we also eliminate any mechanical difficulties. We refer, for example, to the synchronization at the level of the flow of water, by setting up the functioning of one wrist to drive the water stream. The problem situation (Boilevin, 2005) that we propose enhances students' attention thanks to its originality. Students verbalize their ideas in the most of the times. This problem situation also brings out the reasoning of students. We are interested in the phase of the preliminary analysis (Artigue, 1988) of pupils' conceptions, which allows us to proceed to a cognitive analysis. Identification of mimetic and language elements within students' reactions (Xirouchaki, 2017) using video capture favours our analysis.

VII CONCLUSION

The theoretical register and empirical phenomenological primitives (diSessa, 2017), leads us validate our initial assumption. The inverse relationship between time and speed is one of the obstacles that students aged 5 to 7 can face. We take into account the richness and the diversity of students' responses. We focus our interest on the assumptions made by students when formulating our first two questions. The variable of the volume of the jars proposed let us identify the report of students to the inverse relationship between time and speed. Individual interviews allow us to identify the ideas of each student without the interference of other factors that could influence the results. We consider that these first results on the conceptions of 5 to 7-year old about the inverse relationship between time and speed constitute an interesting start regarding the obstacles that young students may encounter on time perception and measurement.

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