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Learning to use a protractor: Touch screen tablet or not?

Cécile Allard¹ and Edith Petitfour²

¹University Paris Est Créteil, Créteil, LDAR (EA4434) Créteil, France; cecile.allard@u-pec.fr

²University of Rouen, Rouen, LDAR (EA4434) France; edith.petitfour@univ-rouen.fr

In the present study, we compare the practice of one teacher in two 5th-grade classes for the same teaching concept (about angles) according to different working arrangements. In one of her classes, the teacher combines lecturing and interactive class: she talks and she exposes knowledge in front of her students. In the second class, she decides to try a new working arrangement: the flipped classroom. We compare the knowledge at stake by studying actions, gestures and language when video lectures are used on the one hand and when such devices are not used on the other hand. Thus, we compare the knowledge, which was shared and discussed in the classroom.

Keywords: Practice, protractor, language, angle, touch screen tablet.

Introduction

Our goal is to study the impact of the working arrangements' modifications (use of the touch screen tablet or not) about knowledge exposure (Allard, 2016). More specifically, we study the geometric knowledge exposure when the students learn to use an instrument (the protractor). We think that the use of artifacts have a contribution at the cognitive level (Mariotti & Bartolini Bussi, 2008). Thus learning to use a protractor contributes to the construction of the angle's concept.

This paper focuses on the teaching and learning of the angle's concept. It involves one teacher, Marie, and her grade 5 students in their use of the protractor. In France, at primary school level, students learn how to compare angles and how to reproduce a given angle using templates or tracing paper. In 5th grade they are then trained to use a protractor to measure angles and to construct an angle with a given measurement.

For several years, ministry of education recommends the use of new technologies and more recently emphasizes the need to individualize teaching: the flipped classroom may provide the means to meet these demands. This model of classroom instruction can be defined as an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom (Bishop & Verleger, 2013).

Theoretical framework

This qualitative study is built on prior work on the Double Approach by Robert & Rogalski (2005), current work on the concept of angle and on the study of actions with instruments Petitfour (2015).

About practice

To analyse and interpret teacher's practices, we use the theory of the Double Approach defining five components: personal (teacher's choices, beliefs), social (teachers' working place, their colleagues and the social environment of their students, in both disadvantaged and advantaged areas), institutional (curriculum, relationship with supervisors), cognitive (choices about mathematical contents, tasks, organization and forecasts on how to manage the session) and mediative (improvisations, speeches, motivation of the students' participation, devolution of instruction and

knowledge exposures). The study of the students' activities allows to give information on cognitive and mediative components (what students did, what they said about their activities and what they learnt). Consequently, we have to clarify the elements of knowledge at stake, misconceptions and difficulties in the learning of the concept of angle.

About angle

Angle appears to be a very complex and multifaceted concept, which can be defined in three different aspects: turn (an amount of turning between two lines meeting at a point), ray (a union of two rays with a common end point) and region (the intersection of two half-planes) (Mitchelmore & White, 1998).

Students encounter numerous difficulties in the learning of angles and misconceptions have been pointed out in several experimental studies (Berthelot & Salin, 1995; Mitchelmore & White, 1998; Devichi & Munier, 2013). Many students for instance consider that an angle's size depends on the length of its arms; or that one arm must be horizontal and the direction always counterclockwise; or that the angle is a sector in a circle (i.e. a "slice of pizza"). Tanguay and Venant (2016) hypothesize that this misconception is a possible effect of the systematic use of the protractor, when measures in degrees are at stake. Moreover, the confusion between the mathematical concept and the shape that represents it generate mistakes when students consider the spatial characteristics of the design representing the angle (Balacheff, 1988).

Students face some difficulties in using a protractor, which have been stressed in the literature. For example, Close (1982) observed mistakes due to a lack of mental representation of the protractor's angle to superimpose to the angle to be measured or due to the complexity of the dual scale. Tanguay (2012) summarizes some well-known difficulties encountered by students: they align the edge of the protractor body itself along one of the angle's arm instead of the baseline; or they don't place the protractor origin over the vertex of the angle to be measured. They can also read the measure on the wrong scale or on the right scale but in the wrong direction, for example by reading on counterclockwise graduation 39° left to 40° instead of 41° .

About actions with instruments

We consider four categories of knowledge according to a theoretical framework to study actions with instruments (Petitfour, 2015)¹:

- *geometric knowledge* about geometric objects, relations and properties
- *graphic knowledge* about representation of geometric objects (symbolic signs, drawings)
- *technical knowledge* about the instrument functionality, its use to obtain the graph and the theoretical relationship between the graphical trace and parts of the instrument
- *practical knowledge* about a given artifact, connected to its concrete handling and to a concrete organization of the action with it

Methodology

We study the practice of one teacher, Marie, who wanted to experiment with a new style of instruction: the flipped classroom. Thus, her students should learn some mathematical content online,

¹ This framework is based on an instrumental approach (Rabardel, 1995).

by watching video lectures at home before the class session, whereas in the classroom, they should solve more exercises. Consequently, the teacher would be freer in the class session for discussing with the students: that should lead her to a more personalized guidance and to greater interactions with students than traditional teaching.

In our study, three components are common to the two situations that we analyze here: institutional, personal and social. Marie's components can be defined as follows: she is appreciated by her supervisors, colleagues and students. She thinks that in order to learn (and to teach) well it is necessary to handle and to solve a lot of exercises. She finds that she has never enough time. She is concerned about the learning of her students. She teaches in a rural school without social difficulties. In her two 5th-grade classes, she volunteers to include gifted students. These three components are stable and the same in the two situations. Thus, we can compare the practice of the same teacher in two 5th-grade classes in the same area. Consequently, we can focus only on the mediative and cognitive components. In order to foster the comparison, we asked Marie to teach the same content and to propose the same tasks in her two different classes, one with video lectures and the other one without.

Data

In order to describe practices and inform mediative and cognitive components involved in the Double Approach, we focused on:

- one video for the 'flipped classroom' and two for the ordinary class that we have transcribed
- two short video lectures which we have transcribed
- the notebook lessons, exercises book and topics of assessment
- the teacher's interviews conducted before and after the sessions

We have split each session in episodes. We have identified different types of episodes in relation with the teacher's specific goals and exposure of knowledge (Allard, 2016). For example, in the lecturing session, the teacher remembers specific words (how to call angles according to their openings measured in degrees) at the beginning of the class session. The teacher also recalls to the students the specific symbol to note an angle (\widehat{ABC}). These moments are reminder episodes (type 1): the teacher recalls of previous knowledge. Regulation episodes (type 4) are moments when the teacher intervenes to explain and to anticipate difficulties. The main goal of the regulation episodes is to provide students' progress. So we have identified six types of episodes.

For lecturing sessions

The two lecturing sessions last 45 minutes. The aim of the first session is to measure an angle with the protractor. The aim of the second session is to draw an angle of a given measurement. They follow the same organization in six types of episodes (table 1).

1	Reminder episodes: <ul style="list-style-type: none"> - categorizing angles according to their opening measured in degrees (1st and 2nd sessions) - noting and naming the angles (1st and 2nd sessions) - defining the center of the protractor, based on a description of the artifact (1st and 2nd sessions) - measuring angle with a protractor (2nd session) - estimating and controlling the measure (2nd session)
2	Methodological episode: estimating and controlling the measure
3	Presentation of the new knowledge: presenting and discussing the methodological sheet about measuring (first session) and drawing angles (second session) with a protractor.
4	Regulation episode: <ul style="list-style-type: none"> - anticipating difficulties (in relation with the dual scale or extend ray) - reviewing any personal concerns or difficulties that are raised during the session
5	Exercises episode: providing activities and handing out methodological and exercises sheets
6	The correction of the exercises: exposing knowledge and the difficulties encountered

Table 1: the six types of episodes for ordinary session class

The teacher talks to the entire class during certain types of episodes: 1, 2, 3, 4 and 6. Students are then facing the blackboard. It is only during the episode of type 5, that students work individually to solve exercises and the teacher interacts with them about their errors or difficulties.

For the classroom with tablet

Some students did not have access to the learning platform at home (because of one technical problem), as a result they did not watch the video session before the session in the classroom. Therefore, the teacher improvised and gave time during classroom session to watch and to listen to the video-class on the touch screen tablet. So, it's an opportunity for us to observe students discovering by themselves a mathematic lesson. This session lasts 45 minutes. We have then identified three types of episodes (table 2).

3	Presentation of the new knowledge by the video sessions about measuring and drawing angles with a protractor
4	Regulation episode: reviewing any personal concerns or difficulties that are raised during the session
5	Exercises episode: providing activities and handing out methodological and exercises sheet

Table 2: the three types of episodes for video session

Students worked in groups (by pairs) and watched the video lessons (episode of type 3). After that, they completed some exercises (the same ones that in the ordinary session class). The teacher walked around and talked with students to regulate their work one by one. For example, once more she explained how to handle the protractor.

Data analysis

Comparison of the episodes

Ordinary class requires two sessions instead of only one for the class with the touch screen tablet in order to learn the same content. For the teacher, it seems to be an efficient method. But our study shows that less knowledge is going around in the class in the case of touch screen classroom (episodes of type 1, 2, 6 are absent), there is no link between previous knowledge and the new one, no collective reminder by the teacher and a lack of formulation of the knowledge by the students.

In the ordinary classroom, students listen to each other and listen to the teacher, they raise their hand in order to come to the blackboard, they do individual exercises and sometimes ask questions or answer question the teacher's ones. They are facing the blackboard, which promotes discussions between themselves and the teacher. In the touch screen tablet session, students watch the first video session several times and they solve the exercises individually. While they work on the exercises, many students listen to the touch screen tablet: they look at the gestures in the screen and they try to do the same, they stop, observe and copy. After that, they watch the second video and do exercises. Meanwhile, the teacher walks around the pair groups, corrects mistakes, rectifies the bad handling of the protractor.

In the ordinary classroom, the teacher leads her students to use an appropriate language during the presentation of the new knowledge episode: for example, "center" for the center of the protractor instead of "hole". We can see that the students appropriated this formulation in the ordinary classroom whereas they did not in the other classroom even if they had listened to the session video several times. We can see in this comparison to what extent the working methods seems to change what is said and what is shared.

Now we compare what changes at the level of the potential learning about angle and the use of the protractor.

Knowledge at stake

Actions with a protractor in order to measure an angle or to draw an angle with a given measurement involve different pieces of knowledge. We study the knowledge at stake in the types of episodes where this knowledge is exposed to all the students, that is to say where the whole class has the opportunity to hear or to see the same thing. It concerns episodes of types 1, 2, 3, 4, 6 in the sessions without a tablet and type 3 in the session with a tablet.

Some geometric knowledge appears explicitly in the session without a tablet whereas it does not in the session with a tablet. On the one hand, the classification of angles based on the degree measurement is recalled: angles are categorized according to their openings measured in degrees: an angle can be right, acute, obtuse, straight, zero or reflex. On the other hand, "angle" is defined as formed by two rays (sides) that have the same endpoint (vertex), and "ray" is defined as a line extending indefinitely in one direction from a point. In the same way, graphic knowledge appears explicitly only in the session without a tablet: first, the symbol \angle enables to distinguish an angle and a triangle; second, an angle can be named with three letters, the second letter names the vertex, the first names a point on one side and the third a point on the other side. The fact that the line representing the ray can be extended in one side is mentioned in both sessions but only explained referring to some geometric knowledge in the session without a tablet.

As far as the representations of an angle are concerned, drawings are more numerous in the session without a tablet. Indeed, in this latter session, five angles are drawn on the whiteboard, one is freehand traced and the others are traced with one of the edges of a set square. Besides, one is obtuse and four are acute with similar opening around 45° but which one with the vertex at right (it allows to use both protractor's scales) (Figure 1). At last, the five drawings have a horizontal side and are named with three points.

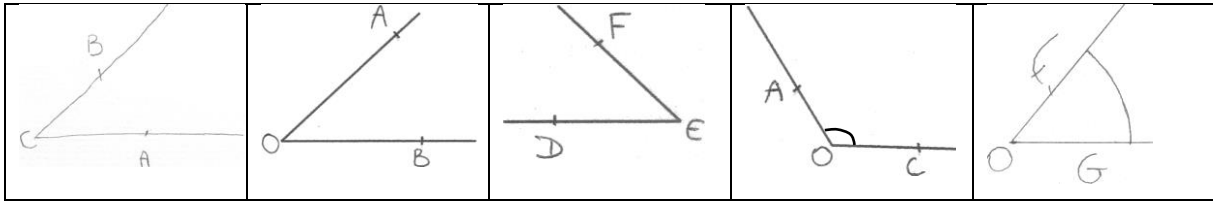


Figure 1: Drawings of angles in the session without tablet

The drawing of the angle \widehat{FOG} , 52° had been presented by two students on the blackboard and each time, they have drawn an arc of a circle along the semi-circular edge of the protractor despite the fact that the teacher mentioned the uselessness of this curved line. This representation has led some other students to speak explicitly about “cake slice” which reveals the misconception of the angle as a sector in a circle.

Only two acute angles are drawn on a paper in the session with tablet. They are oriented in a non-prototypical way and are named with the letter of the vertex (upper case) and the letters of the direction of each ray (lower case) (Figure 2). It is not this latter notation that is used in the application exercise but the notation with three points.

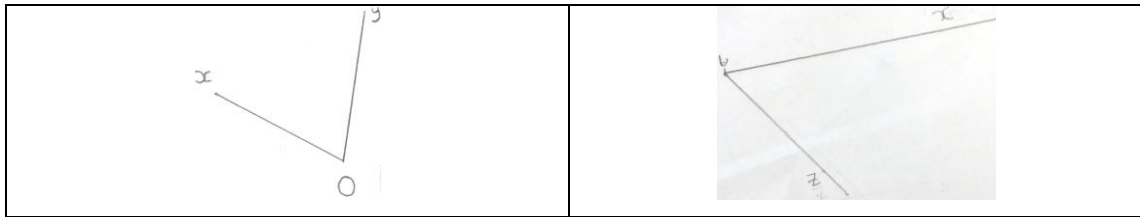


Figure 2: Drawings of angles in the session with tablet

In both sessions, drawn angles are named both spoken and written. In the session without a tablet, the teacher sometimes used gestures too (Figure 3) expressing either the “ray” aspect or the “region” aspect of an angle.

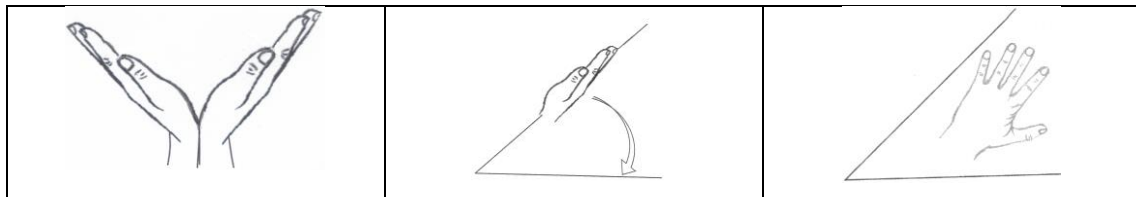


Figure 3: Gestures about angles (Left, “ray” aspect and middle and right, “region” aspect)

Moreover, in the case of the obtuse angle \widehat{AOC} (Figure 1), she used a symbolic sign – a small arc of a circle – in order to indicate what angle is to be considered. In the session with a tablet, there are only deictic gestures pointing the letters “x”, “O” and “y” when they are uttered in order to name the measured angle.

Some technical knowledge is recalled only in the session without a tablet. This knowledge concerns the protractor’s functionality: a protractor is a measuring instrument, the measurement is expressed in degrees; and a description of the protractor parts to link with the graphical representation of an angle. Indeed, the localisation of the protractor’s centre is first given in a general way, by the use of

language accompanied by gestures, then the graduation 0° and the dual scale (inner and outer) from 0° to 180° are named and pointed on the protractor by the teacher.

The steps to measure an angle and the steps to draw an angle using a protractor are formulated in the same way in the two sessions. What is said is exactly what is written on the summary sheet given to the students. For example, here are stated the three steps to measure an angle: first, place the protractor so that the centre is over the vertex of the angle to be measured; second, place the graduation zero degree over one side of the angle; third, follow the graduations of zero degree, ten degrees, twenty degrees, ... until you reach the other side of the angle. It is also stated that perceptive evaluation of the opening of the angle – greater or smaller than the one of the right angle – enables to control possible measurement errors.

In the session with a tablet, the students can hear and see the operating filmed sequence as many times as they wish, pause and go back whereas in the session without a tablet, the operating sequence is presented several times by different students on the blackboard (for example, three times to measure an angle before doing the application exercise). The teacher helps the students to formulate the method they implemented.

Practical knowledge appears only in the session without a tablet. For example, some protractors have a hole to show the centre near the bottom of the protractor whereas the blackboard's protractor has his centre on the bottom; the semi-circular edge of the protractor can be damaged so that it is better to avoid tracing along this edge; if the protractor goes beyond the lines represented sides of an angle to be measured, then the lines must be extended. Regarding organizational aspects, the teacher gave students the advice to store the protractor in a pocket in their workbook to avoid breaking it.

Results and conclusion

Our analysis of one teacher's practice about the use of the protractor allowed us to point out the following results. Some of the students' difficulties and mistakes are the same in both sessions, with and without tablet, when the students trace or measurement by themselves during the exercises episodes: wrong localization of the measure on the protractor, measurement without extending the line representing ray when it is necessary, clumsy handling of the protractor. Errors to note and to name points and rays appeared only in the session with tablet (students didn't manage to adapt what was presented in the video lecture). Moreover, there are inaccurate wordings that show confusion between length and angle. The correction of the arising errors is private in the both sessions but also public and shared in the session without a tablet. Finally, whatever the case, there is no difference between the assessment results of the two classes, according to the teacher and the collected data cannot inform us about the arrangement that would better foster learning.

This study confirms that the modifications tied to the mediative component, in particular in terms of working arrangements, have a very important impact on the knowledge exposure (Allard, 2015). Indeed, in the session with tablet, the only exposed knowledge is the knowledge of the tablet, without possible links with difficulties met by the students. In the lecturing session, there is more knowledge exposure thanks to the interactions between the students and their teacher.

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