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IMPACT OF INITIAL TRAINING ON CONCEPTIONS ABOUT “MEASUREMENT” AND “ATTRIBUTE” OF PRE-SERVICE PRIMARY SCHOOL TEACHERS

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The teaching of the “attribute” and “measurement” concepts at primary school in France is an interdisciplinary issue shared by mathematics and physics teaching. In a previous study presented at ESERA 2019, we confirmed that at the end of their initial training Pre-Service Teachers (PSTs) related the attribute concept to something vague and the measurement concept to something precise. They generally believed that several values are needed to define a measurement value. They noticed that error sources are necessary to be taken into account to enhance the measurement process and obtain better measurement values. In this second study, we investigate the impact of the initial training these trainees received a test similar to the one use in the previous study. The PSTs' responses are analysed at the beginning of the training in order to compare them with previous results obtained at the end of a similar training. Additionally, a specific pedagogical situation dedicated to the concepts involved in this study has been conceived. We look at the evolution of the understanding of the trainees who have taken this specific session. The results indicate a very small effect of the initial training on the trainees' understanding of the attribute and measurement concepts. Beside the specific situation appears to have only a slight effect on their understanding of data collection.

Keywords: Initial Teacher Education (Pre-service), Measurement, Primary School.

ATTRIBUTE¹ AND MEASUREMENT IN LITERATURE

The 14th conference of the ESERA spotlighted the uncertainty of the world and moreover this issue in science education from different perspectives. Yet uncertainty is a main issue of the metrology, which is the dedicated field studying measurement for science and technologies. This concept is defined in a guide establishing rules for evaluating and expressing uncertainty in measurement (JCGM, 2008). Although the access to the concepts of uncertainty and error in a measurement issue needs to fully understand the concept of measurement and thus the one of attribute. The main goal of a measurement is to quantify interactions and relationships between objects and phenomena to build mathematical models. The International Vocabulary of Measurement (JCGM, 2012) defines Attribute (Quantity) as “ Property of a phenomenon, body, or substance, where the property has a magnitude that can be expressed as a number and a reference” (p.2) and Measurement as a “ Process of experimentally obtaining one or more quantity values that can reasonably be attributed to a quantity” (p.16). Teaching those concepts at primary school should enable pupils to get access and to observe the reality of the world but also to introduce that the validity of those observations are limited.

¹ The concept of “grandeur” in French could be translated in English as quantity, magnitude or attribute. The choice to use the term “attribute” is consistent with many English language standards and with research on mathematics education as described by Passelaigue and Munier (2015).

Literature in mathematics and physics education raises the question of the status of attribute and measurement in primary teaching. Since 2015, French curriculum of mathematics spotlights both concepts. It focuses particularly on the building of the number (MEN, 2015). Brousseau (2002) explains that teaching the attribute concept at primary level is valuable as it is linked to fundamental knowledge of mathematics. Then Chesnais and Munier (2015) set out that the practical concepts of measurement and the uncertainties are often set aside during the teaching of mathematics. Those two notions are mostly linked with the experimental sciences education. They appear in the curriculum at the end of primary school for pupils of ten years old. Chesnais and Munier (2015) explain that a differential treatment of the reality between physics and mathematics still exists at primary school. Yet, teachers at primary school in France are shortlisted by a national competitive exam. Then they become teacher trainees attending a Master 2 in which they spend half time in class and half time at a training centre (INSPE²). Majority of them did not have a previous specific science or mathematic education at university before this training. Then we can imagine that the teaching of both concepts could be difficult task to them.

In a previous study, presented in the ESERA 19 conference, we wondered how Pre-Service Teachers (PSTs) of primary school understood attribute and measurement concepts by the end of the training year 2017-2018. We first confirmed previous results obtained by Passelaigue and Munier (2015) that French PSTs have a lack of understanding of those concepts at the end of their initial training. They often described the concept of attribute as “something vague, ill defined, not very precise” (p.332). Trainees also explained that “an attribute is only an approximate quality” (p.332) until it is measured. This interpretation is deviated from the nature of the concepts they would have to teach. Second, we studied the way they reasoned about collecting data linked to a measurement. We obtained that they mostly had ideas of statistical processes (average calculus) and seemed to look for error sources to deal with variations in the data collected. Thus we wonder if this lack of understanding is due to very strong misconceptions which already exist before the training or if this one changes their way of understanding both of those concepts. Thus we think it is important to learn more about the effects of the initial training on those concepts by comparing trainees’ understanding at the beginning of the training and its end. In addition, we wonder if a specific teaching linked to experimental sciences situations focusing on both concepts could help trainees to develop their understanding. Thus, we conceived such a training session and we looked which could be its effects on PSTs’ understanding.

METHODOLOGY

Data collection procedure

The training received by PSTs in the INSPE is focused on the teaching aspects of their future job. Most of them had a non-scientific education before their training. Thus, we assume the group of trainees of the year 2017-2018 and the one involved in this study (year 2019-2020), have similar competences since they pass the same competitive exam before accessing to this initial training. Moreover, we assume the training given in a same site is similar from one year

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to another. Thus our methodology deals with two comparisons: A) the comparison of different PSTs' views at the beginning of the training and its end; and B) the comparison of similar PSTs' understanding having a specific training in an experimental sciences education course. This methodology is represented in the figure 1.

Consequently we use for the comparison A the results obtained with 60 PSTs during the previous study in June 2018 at the end of the training year. We compare them to new results obtained with 89 PSTs (4 groups) at the beginning of the year 2019-2020 (in October and November).

Concerning the comparison B, 61 PSTs (3 groups on 4) of the 89 previous ones attended the specific training situation in the form of a 3 hours course. They dealt first with the place of the concepts of measurement and attribute in curriculum and the definition of specific vocabulary. Later PSTs had to manage two situations of estimation and measurement: the mass determination of a small earth globe with modelling dough sticks and a Roberval scale, and the width determination of the classroom with paper stripes. Finally, PSTs watched a video of an in-practice science session in classroom dealing with the measurement of the temperature of melting ice³. This specific training situation targets issues such as : the introduction of specific vocabulary link to “attribute” and “measurement”, the concept and the procedure of estimation, the implementation of measuring procedure for several attributes, the data processing, the notion of errors and uncertainties, and the statistical treatment and probabilistic aspects. 3 to 4 months later (March or April, depending the group), a similar questionnaire was filled by 40 PSTs. 34 of them filled the one at beginning of the training year.⁴

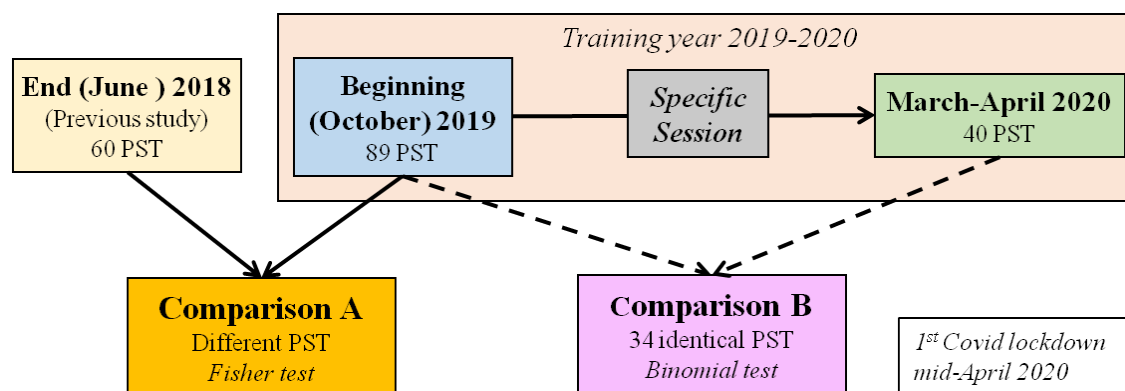


Figure 1. Data collection procedure.

Questionnaire

To assess the understanding of those concepts by the trainees in each of the situations, they complete a similar questionnaire. This questionnaire is based on the one given on the previous study (in June 2018, Maisch, 2019). This paper-and-pencil form is composed of two parts based on two surveys. In one hand, we used the test designed by Passelaigue and Munier

³ <https://www.reseau-canope.fr/bsd/sequence.aspx?bloc=197043>

⁴ One group (25 PST) filled the questionnaire during a training course, when the 15 others filled it on-line due to the COVID lockdown situation. This explains the weak rate of answers for the last sample.

(2015). Trainees have to define the attribute and the measurement terms and next to make a stand about a list of words referring to those concepts⁵: length, volume, comparison, equivalence, estimation, instrument, gram, decimetre, unit, standard, uncertainty, precision, and number. They also have to provide a justification for each word in order to explain their choice. In the second survey, we passed a three questions test defined by Buffler et al. (2001) to obtain student's idea about the way to think of a data collection. Three fictional characters are discussing about the way to consider the distance covered by a ball dropped from a table (figure 2). Three situations are described: the ball is dropped once, two times, and 5 times. The height of the ball dropped is the same but distances of impacts on the ground change. In the two first situations, each character suggests either to keep the value obtained as a result, or to collect a new value, or to collect several new values. In the last situation, the trainees had to decide which result for the distance they could give. Thus they could choose one or several values of the list or they could do a calculation. In each situation, the trainees had to justify their choices.

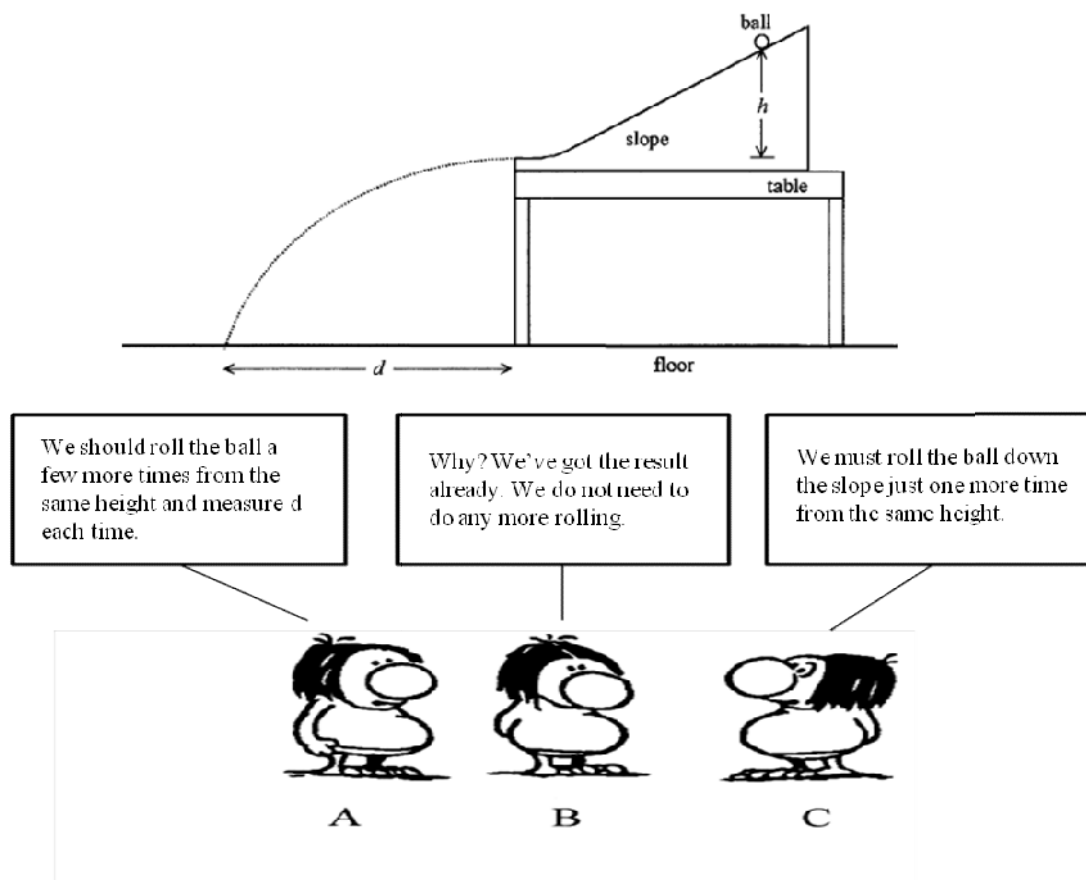


Figure 2. Situation and example of debate (Q1) in the data collecting test (Buffler et al., 2001).

Analysis framework

Regarding the analysis of the questionnaire, we look first at the way PSTs defined both concept following categories obtained in the previous studies (Maisch, 2019). Second, we

⁵ They have to choose if each word is more linked to the attribute or to the measurement concept.

look at the validity of their ranking linked to the definition they gave. To this end, we use a categorization under the form of a table defined by Passelaigne and Munier (2015) and implemented with results of our previous study. Regarding the measurement survey with the data collecting part, we classify PSTs' answers in items depending on issues such as the iterations of the data, the variations, the estimation, the errors, the precision, the average, the spread and the uncertainties. Those items are also classified as valid or non valid regarding to expert definitions obtained in the International Vocabulary of Metrology (JCGM, 2012).

Our first goal is to know if the general training given at INSPE helps PSTs to change their views about the concepts of measurement and attribute and with related concepts. Secondly, we look if a specific training session in a science education context could help them to improve such changes. This means the necessity to compare their results to the questionnaires at different times of the training year. In order to determine the effect of those situations, we use statistical analysis. Regarding the comparison A, we use a Fisher test to compare the answers as PSTs tested are different for each questionnaire. Whereas for the comparison B, PSTs are similar, thus we can use a binomial test to look at possible links between their answers.

RESULTS AND DISCUSSION

Comparison A

In the comparison A situation, we compare the distribution (in percentage) of trainees' answers of the last study obtained at the end of their training to the answers of trainees at the beginning of it. First we observe in figure 3 and 4 that both sets of PSTs defined "Attribute" and "Measurement" in a similar way without focusing on a valid answer (framed in green in figures). This result is corroborated by statistical results obtain with fisher tests.

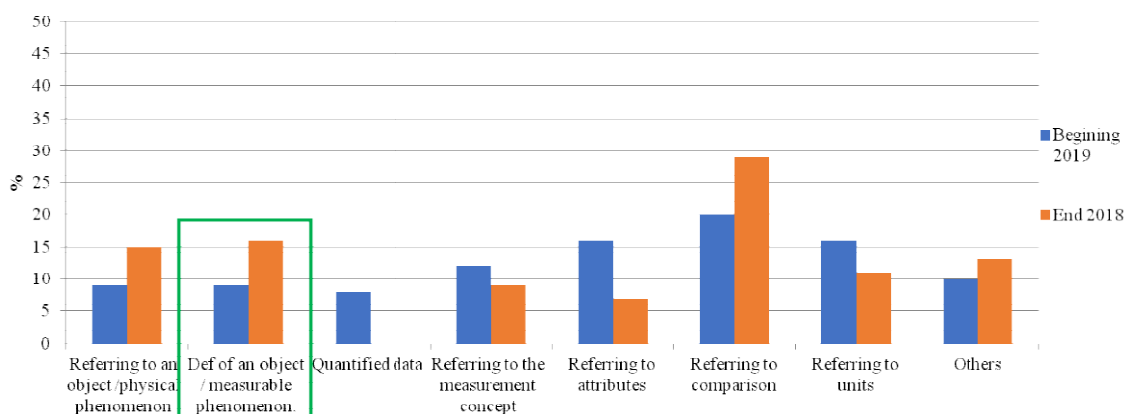


Figure 3. Definition of Attribute beginning 2019-end 2018

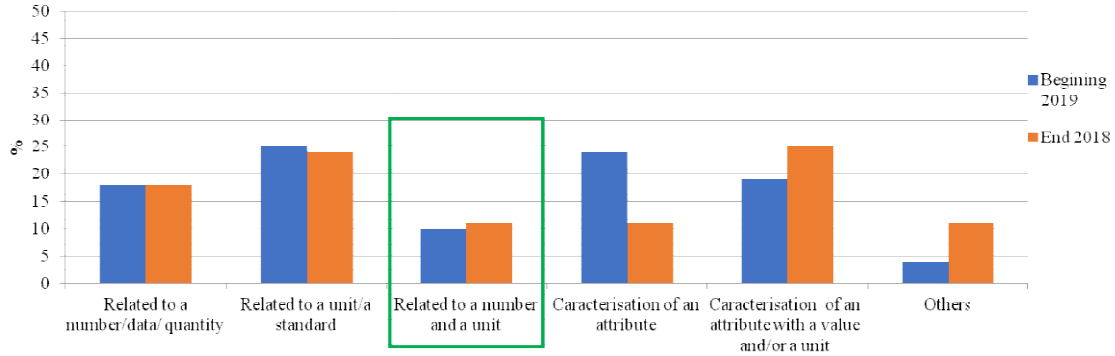


Figure 4. Definition of Measurement beginning 2019-end 2018

A similar statement can be made on the validity of their classification of the list of words but with slight differences (figure 5). Indeed, Fisher tests show significant differences for the notions of Length ($p = 0.0009$) and Volume ($p = 0,0038$) (circled in red in figure 5). Trainees use more unclassified answers (/) at the end of the training than at the beginning but do not seem to use more valid answers. But this statement is limited to both notions. Concerning the other notions, the validity of their justifications follows a similar trend in both cases.

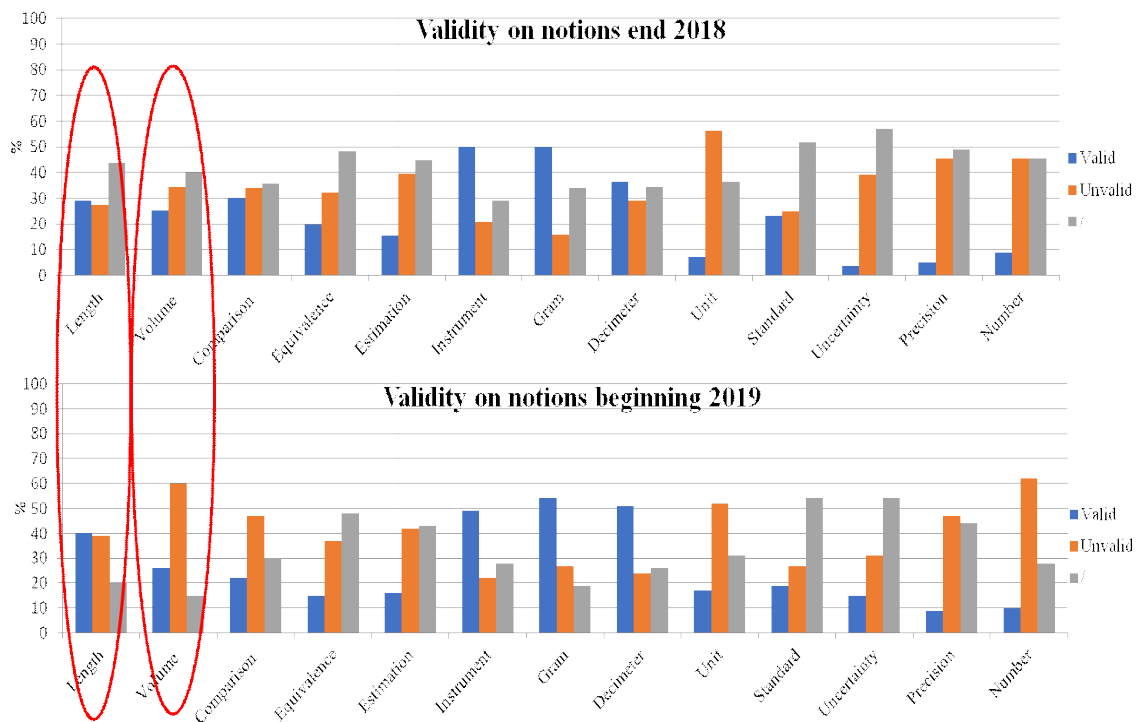


Figure 5. Comparison of validity on notions beginning 2019-end 2018

Concerning the way to deal with a data set (measurement survey) (figure 6), the trainees used different reasoning to answer to first and second question as showed Fisher test (circled in red, Q1, $p = 0,0034$; Q2, $p = 0,0036$). Those results seem to show a change from valid answers to unclassified ones (/). Moreover, PSTs seem to use more valid answers when they have to treat several data.

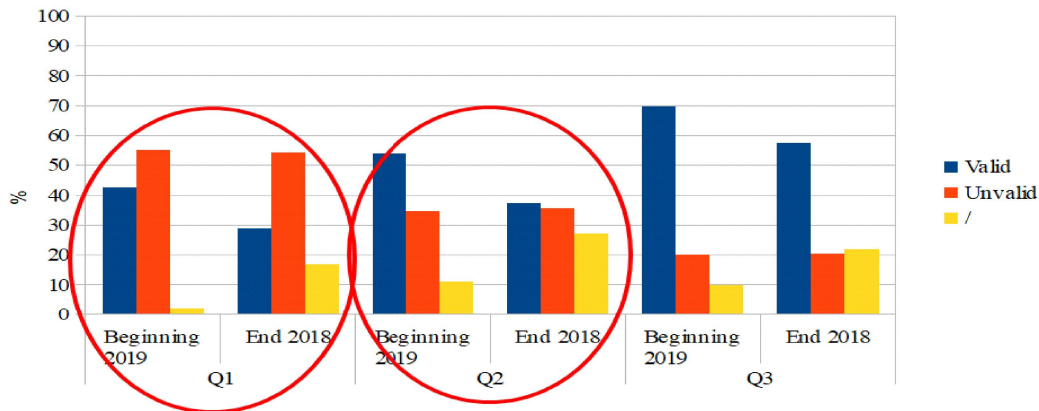


Figure 6. Validity on measurement survey beginning 2019-end 2018

Comparison B

In comparison B, we search for impacts of the specific session on PSTs' reasoning. Thus we compare their answers at the beginning of the training year and few months after the specific session. Their ways to define the attribute and measurement concepts (figures 7 and 8) do not show statistical significant differences. But trainees seem to use a better definition of attribute linked to the expert point of view after the specific session.

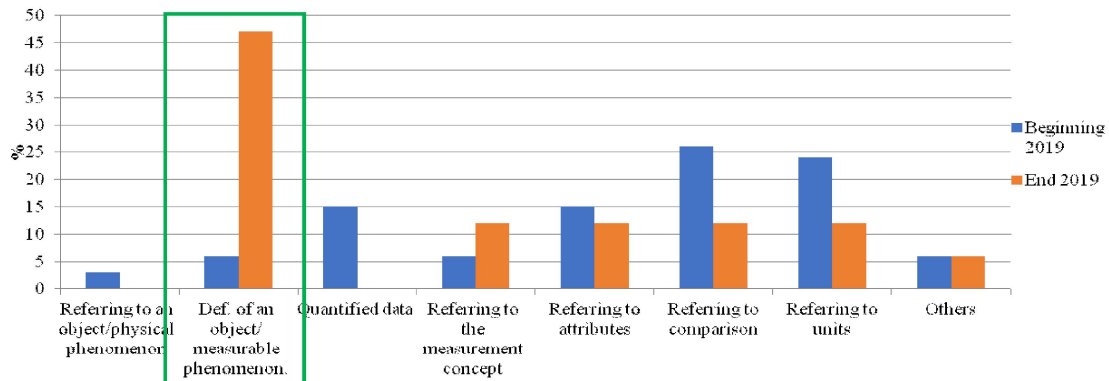


Figure 7. Definition of Attribute beginning 2019-end 2020

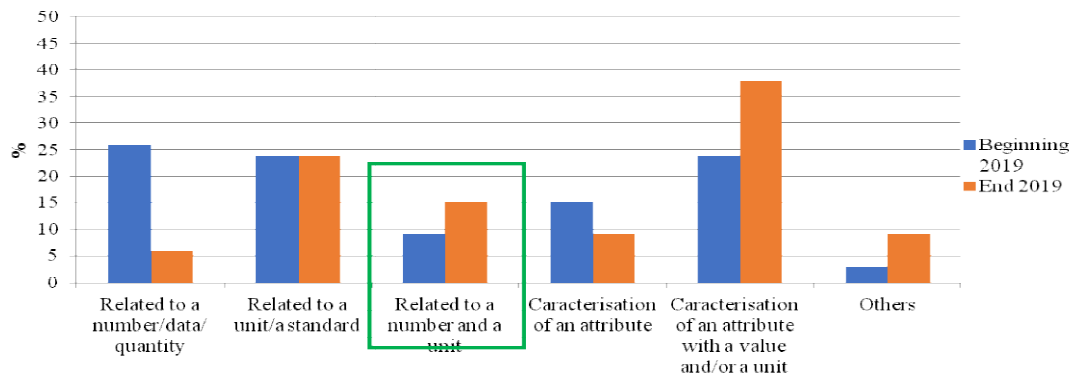


Figure 8. Definition of Measurement beginning 2019-end 2020

When they have to rank the vocabulary linked to both concepts (figure 9), once again no statistical significant differences appear. We can notice that PSTs seem more inclined giving answers which could be classified after taken the specific course. But those answers seem more recognised as invalid than valid.

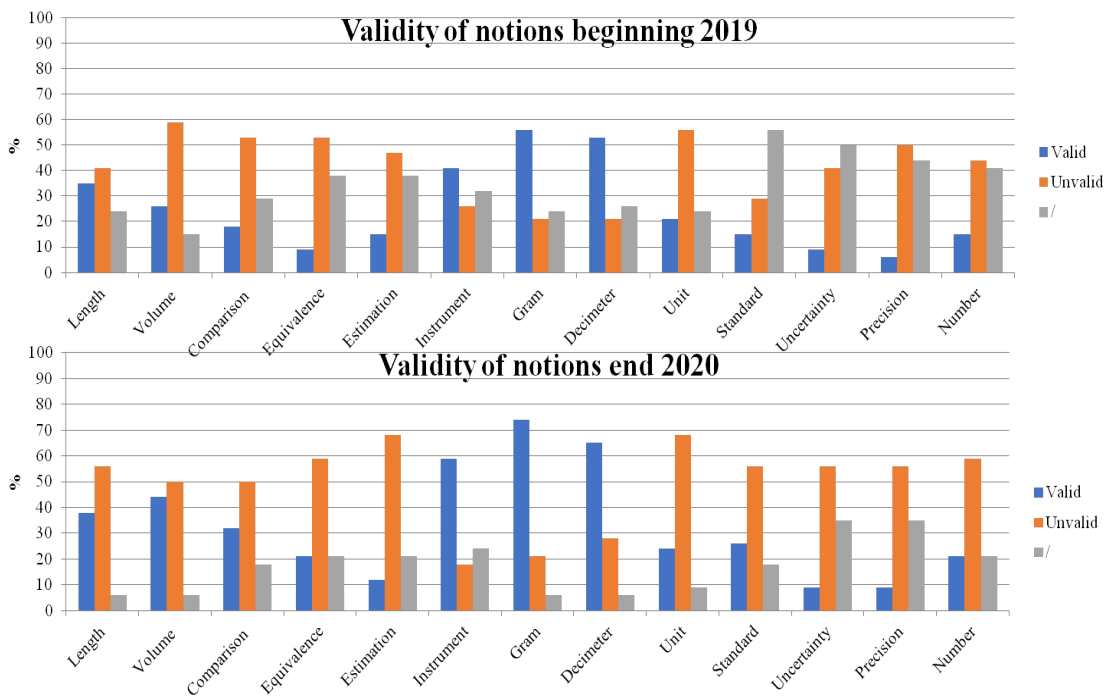


Figure 9. Comparison of validity on notions beginning 2019-end 2020

Finally regarding the measurement survey (figure 10), there is a significant difference only on their answers to the first question (circled in red, Q1, $p = 0,0001$). This result put forward a change from invalid reasoning to valid ones when they answer to this question. For the two other questions, only slight changes seem to occur improving valid reasoning without to be significant.

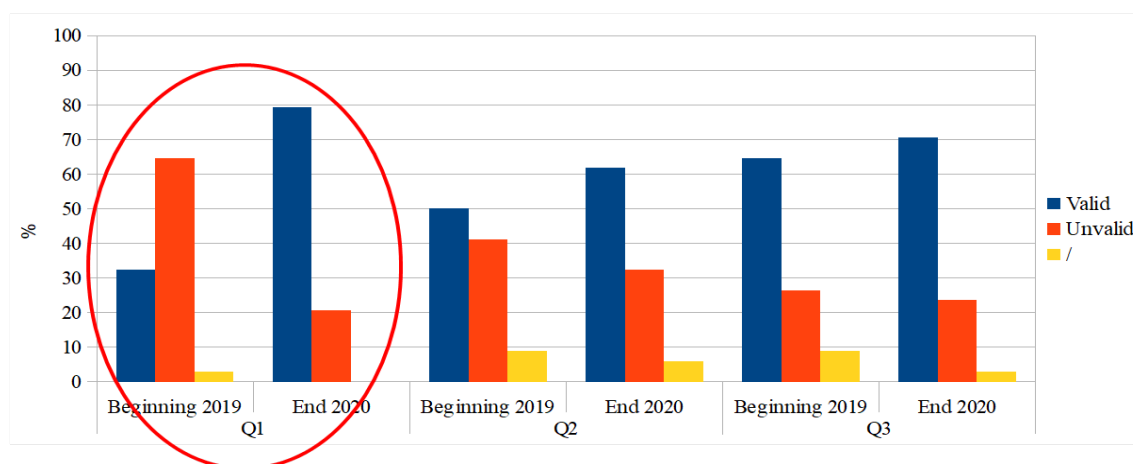


Figure 10. Validity on measurement survey beginning 2019-end 2020

DISCUSSION

Comparison A

This comparison shows almost no change in the PSTs' understanding of the concepts of attribute and measurement and only a change in their view of the notions of length and volume linked to the concept of attribute. We can suggest those changes are due to specificities of mathematical education training focused on those two attributes with geometrical and units issues (which could be also linked to the attribute of area, as explained by Clements and Stephan, 2004). The measurement survey shows also changes in their way to reason about collecting data. These changes seem to show more unclassified answers when the number of valid one is reducing. This result does not fit with what we could wait. This means that the INSPE education do not improve their understanding and even seem to obscure its.

Finally, results obtained in the previous study (and fitting with previous results of Passelaigue and Munier, 2015) show a consistency with what trainees think about the measurement and attribute issues before training. This confirms that INSPE training in science and mathematic education is ineffective to help students to better understand both concepts and other issues related to.

Comparison B

We lead a specific session about measurement and attributes concepts in science education training in order to help PSTs to improve their understanding. Results obtained about their understanding of the concepts and notions do not show statistically any significant improvement. However, they seem to shift toward better understanding of the concept of attribute and to use less unclassified definition of the notions. Results obtained on their way to reason about data collecting show a significant improvement when they have to answer to the first question, namely when they have to decide to collect several data. The trend in the following questions seems to be different from results obtained with comparison A. Eventually, we could say the specific session seems to have slight effects and especially on their way to collect data. The low impact of this situation may be explained by its shortness in time. It can be linked to the Brousseau's explanation that the attribute concept is "taught through an early and extended natural and scholar process" (2001, p.2).

CONCLUSION

Finally, it seems relevant to confront the trainees to the concepts of measurement and attribute all along their initial training, and not only with specific sessions. This training has to be an interdisciplinary goal, involving instructors of experimental sciences education and mathematics education. Thus, they have to lead trainees to provide a meaning to the different concepts whether to build the concept of number or for geometry in mathematics education, or to measure physical objects and to deal with errors or uncertainties in experimental science education.

Future analysis of trainees' practices in classroom will provide an understanding of the choices they make in the design and the implementation of teaching situations involving the concepts of measurement and attribute in mathematics and physics.

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