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The teaching of statistical literacy in France: A curricular study

Charlotte Tarabant¹ and Floriane Wozniak²

¹Université Jean Jaurès, laboratoire EFTS, Toulouse, France; charlotte.tabarant@univ-tlse2.fr

²Université de Montpellier, laboratoire IMAG, Montpellier, France

Our societies are confronted with a permanent increase in data and the multiplication of information. Given the educational challenges that this context represents for exercising critical citizenship, teaching statistical literacy is a major concern. In the framework of the research presented here, we are asking what potential there is for developing statistical literacy in the current French compulsory education program. In order to do so, we identify the key elements of this statistical culture from which a set of criteria is elaborated. These criteria constitute a reading grid to identify these potentialities in the curricula of the disciplines most directly concerned by its development. The results obtained tend to show that such a potential exists and that it requires a multidisciplinary approach to be updated.

Keywords: Statistical literacy, curricular studies, data, information, variability.

Introduction

It is increasingly recognized that, due to the evolution of our societies, the increase of uncertainties, and the masses of data generated by the development of Big Data, the development of statistical literacy is today a major educational challenge. The purpose of our ongoing PhD is to study what is the potential of the current French compulsory education curriculum (primary and junior high school) to meet this challenge and develop such literacy in all students. More precisely, the study reported here aims at investigating the potential offered by the prescribed curriculum, by analyzing the curricula of teaching grade 1 to 9 which correspond to elementary and junior high school (grades 1 to 9, students aged 6 to 15). Chevallard and Wozniak (2005) and Wozniak (2021) show the need of an interdisciplinary approach to develop learners' statistical literacy, so our curriculum study is not limited to the mathematics curriculum. We analyze school subjects where data (textual or numerical) are used: moral and civic education, history-geography, questioning the world, experimental sciences, technology, physical education and sports (EPS) and mathematics.

Based on Franklin et al. (2007) with the GAISE (Guidelines for Assessment and Instruction in Statistics Education) report, Shaughnessy (2007 and 2019), Sharma (2017) and Hidayati et al. (2020), we identify the key elements of the statistical literacy. We establish a set of criteria that we use to identify its potential development in French school curricula.

Following this introduction, our text is structured in four sections. In the first section, we present the main elements we retain from the existing literature on mathematical literacy and the resulting criteria; this constitutes our theoretical framework. In the second section, we specify the methodology of this study and, in the third, we present the first results obtained, in a synthetic way, before discussing these results in the last section.

Literature review

As Shaughnessy (2007) mentions, the wealth of literature on education and statistical literacy represents a difficulty in synthesizing them. In order to identify the characteristic elements of

statistical culture that we will retain for our curricular study, we have given priority to the review articles reinforced with Chevallard and Wozniak (2005) and Wozniak (2021). We therefore relied mainly on the GAISE (Guidelines for Assessment and Instruction in Statistics Education) report by Franklin et al. (2007), the review article by Shaughnessy (2007) and the more recent one by the same author Shaughnessy (2019), as well as the two articles by Sharma (2017) and Hidayati et al. (2020).

The first observation that can be made from these different texts is that there does not seem to be a consensual definition of what statistical literacy is to which we can refer. Different models, analytical frameworks and definitions are proposed by different authors. For example, the GAISE report supported by the National Council of Teachers of Mathematics in the USA proposes a model organized around two interacting dimensions, one concerning the development of statistical thinking and distinguishing three levels, the other concerning the process of statistical investigation and distinguishing four steps (Formulate Questions, Collect Data, Analyze Data, and Interpret Results). For each step, the three levels are made explicit (e.g. beginning awareness of the statistics question distinction, increased awareness of the statistics question distinction, students can make the statistics question distinction). The model also considers variability as an essential feature of this process, and specifies the nature of the variability associated with each step of the process. Chevallard and Wozniak (2005) define statistics as the science of variability, a set of mathematical tools, methods and concepts that support this reality of the natural and social world, uncertainty. Wozniak (2021) distinguishes two types of variability associated with the measurement of quantities: one associated with quantity (the measurement of quantities varies from one individual/object to another within a population/set) and the other associated with the measurement process which, depending on the level of precision, produces "different measured values of quantity" on the same individual/object. This gives the teaching of statistics an interest in extra-mathematical questions and interdisciplinarity. To continue our observations in the review articles, Shaughnessy, in his review (2007), refers to a wide variety of models, such as the Wild and Pfannkuch's (1999) model of statistical thinking, which is also associated with a four-dimensional process (Formulate question, Collect data, Analyze data, Interpret result), and which emphasizes what he calls transnumeration:

A work that went beyond a mere transformation or representation of the data, so as to identify instances in which striking features of a context are suddenly revealed. (Shaughnessy, 2007, p.963)

Some of these models/frameworks (both terms can be used for example in Gal (2005)) distinguish different types of statistical literacy. For example, the study of Kirsch et al. (1998), cited by Shaughnessy, distinguishes three types of statistical literacy according to the sources of information concerned: document literacy, prose literacy, quantitative literacy; Curcio (1989), for his part, distinguishes different levels of reading of graphical representations (reading the graph, reading within the graph, reading beyond the graph) and Shaughnessy associates them with different forms of activity when reading the information in tables and graphs (locating/representing, cycling, integrating, generating, making inferences) identified in Kirsch et al. (1998). Gal (2005), also cited, proposes a model of statistical literacy that distinguishes between knowledge elements (literacy skills, statistical knowledge, mathematical knowledge, context knowledge, critical questions), and disposition elements (beliefs and

attitudes, critical stance). In the associated descriptors, the emphasis is on understanding, interpretation and critical evaluation of statistical information. Several models distinguish different levels of statistical literacy as GAISE. For example, Watson's (1997) model distinguishes three levels: understanding terminology, understanding terminology in context, critical questioning of claims made without justification. This model is refined in Watson and Callingham (2003) who construct a six-level scale: idiosyncratic understanding, informal understanding, inconsistent understanding, consistent non critical understanding, critical understanding, critical mathematical understanding. This second model is adapted by Sharma (2017), whom his literature review leads to the development of a four-stage model for diagnosing students' statistical literacy thinking, a model he uses as a tool for teacher education (stage 0-1: idiosyncratic/informal understanding, stage2: consistent noncritical understanding, stage 3: early critical, stage 4: advanced critical).

Finally, Hidayati et al (2020), drawing on a variety of research studies, show that there is no single perception of the statistical world. According to these authors, some research sees the world of statistics as that of data, with the interpretation of a large amount of information and its organization in the form of tables, graphs, charts or representations via curves. This is to facilitate the understanding and interpretation of information. In other research, statistical literacy is associated with the understanding of concepts, vocabulary and symbols, and probability as a measure of uncertainty or the ability to:

Formulate, apply and interpret mathematics in various contexts, including the ability to make reasoning statistically and use concepts, procedures, and facts to describe, explain or predict an event. (Ibid, pp.1)

These authors also attempt to situate statistical literacy in relation to mathematical literacy. They point out the differences between the associated forms of thinking which they perceive as inductive-probabilistic in statistics and deductive deterministic in mathematics. Nevertheless, they also recognize the existence of commonalities, writing that:

In the context of literacy, statistical literacy, and mathematical literacy have in common, which can be interpreted as an effort to use concepts, facts, and procedures, conduct reasoning, and interpret an object in various contexts of solving problems in daily life. (Ibid, pp.6)

But that the scope of mathematical literacy is broader.

There is therefore a diversity of approaches, models and definitions. In some works, priority is given to the process of statistical inquiry linked to an investigative approach, from the elicitation of a statistical question to the processing and interpretation of data, and significant attention is given to variability. In others, the emphasis is on the progressive development of statistical thinking or reasoning and the identification of benchmarks in this progression. These perspectives are in a sense complementary. In terms of the objects at stake, there is a not surprising convergence in the central importance of data/information, and a vision of statistical competence that includes all the stages of statistical investigation, from the ability to ask questions that will be subjected to statistical work to the critical evaluation of the results obtained. Another characteristic of this field of study that is very present in the texts studied is variability, to which Shaughnessy (2019, pp.14) returns when he writes that "Make sure that attention to variability is foremost throughout the statistical investigation cycle." On the other

hand, the proposed conceptualizations of statistical literacy make it an object that cannot be confined to the mathematical sphere. If mathematics education has an important role to play in the development of statistical literacy through the concepts, techniques and tools of representation it proposes, it is not the alpha and omega of statistical literacy and must interact with other disciplines. Thus, this literature review leads us to consider data, information and variability as the three characteristic dimensions of statistical literacy whose the stakes is to understand information or learn from data in situations where variability is present.

Methods

As noted above, an approach to the potential of a curriculum to support the development of statistical literacy must necessarily be multidisciplinary. Therefore, in this curriculum study, we have considered the disciplines most likely to contribute to this development because of their stakes (such as the development of civic and scientific culture) or their methods (such as numbered data processing, information processing, investigative approach): moral and civic education (EMC), Questioning the world, history-geography, experimental sciences, technology, physical education and sports (EPS) and mathematics.

Our analysis grid (see Table 1) associates the three dimensions "data", "information" and "variability" with criteria presented as characteristics of a statistical approach in our corpus of articles: production, collection, representation, processing, meaning, interpretation of numerical or informational data in connection with considering the context of the survey to develop a critical analysis of information.

Table 1: Curricular analysis grid

Dimension	Criterion
Data	<ul style="list-style-type: none"> a) their production, their collection (who, how, why: what questions are asked? (the collection of data, their production must respond to a need; there must be a question asked that they make it possible to answer) b) their representation, choice of a representation and discussion of its relevance (this includes what makes it possible to "read a graph" simply or beyond what is apparent, and transnumeration (see above)) c) their processing (use of statistical indicators, which makes it possible to summarize what the data say) d) making sense of them to derive information (for example, understand the information provided in a chart when you see it: (what it says, what it is about) e) their interpretation (making inferences about the data, using the data to draw conclusions and answer the questions posed by going back over the questions; critical analysis, a critical look at the data itself (how it was produced, represented) and at the use of the data (assessing the acceptability of its interpretation))
Information	<ul style="list-style-type: none"> a) its origin, its production (Where does the information come from?) b) its processing (How is the information given? In what form?) c) its understanding (know how to read it, understand it, observe it, identify it) d) its critical analysis (reliability of the information and its use)

Variability	explicit mention or taken into account
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Our analysis of the curriculum was carried out in two stages. A first systematic search of the three dimensions "data", "information", "variability" was followed by a second search based on the keywords associated with our criteria which refer to the stages of a statistical study and/or to the statistical tools it mobilizes: "production", "collection", "representation", "processing", "interpretation", "origin", "understanding", "criticism". Finally, we have proceeded to a reading of the programs in order to identify any omission linked to formulations close to the selected key words by considering what comes under the study of a question, associated or not with the collection of data. The extent and number of occurrences of the key elements and criteria allow to measure the potential for statistical literacy development in the French school curriculum.

Results

We summarise the results obtained in two tables. Table 2 identifies the presence of a criterion by a cross for the disciplines present in the curriculum grades 1 to 6: moral and civic education (MCE), questioning the world, history-geography (HG), experimental sciences and technology (Sc and Techno), physical and sports education (PSE), mathematics (maths). Table 3 corresponds to grades 7 to 9 where experimental sciences and technology are separated into three disciplines: physics-chemistry (PC), life and earth sciences (LES), technology (techno).

Table 2 : Analysis of curriculum occurrences in grades 1-3 (3 disciplines) and grades 4-6 (4 disciplines)

	MCE		Questioning the world	HG	Sc and Techno	PSE		Maths	
	1 – 3	4 – 6	1 – 3	4 – 6	1 – 3	1 – 3	4 – 6	1 – 3	4 – 6
Grades 1 – 3 or 4 – 6									
Data									
Production, data collection			X		X	X	X		
Representation			X	X	X	X	X	X	X
Processing					X	X	X	X	X
Making sense of information				X	X	X	X	X	X
Interpretation					X	X	X		
The information									
Origin	X	X	X	X	X				
Processing		X	X	X					
Understanding		X	X	X	X				
Critical analysis	X	X		X	X				
Variability									
Taken into account						x	x		

Table 3 : Analysis of curriculum occurrences in grades 7-9 (6 disciplines)

Grades 7 to 9	MCE	HG	PC	LES	Techno	PSE	Maths
Data							
Production, data collection			X	X	X	X	X
Representation				X	X	X	X
Processing			X	X	X	X	X

Making sens of information		X	X	X		X	X
Interpretation		X	X	X		X	X
L'information							
Origin		X	X				
Processing		X			X		
Understanding		X	X				
Critical analysis	X	X	X		X		X
Variability							
Taken into account						x	

Our question is about the possibility of teaching statistical literacy in the different school disciplines and not to identify in which discipline this teaching is most mentioned in the curriculum. Thus, a cross indicates that the criterion is present in the curriculum without indicating its number of occurrences.

Discussion and perspectives

The results obtained show that there are indeed opportunities for the development of statistical literacy, starting from primary school. They also appear in the general introductions of the syllabuses, in connection with citizenship education, the importance of data processing and information processing as well as the consideration of interdisciplinarity. For example, grades 7 to 9, the preliminaries of the syllabuses connect mathematics and citizenship:

Demonstration, a form of argumentation specific to mathematics, complements those developed in other disciplines and contributes strongly to the formation of the person and the citizen (domain 3 of the base). (MEN, grades 7 to 9, p.127)

Also, these general introductions of grades 7 to 9 programs mention interdisciplinary links:

Students will consolidate their understanding of mathematical concepts in the program such as orders of magnitude, proportionality, literal calculation, coordinate systems, location or statistics by mobilizing them in situations arising from physics, chemistry, life and earth sciences, technology, or geography. (MEN, grades 7 to 9, p. 129)

The same rhetoric is used for grades 4 to 6:

Students gradually learn to solve problems involving contexts and data from other disciplines. Indeed, a variety of information-gathering media (texts, tables, graphs, plans) make it possible to work with real data from different disciplines (history and geography, science and technology, physical education and sports, plastic arts). (MEN, grade 4 to 6, p. 108)

This transdisciplinarity of statistical literacy is also underlined in the didactic work of Chevallard and Wozniak (2005).

The above tables also show that the different dimensions and criteria are not evenly distributed and allow us to know in which discipline(s) the criteria are most represented. We observe that data are more related to the experimental sciences (Physical Science, Life and Earth Sciences, Technology) and physical and sports education and the information to the humanities (MCE, History-Geography). Overall, the physical sciences and technology and physical and sports

education syllabuses seem to offer the most varied potential for the development of statistical literacy across the grades 1 to 9.

We observe, however, a weakness in the syllabuses concerning variability. This criterion is explicitly presents only in physical and sports education where measurements are essential for analysing the development of one's own performance and comparing it with that of others . It may seem surprising to find no explicit mention of variability in the experimental or life and earth sciences, given the importance of the variability associated with the measurement of magnitudes. A detailed analysis of the official documents accompanying the syllabus will be necessary. Its consideration is perhaps implicit because it is an integral part of the experimental sciences or life and earth sciences. Wozniak (2021) makes clear interrelations between magnitude-statistics-measurement which do not appear in the official syllabuses. In the mathematics syllabuses, from grade 1, data are essentially present in the "organization of data" section, which is dissociated from the domain "quantities and measurements". But, as Wozniak (2021) mentions, measurement of quantities and statistics are two related fields.

If we consider the evolution of the types of tasks through Tables 2 and 3, we see that up to grade 6, it is about representing, processing and making sense of the data. It is not until grade 7 that the production and interpretation of data is explicitly present. This corresponds to the moment when the rubric "organization of data" becomes an autonomous domain, until then it was a section of the domain "numbers and calculations". Our analysis thus reveals that in mathematics, it is first a question of learning the tools before understanding the methods and goals of statistics. This supports the idea that statistical literacy instruction should be approached from a multidisciplinary perspective.

This study reveals that current French compulsory schooling curriculum offers potential for developing statistical literacy in all students, especially in experimental sciences. Nevertheless, it seems that it is mainly a matter of teaching the means to represent or process data without understanding what motivates these types of tasks. The major fact of our study is the absence in the curriculum of variability. This criterion is not explicitly present in any discipline, not even in the experimental sciences. While Wozniak (2021) clearly establishes magnitude-statistic-measurement interrelationships, these are not addressed in the curriculum. Is statistical literacy instruction possible? Do teacher resources, textbooks, or even teacher practices fill this absence? Our PhD work will thus continue with an analysis of mathematics textbooks and more broadly of teachers' resources, and then with the observation of their practices in order to study the operability of the curriculum's potentialities.

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