The role of decision-making in the legitimation of probability and statistics in Chilean upper secondary school curriculum

Elicer, Raimundo

Published in:
Proceedings of the Eleventh Congress of the European Society for Research in Mathematics Education

Publication date:
2019

Document Version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
Elicer, R. (2019). The role of decision-making in the legitimation of probability and statistics in Chilean upper secondary school curriculum. In U. T. Jankvist, M. van den Heuvel-Panhuizen, & M. Veldhuis (Eds.), *Proceedings of the Eleventh Congress of the European Society for Research in Mathematics Education* (pp. 930-937). Freudenthal Group & Freudenthal Institute, Utrecht University and ERME.

The role of decision-making in the legitimation of probability and statistics in Chilean upper secondary school curriculum

Raimundo Elicer

The role of decision-making in the legitimation of probability and statistics in Chilean upper secondary school curriculum

Raimundo Elicer

Roskilde University, Denmark; raimundo@ruc.dk

Decision-making is argued to be intrinsically embedded in the historical emergence of probability and statistics, as well as in the justification for their inclusion as school mathematics subjects. In this article I investigate the role of decision in probability and statistics in both the current and upcoming Chilean upper secondary school mathematics curricula. Drawing upon Fairclough's model for Critical Discourse Analysis, I analyse selected texts as examples of broader discourse practices, in particular, I focus in assumptions, modalities, and intertextualities. They evidence the role of decision-making as legitimation of the subject matter and as a mediator of agency by teachers and students. I claim there is a shift towards less appeal to authority in legitimising the curriculum, and an increasing responsibility of students in the educational process.

Keywords: Critical discourse analysis, curriculum, decision-making, probability, statistics.

Introduction

As a scientific and mathematical field of knowledge, it can be argued that the history of probability and statistics is the history of making decisions when uncertain outcomes are to be evaluated. According to Hacking's (1975) historical and philosophical address, the notion of probability comes to answer whether a statement is an opinion or demonstrable knowledge during the middle ages. Later on the 17th century, probability, induction and statistical inference come to define the fair share when a gamble game is interrupted, whether an accused person is to be condemned, to decide the price of annuities and policy regarding pensions, and to take a stand about scientific hypotheses to be true or not. So risk and decision-making define the "logic" of probability (Borovcnik, 2015). Risk, as vague as this concept may be, is the way we evaluate decisions under uncertainty beyond the possible impacts of different choices, but also with some weight given to their likelihood. Probability comes to be an attempt to quantify these levels of likelihood.

As for probability and statistics as teaching-learning subjects, Pfannkuch (2018) has identified emerging curricular approaches to be addressed in future research. One proposition is to get "*more insight into fostering statistical argumentation* including learning how to make evidence-based claims in data-rich environments and critically evaluating data-based arguments in diverse media from a statistical literacy perspective" (p. 407, emphasis in original). This trend is grounded in research experiences focused in the complexity and scaffolding of decision-making tasks under uncertainty. Researching the 'critical lens' of decision processes would require different approaches such as action research, phenomenography, and critical discourse analysis (Petocz, Reid, & Gal, 2018, p. 81).

In this article I attempt to join both propositions by investigating the role of decision-making in current and upcoming probability and statistics official curricula, through a version of Critical Discourse Analysis [CDA]. In order to narrow down and have a sense of what is aim for regarding

students' future participation as citizens; I make an exemplary analysis that focuses in the Chilean last two grades of secondary mathematics school curriculum.

The general research questions addressed in this article are: (1) what is the role given to notions of decision-making in the Chilean upper secondary school probability and statistics curriculum? And (2) what has changed from the up-to-date version of the curriculum and the upcoming curricular framework for the same subject and grades?

Interpreting roles and spotting changes are broad intentions, so in the following section I address the conceptual framework and methods concerning a version of CDA, in order to understand these questions in a more precise way.

Methodology

Inspired by Fairclough (2010), I am describing the methodology as an altogether analytical strategy, since "we cannot so sharply separate theory and method" (p. 234) while constructing the object of research. Starting with theoretical generalities, then I provide the necessary conceptual definitions that methods for selection and analysis require.

Fairclough (2010) defines a general methodology for critical research in an interdisciplinary way. In that line, the present discourse analysis dialogues with statistics education research. Key interrelated concepts are social structures, practices and events: "social structures define what is possible, social events constitute what is actual, and the relationship between potential and actual is mediated by social practices" (Fairclough, 2003, p. 223). In this frame language is a social structure. Among its infinite possibilities, choices are made to produce texts as part of social events, mediated by discursive practices, where discourse is understood as semiosis, i.e. the process of meaning-making.

My analytical strategy consists in selecting texts from the upper secondary school Chilean curriculum which refer to decision-making in probability and statistics, and then extracting elements of textual analysis which illustrate broader discursive practices. Textual analysis describes *what* is in the texts, and the discursive aspect addresses how these elements *give meaning*.

Selection of texts

Chilean secondary education is defined from grades 7 to 12. These are called 7th-basic and 8th-basic, and from 1st-middle (9th-grade) to 4th-middle (12th-grade)[1]. All of these grades have their own study programs, but more general curricular frameworks are available for 7th-basic to 2nd-middle and the one for 3rd and 4th-middle is under construction. The text selection takes into account 3rd and 4th-middle curricula, and the aforementioned upcoming curricular framework, summarized in table 1.

For current versions of the curriculum, I will only take common plan programs, i.e. those directed to every student in the scholar system. Excluded programs are those differentiated mathematics studies

[1] Not to be confounded with middle school, as in between primary and secondary school. In Chile, *enseñanza media* (middle education) is the bridge between *enseñanza básica* (basic education) and *educación superior* (higher education).

defined for scientific education. Therefore, the texts are extracted from grades 3rd-middle and 4th-middle study programs.

Document	Label	Year	Curriculum	Author
Mathematics Study Programme, Third Middle	3M15	2015	2009	Curriculum and Assessment Unit, Chilean Ministry of Education (MINEDUC)
Mathematics Study Programme, Fourth Middle	4M15	2015	2009	
Curricular proposal for 3rd and 4th-middle: Public consultation document	34M17	2017	2018	

Table 1: Sources of selected texts

Study programs are divided into units (numbers, algebra, geometry, and data and chance). Within the units of data and chance, I look for sentences which make references to 'decision' (*decisión* in Spanish), including conjugations of the verb 'to decide.' These sentences will compose the texts.

The same selection applies the upcoming curricular proposal for these last two grades, within the mathematics subject. It does not still have the form of study programs, but it can be considered to be of the same genre, for it means to become the next version of such. It is a general proposal based on a process that involved national experts, international experiences and consultation to civil society participants. The document is published in MINEDUC's website.

Data analysis

The analysis is performed at two levels: textual and discursive.

Among the several possibilities for identifying and categorising elements in the texts, I will focus in three: modality, collocation, and intertextuality. Modality expresses a commitment the author does with truth and necessity, respectively by epistemic and deontic modalities (Fairclough, 2003, p. 165). It can be evidenced –nonexclusively– by the use of modal verbs, such as 'may' (epistemic) and 'must' (deontic). Collocation is the repeated co-occurrence of certain concepts, such as 'hard working' appears as a common binomial in political speeches. Intertextuality is the more or less explicit presence of elements of other texts and their authors' voices. These elements can be dialogued with, assumed, rejected, and so on (pp. 41–42).

Beyond identification of modality, collocation and intertextuality in texts, I will point out the way they are chosen to be expressed as indicators of discursive practices. In particular, I focus in legitimation strategies. Legitimation is the discursive practice of justifying what is made factual in the texts, through reference to authority, value systems or utility, or conveyed through narrative (Fairclough, 2003, p. 98).

Coming back to the research questions, I define the 'role' of decision-making as choices for the use of legitimation strategies as discursive practices. Additionally, I shall identify changes from current to the upcoming version of the curriculum. Characterising this shift is the final stage of the analysis.

Selected texts

As a way of organisation, Chilean study programs are divided into units. Each unit is described having purpose, previous knowledges, key concepts, contents, abilities, attitudes, expected learning outcomes (and their respective assessment indicators), didactical orientations, and suggested activities for each expected learning outcome. The following are the selected texts, and above them are the contexts within the study programs where they are found. All translations from Spanish are made by me as literal as possible.

In the 3rd-middle grade current curriculum (3M15), 'decision' appears in the form of 'decision tree representations', as a follow up for the goal of understanding the concept of conditional probability. I will not take it as part of the analysis, since it actually refers to 'probability tree representations.' Then it forms part of the general didactical orientations for the unit:

3rd-middle. Unit 4: Data and chance.

Purpose

1 Experimental problems are worked with **decision** tree representations, which enable a bigger understanding of contents and a tool for probabilistic calculations. (3M15, p. 120, emphasis added)

Didactical orientations

2 In this line, it is fundamental that the teacher promotes the development of random thinking, i.e. that students learn to make **decisions** with evidence in situations of uncertainty. (3M15, p. 123, emphasis added)

In the last grade current study program (4M15) there are actually two units about data and chance, with no mentions of 'decision' in 'data and chance 2,' which includes graphic notions about binomial and normal distributions. In 'data and chance 1,' 'decision' is part of the didactical orientations as in the 3rd-middle grade. Later on, there is a mention to 'decision' as a comment for teachers when engaging in activities for the learning goal to critically evaluates information:

4th-middle. Unit 3: Data and chance 1.

Didactical orientations

3 In this unit, it is expected that students critically evaluate information published on the media and internet, from the analysis, interpretation and synthesis of such information, with which they can obtain results about a population considering its size and the variable's distribution; infer conclusions from the mean, variance and standard deviation; and to make **decisions** grounded in statistically significant information. (4M15, p. 86, emphasis added)

Suggested activities

4 Furthermore, it is important that the teacher promotes contextualized learning so students develop progressively the statistical literacy, which gives them tools for making grounded **decisions**. (4M15, p. 88, emphasis added)

As for the public consult document for the upcoming curricular framework (34M17), decision first appears as part of the general purposes of the mathematics subject:

Mathematics: Formative purposes

5 In order to achieve the latter, students will work collaboratively in mathematical modelling of situations, to make grounded **decisions** in disciplinary problems, as well as in the interdisciplinary, social, environmental or economic scope. (34M17, p. 49, emphasis added)

And then, utterances about decisions are part of mathematics learning goals in both grades:

Learning goals for 3rd-middle

6 [It is expected from students to be capable of] 3. Making **decisions** in situations of uncertainty, with information involving dispersion measures, double entrance tables and conditional probabilities. (34M17, p. 52, emphasis added)

Learning goals for 4th-middle

7 [It is expected from students to be capable of] 3. Solving problems in contexts of uncertainty, through the application of the binomial distribution and calculation of probabilities, for **decision**-making and critical analysis of statistical information. (34M17, p. 52, emphasis added)

Both learning goals have a parallel in the previous texts. In the current study programs (3M15 and 4M15), topics such as dispersion measures, conditional probabilities and the critical analysis of statistical information are covered.

Textual analysis

I shall first identify and describe elements of textual analysis found in the excerpts as to provide input to the following discussion. I focus in modality, collocation and intertextuality.

Modality

Modal forms expressed as ‘it is expected from/that students’ (3, 6 and 7) can be identified as epistemic modalities, i.e. as expressions of probability and truth, in this case, the expected and not certain to happen. It can be argued that, given the official character of curricula, these are actual expressions of the necessary, falling into the category of deontic modalities.

Explicit deontic modalities are evidenced as ‘it is fundamental that’ (2) and ‘it is important that’ (4), and they express necessity for particular promotions of the teachers in order to provoke students’ skills for making decisions.

Collocation

References to decisions do not appear alone. A habitual co-occurrence of the substantive ‘decision(s)’ comes with ‘grounded’ as company; both as an adjective as in ‘grounded decision-making’ (4) and ‘grounded decisions’ (5), and as an adverbial form as in ‘decisions grounded in…’ (3). A similar adverbial accompanying form is ‘decisions with evidence’ (2) and ‘decisions with information’ (6). This collocation suggests a reference to a particular type of decisions or decision-

making processes, based on quantitative arguments, distinguishable from a mere act of making a choice.

Intertextuality

Texts 2 and 4 can be read in parallel as having the same structure:

In this line, it is fundamental that the teacher promotes the development of random thinking, i.e. that students learn to make decisions with evidence in situations of uncertainty. (2)	Furthermore, it is important that the teacher promotes contextualized learning so students develop progressively the statistical literacy, which gives them tools for making grounded decisions. (4)

These texts make references to two different concepts, namely 'random thinking' (2) and 'statistical literacy' (4) in a similar way: as notions to be promoted by the teacher, implying students to make grounded decisions. So intertextuality is found within selected texts. Moreover, these concepts are not defined in the documents, but they are traces of another text published by the Chilean Statistics Society as experts' curricular recommendations (Araneda, del Pino, Estrella, Icaza, & San Martín, 2011). The term 'random thinking' is not found in the literature, rather I presume the texts intend to refer to 'statistical' (Garfield & Ben-Zvi, 2007) or 'probabilistic thinking' (Chernoff & Sriraman, 2014). Both 'statistical thinking' and 'statistical literacy' are described as core answers to the section 'Why teach statistics?' (pp. 11–17) referencing a paper published in the International Statistical Review (Garfield & Ben-Zvi, 2007). Overall, texts 2 and 4 are referring to authority, introducing notions without further explanation, which are developed within national and international statisticians associations.

Discussion: Discursive practices

Within Faircoulgh's model, texts are part of social events, and they are signs of broader discursive practices. In the following I point out legitimation strategies evidenced by preceding elements of the textual analysis.

Legitimation

Making decisions appears as a way of justifying the teaching and learning of statistics in the curricula. The texts fulfil the purpose of not only saying what and how to teach and learn, but also why and for what. Fairclough (2003, p. 219) claims that much of the legitimation of a social order – such as the inclusion of particular knowledge in the official curriculum– is textual. In particular, the texts show three of the legitimation strategies identified by Van Leeuwen (2007), namely through mythopoesis, rationalisation, and authorisation.

Mythopoesis or legitimation conveyed through narrative is evidence by the collocation of 'decision' with 'grounded' (3, 4 and 5), and similar accompanying adverbial forms such as 'with evidence' (2) and 'with information' (6). This strategy is stable through the texts and makes the case for justifying probability and statistics, since not just any kind of decision is included, but only those rooted in data and mathematical rationality. It allows a steady association between such school subjects, and rational choice.

Merely associating probability and statistics to rational decisions is not enough, it is still necessary to justify the teaching. Aforementioned deontic modalities are evidence of legitimation through rationalisation, which refers to utility. Within the current curriculum (3M15, 4M15) teachers' promotions are 'fundamental' (2) and 'important' (4) for students to make grounded decisions. The upcoming proposal (34M17) provides a similar rationalisation in the form of 'in order to achieve the latter' and 'to make grounded decisions'(5), but this time it is mediated by the students' action, namely their collaborative work in mathematical modelling situations (5). In a way, this change represents another shift in the agency from teachers to students in the teaching-learning process.

I have already pointed out that traces of an authorisation strategy are found in texts from the current curricula (3M15, 4M15), through the inclusion, without further definition, of 'random thinking' and 'statistical literacy'. What is worth highlighting is the fact that this strategy is not found in the upcoming curricular framework (34M17). This shift resonates with the bottom-up nature of the latter document, where civil society plays a bigger role in the justification of curriculum. This alteration is coherent with another broader mention to 'decision' in the diagnosis chapter of the same document, where students "demand protagonism in decision making and aspire to contribute to solve problems in the world they live in, such as poverty eradication, climate change and sustainable development." (34M17, p. 13)

Concluding remarks

Critical discourse analysis allows us to see texts as part of social structures mediated by discursive practices. In this article I analyse Chilean upper secondary school written curricula as evidence of legitimation strategies, showing that study programs not only describe what is to be taught, but also why. Decision-making appears as a key element of such legitimation, by establishing a narrative of probability and statistics linked to grounded, evidence-based and rational choice.

The analysis illustrates signs of change towards a justification which relies less in professional statisticians and educational researchers as authorities, and more into students' own learning activities as decision makers. This shift is part of the wish for a bigger role in decision processes which go beyond the disciplinary scope.

This article addresses a justification problem in mathematics education research (Niss, 1996). Future works should address whether it is possible connect decision-based motivations and curricular contents, and how this can be approached in teaching practice. Both possibility and implementation problems are part of the broader PhD project this article is embedded in.

This work was funded by the doctoral scholarship CONICYT BCH/DOCTORADO 72170530.

Sources

Ministerio de Educación (2015a). *Matemática, Programa de Estudio, Tercero medio* [Mathematics, Study Programme, Third middle]. Santiago: Unidad de Currículum y Evaluación, Ministerio de Educación de Chile. Retrieved from: http://www.curriculumenlineamineduc.cl/605/articles-34361_programa.pdf

Ministerio de Educación (2015b). *Matemática, Programa de Estudio, Cuarto medio* [Mathematics, Study Programme, Fourth middle]. Santiago: Unidad de Currículum y Evaluación, Ministerio de Educación de Chile. Retrieved from: http://www.curriculumenlineamineduc.cl/605/articles-34362_programa.pdf

Ministerio de Educación (2017). *Propuesta curricular para 3º y 4º medio: Documento de consulta pública* [Curricular proposal for 3rd and 4th-middle: Public consultation document]. Santiago: Unidad de Currículum y Evaluación, Ministerio de Educación de Chile. Retrieved from: http://basesdelfuturo.educarchile.cl/wp-content/uploads/2017/03/Propuesta_Curricular-Consulta-P%C3%BAblica.pdf

References

Araneda, A. M., del Pino, G., Estrella, S., Icaza, G., & San Martín, E. (2011). *Recomendaciones para el currículum escolar del eje datos y azar* [Recommendations for school curriculum on the axis of data and chance]. Santiago: Sociedad Chilena de Estadística.

Borovcnik, M. (2015). Risk and Decision Making: The Logic of Probability. *The Mathematics Enthusiast*, *12*(1,2&3), 113–139.

Chernoff, E. J., & Sriraman, B. (Eds.). (2014). *Probabilistic Thinking*. Dordrecht, The Netherlands: Springer.

Fairclough, N. (2003). *Analysing discourse: Textual analysis for social research*. London: Routledge.

Fairclough, N. (2010). A dialectical-relational approach to critical discourse analysis in social research. In N. Fairclough (Ed.), *Critical discourse analysis: The critical study of language* (2nd ed., pp. 230–254). Harlow: Routledge.

Garfield, J., & Ben-Zvi, D. (2007). How students learn statistics revisited: A current review of research on teaching and learning statistics. *International Statistical Review*, *75*(3), 372–396.

Hacking, I. (1975). *The emergence of probability: A philosophical study of early ideas about probability, induction and statistical inference*. Cambridge: Cambridge University Press.

Niss, M. (1996). Goals of mathematics teaching. In A. Bishop, M. A. (Ken) Clements, C. Keitel-Kreidt, J. Kilpatrick, & C. Laborde (Eds.), *International handbook of mathematics education* (pp. 11–47). Dordrecht: Kluwer Academic.

Petocz, P., Reid, A., & Gal, I. (2018). Statistics Education Research. In D. Ben-Zvi, K. Makar, & J. Garfield (Eds.), *International handbook of research in statistics education* (pp. 71–99). Cham: Springer.

Pfannkuch, M. (2018). Reimagining Curriculum Approaches. In D. Ben-Zvi, K. Makar, & J. Garfield (Eds.), *International handbook of research in statistics education* (pp. 387–413). Cham: Springer.

Van Leeuwen, T. (2007). Legitimation in discourse and communication. *Discourse & Communication, 1(1)*, 91–112.