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Review article on students' conceptions of statistics

Anna Reid and Peter Petocz (2002) Students' Conceptions of Statistics: A Phenomenographic Study, *Journal of Statistics Education*, 10 (2) pp 1-18; Http://www.amstat.org/publications/jse/v10n2/reid.html

In general, teaching statistics to sociology and other social sciences students is not an easy task. There are several reasons for that: few students see statistics as a crucial part of their education as social scientists and their future profession, many hold certain prejudices against and misconceptions about statistics, or have a low level of numeracy or other learning issues. Of course, it is not (always?) students that are 'responsible' for such a perception of the subject. My job as a teacher of statistics should entail 'deconstruction' of those perceptions by making subject more interesting and stimulating, and by raising students' motivation. In order to achieve such a task, it is necessary to understand students' perceptions of the subject, which is the focus of the study by Reid and Petocz (2002).

The authors describe their article as a report on the results of an empirical study of students' conceptions and understanding of statistics. The main assumption of the article is that the awareness of the way how students 'understand statistics, and how they perceive their own work will enable teachers to develop curricula that focus on enhancing the student learning environment and guiding student conceptions of statistics' (*ibid*: 1).

Reid and Petocz claim that traditionally teachers tend to develop curricula solely on the basis of the subject content, hoping that through classes, assessments and examinations students will 'come to understand the unique qualities of their chosen discipline' (*ibid*.). Contrary to this perspective of students' learning, the authors emphasise the importance of so-called 'emotional components' related to learning. While there is a relative agreement among those who are dealing with pedagogy of statistics that students learn through experience, Reid and Petocz stress that traditionally it was the teacher's experience as a researcher and statistician that dominated the class curricula. They call for a re-examination of traditional attitudes, where students' experiences of the subject and their chosen profession will be the main factor in designing teaching of statistics. Yet, 'students understand their chosen discipline in a variety of different ways, and hence approach their learning in different ways' (*ibid.*: 2).

This assumption let the authors to investigate how students understand statistics. They conducted an empirical research on a sample of randomly selected 20 first- and third-year students of mathematics-related subjects who took some classes in statistics. The authors applied phenomenographic method with the aim of establishing hierarchical set of logically related categories. Data was collected through a series of in-depth, open-ended interviews, with the idea that this method would allow students fully to describe their experience of learning statistics.

The analysis revealed the existence of six qualitatively different hierarchical categories, each of which had two elements: what the students focus on in the subject, and their related approach to the subject. These concepts range from limited views (where students are unable to describe any integrated characteristics of the subject) to more extensive views.

The first three concepts comprise a set concentrated on ***different techniques of statistics***. The first concept entitled **Statistics is individual numerical activity (1)** is limited and fragmented understanding, where students see statistics as a sort of mathematics. The common expressions used by these students in describing statistics are 'boring calculations', 'numbers' or 'probability'. In the second concept, **Statistics is using individual statistical techniques (2)**, students see statistics as 'individual techniques that can be used to look at data; for instance, graphing, line-of-best fit, collecting data, regression' (*ibid*.: 5). Here the students concentrate on fragments as well, but unlike in the first concept, they use statistical rather than mathematical terms. The last concept in this category is entitled **Statistics is a collection of statistical techniques (3)**. According to the authors, in this concept students describe statistics as a collection of different techniques. These first three categories are cumulative, so that each category includes more statistical techniques. The authors point out that 'often teachers will inadvertently encourage this view of statistics by treating statistical ideas as separate elements that are gradually added to as the semester progresses' (*ibid*.: 7).

The second set of concepts is ***focused on using data***, where students 'clearly define the relationship between statistical techniques and the use of such techniques to interpret data' (*ibid*.). Two different concepts are established**: Statistics is the analysis and interpretation of data (4)** and **Statistics is a way of understanding real-life using different statistical methods (5)**. While in both concepts 'students aim to interpret a set of data and obtain the information they can from it' (*ibid*.:8), in the later students also focus on looking at a 'variety of models to compare their data with reality, and to test the appropriateness of their conclusions' (*ibid*.).

The final concept the authors see as a qualitatively different from the all previous concepts. This one ***focuses on meaning*** and is entitled **Statistics is an inclusive tool used to make sense of the world and develop personal meaning (6)**. In this concept students 'use statistical methods to develop their own thinking, to create new interpretation of data and life' (*ibid*.: 9).

The authors stress that the hierarchical structure of the given concepts means that students who express their views at the most inclusive level are able to use characteristics of the less inclusive levels. At the same time, it is much harder for individuals who usually experience the narrower conceptions to broaden their view to the more inclusive conceptions. These findings, the authors believe, 'can be used to develop learning environment that can help students broaden their understanding of statistics as well as their approach to the subject' (*ibid*.: 10).

The next task for the authors is to examine how the understanding of statistics is related to students' understanding of their discipline as a whole. For this purpose they refer the findings of Reid's previous research on the case of students of music, and apply it on this case.

Understanding of professional work, which the authors call the 'Professional Entity', consists of three different levels: (1) **Extrinsic Technical**, (2) **Extrinsic Meaning**, and (3) **Intrinsic Meaning**. The first one refers to a perception that 'professional work is constituted as a group of technical components that can be used when the work situation demands it' (*ibid*.: 11). In this perspective work is experienced as being external to the individual. The second perspective describes a perception that 'professional work is about developing the meaning inherent in discipline objects',

where statisticians 'explore and examine the meaning found in a set of data' (*ibid*.: 12). Finally, in the broadest conception entitled Intrinsic Meaning students perceive that their 'professional work is related to their own personal and professional being', where statisticians 'create and develop their view of the world by testing their understanding of the world with statistical evidence' (*ibid*.).

Table 1: The outcome space for students' conceptions of statistics (Reid and Petocz: 2002: 11)

Approach	**Focus**			**Professional Entity**
	Technique	Data	Meaning	
Gathering	Conception 1			Extrinsic Technical
	Conception 2			
	Conception 3			
Applying		Conception 4		Extrinsic Meaning
		Conception 5		
Creating			Conception 6	Intrinsic Meaning

The authors claim that these three perceptions of Professional Entity correspond to the students' three main approaches to statistics (see Table 1). They conclude that 'there is a very close relation between the way that teachers and students perceive the profession and what they think is critical to either teach or lean' (*ibid*.: 12).

In the final part of their article, the authors examine the implications of these findings for learning and teaching statistics. The fact that the analysis did not show difference between perceptions of the first-year and third-year students, brought the authors to a conclusion that the established 'categories are not developmental but simply a feature of student's experience' (*ibid*.). Therefore, the first implication for teaching statistics is to recognise that this range of variations exists at all levels of university study.

Further on, the authors present several implications from these findings for curriculum development, which can be summarised as follows:

- Students' perceptions of their learning context are important factors in the approach that they take to their learning.
- The varied messages about statistics that students get from their teachers are important aspect of their learning environment.
- Teachers should set up learning environments that encourage students to develop the broader conceptions of statistics.
- Teachers should encourage students to look for meaning in the data and relate this meaning to their own personal situations.
- A teacher with a broader conception of the subject encourages students to develop broader conceptions.

Finally, Reid and Petocz stress that the curriculum needs to 'encourage students to be aware of their own perception of their own place in the world, and to develop a critical appraisal of how statistics can help them in this endeavour' (*ibid*.: 14).

With this conclusion Reid and Petocz bring out an interesting point that forces every teacher to reconsider his/her own role in the process of educating students not only in statistics, but in every subject. It redefines the role of the teacher in higher education

from a ‘transmitter’ of information of a specific subject to a more holistic educator. However, in order to perform such a task, according to the authors, a teacher needs first of all to re-examine his/her perception of his/her own job and his/her own attitudes towards the discipline before engaging in the process of teaching. While it is hard to disagree with this point, several issues arising from these conclusions have to be examined.

If the students’ attitudes toward the discipline are an outcome of their experiences, as the authors stress, the same should be the case with the teachers. However, unlike most of the statistics students, teachers have some dose of practical experience as methodologists, statisticians and researchers. Broadening conception of the subject of the teachers, hence, could be quite a task.

The authors conducted their research on a sample of mathematics students. In my statistics class there are students of various social sciences and humanities disciplines. Demonstration of the applicability of students’ studies to their future work and professional role in my class, as the authors suggest, requires a very broad experience that very few teachers have.

Finally, the methodological approach the authors adopted in this study prevents them from offering answers on several important questions. My main problem with this study is **why** students have **different** conceptions of statistics. If the curricula of the statistics classes were too narrow and need broadening, and if the teachers’ approach to the subject does not encourage students to look for meanings, how come that some students **did** manage to develop an Intrinsic Meaning concept? Do teachers have any impact on the fact that some students actually develop a broad conception of statistics? This phenomenographic method, being focused on a small sample and limited scope of the research, methodologically does not allow, first, wider generalisations on students of different subjects and in different settings, and, second, exploration of variety of other factors on different conceptions of statistics.

To conclude, the authors highlight the important point that in deciding how to design his/her curricula, it is crucial for a teacher of statistics to explore students’ previous experiences outside the learning environment, their conceptions of statistics prior to arrival in university, and learning attitudes in students’ other subjects, among others. But the article is rather short on practical solutions to this problem.

From the perspective of my teaching of the subject, I find that the general recommendations of the authors are applicable to my statistics classes. It was my experience as a sociology undergraduate student doing courses in statistics that influenced my approach. This has entailed emphasising the practical application of statistics in social sciences, in ways analagous to the higher order conceptions of statistics identified by Reid and Petocz.

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