Megaclasses in Statistics Education: Establishing a Research Framework in a Complex Domain

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Abstract

Recent years have seen the emergence and expansion of several types of university megaclasses relevant to statistics education, especially regarding introductory statistics. Megaclasses involve very large numbers of students and large teaching teams. They often include online communities of learners and instructors and might build on the use of remote learning and interactive technologies. Given the unique characteristics of such teaching/learning environments, the paper outlines research needs and challenges related to six separate but related areas: (1) teaching methods; (2) cognition and learning; (3) emotions, attitudes and beliefs; (4) self-management and metacognition; (5) social interaction and inquiry patterns; and (6) service satisfaction and user experience. These areas can benefit from the use of mixed methods involving both quantitative and qualitative techniques, coupled with the need for data mining to identify usage patterns, and netnographic methods to evaluate course-related discourses in online and web-based learning environments.

Keywords: Massive Open Online Classes (MOOC), megaclasses, research methods, virtual universities, evaluation methods

1. Background

Recent years have seen the emergence and expansion of several types of university megaclasses relevant to statistics education, especially regarding introductory statistics. O'Reilly, Rahinel, Foster, & Patterson (2007) define 'megaclasses' as those involving 300+ students where teaching teams operate in a complex social and technology-based environment. Megaclasses are not at all an uncommon occurrence in service courses of statistics. They appear in traditional forms of classroom-based large courses, in the context of Massive Open Online Classes (MOOC), or in virtual universities.

Megaclasses could be perceived as a variation or extension of known approaches in statistics education, such as the use of ICT-based distance learning or online courses. Initiatives and issues in this field are documented in multiple sources, such as Bregar & Ograjenšek (1999), Ograjenšek & Bavdaž Kveder (2003), Utts et al. (2003), or Härdle, Klinke, & Ziegenhagen (2007). An obvious challenge for any megaclass is an adequate *infrastructure*, ranging from the most basic issue of a large-enough classroom, to very sophisticated virtual platforms and learning support systems. In addition, the megaclass infrastructure also requires a coordinated work process involving a large multi-facetted teaching staff consisting of a (senior) lead instructor, junior lecturers, teaching assistants and/or tutors, and possibly technical personnel or an ICT helpdesk. Beyond these basic issues, megaclasses present many additional challenges stemming from, or related to, the ramifications of very large numbers of students, broad student heterogeneity, use of remote learning and interactive technologies, the existence and functions of online communities of learners and instructors, as well as numerous other elements.

While megaclasses in [introductory] statistics education emerge and mature around the globe simultaneously, they seem to do so independently and arguably on a trial-and-failure basis instead of systematic study and exchange of experiences. Little research has been conducted on the teaching/learning processes that exist within them, or on the various factors that may contribute to their quality and effectiveness.

We believe that there is a need to better understand the processes in the learning communities that participate in megaclasses, and the interactions between the virtual and real facets that they involve, in order to facilitate design of effective and efficient megaclass learning environments. This paper reviews research needs and identifies research challenges associated with understanding teaching/learning processes and outcomes associated with six separate but related areas or characteristics of megaclasses: 1) teaching methods; (2) cognition and learning; (3) emotions, attitudes and beliefs; (4) self-management and metacognition; (5) social interaction and inquiry patterns; and (6) service satisfaction and user experience issues.

Given space limitations, we cannot present a detailed review of each of these areas. We therefore aim to sketch them in broad strokes and highlight key associated research challenges and the methodological toolbox necessary to deal with them.

2. Research areas in statistics megaclasses

2.1 Teaching methods

In a traditional class, pedagogic activities are typically divided into those taking place ex catedra (i.e., frontal lecture with students as relatively passive recipients of information), those taking place in different forms of smaller tutorials or "exercise groups" (where students and instructors interact) and those taking place via students' independent explorations (e.g. individual or group study projects). The difference in the level of student's activation has important implications for the process of knowledge creation (Garfield, 1995). Virtual megaclasses tend to build on the premise that in vivo ex catedra lectures can easily be replaced by pre-packaged technological solutions which interweave multiple elements into the learning environment, such as video lectures, tutorials and demonstrations, the use of web-based applets, texts and so forth. Yet, although the integration of such elements appears to make a lot of sense, there is in fact little research on the extent to which they cause different learning trajectories for different groups of students.

2.2 Cognition and learning

The research literature on cognitive processes and outcome skills in statistics education and in related fields such as math or science education is vast (Garfield, 1995). However, megaclasses offer a somewhat unique learning environment, given their size and the need to accommodate a wide range of students with diverse background and learning styles. Furthermore, the lead instructor lacks direct contact with learners. Learners working individually, in small groups or in tutorials, while trying to reach the same learning goals as a large class, might be exposed to different teaching and/or communication styles of different instructors and tutors.

The complex learning environment makes it harder, compared to a traditional smaller face-to-face class, to describe the learning process, since different students may proceed along different learning trajectories. Further, it becomes harder to understand which aspects of the "teaching" contribute to which parts of the "learning" (or, on the contrary, impede learning), and hence to suggest innovations or methods that can improve the path towards the desired learning outcomes.

2.3 Emotions, attitudes and beliefs

Research over the last two decades, as well as personal experiences of many instructors, have shown that students may have trouble with the learning of statistics due to *non-cognitive* factors, such as negative perceptions of the value of statistics, low self-efficacy regarding math and statistical skills, etc. (Schau, Millar, & Petocz, 2012). These and other such factors can affect motivation to learn and effort levels, impede learning, or hinder the extent to which students will become statistically literate and feel comfortable to apply what they have learned outside the classroom.

While there is plenty of research on the various types of attitudes and beliefs that are of interest to statistics educators, methods for improving them are still somewhat

elusive and open to research and development. Students certainly bring some attitudes and beliefs with them into the classroom that may be difficult to change. Yet, we believe that teachers' demeanor and the educational and motivational messages they convey to students can positively affect students' attitudes and beliefs regarding statistics. However, megaclasses may offer reduced possibilities for teachers to personally engage with students or react to class events in ways that can affect motivation and attitudes. This is because teaching chores in part are distributed over a team made up of diverse staff, as well as because interactive teaching is partially substituted by pre-packaged technological solutions. For these and related reasons, there is a need to understand and further research the differences between megaclasses and regular classes in terms of their overall impact on students' attitudes and beliefs (both towards learning and statistics), and to explore the relative contributions of different elements of the learning environment, or innovative additions in this regard, to the overall impact of the class on students' attitudes, beliefs, and motivations.

2.4 Self-management and metacognition

In addition to recognizing the importance of emotions, attitudes, and beliefs for the outcomes of the teaching/learning process, it is also necessary to acknowledge the importance of metacognition and the related concept of self-management. Megaclasses require students' ongoing engagement with a complex learning system, and build on many activities that students have to initiate, monitor, and revise on their own. Universities have long ago become aware of the fact that study failure is not necessarily related to lack of intelligence, as illustrated in the excerpt from the *Academic Tip Sheet* on self-management prepared for students of the Edith Cowan University in Australia:

> *Self-management techniques are vital to be a successful student. It is quite common that students drop-out of university not because they find the course too difficult ... but because they become overwhelmed by the workload and are unable to manage study commitments with work and family life. You can avoid this dilemma by being organized and maintaining a healthy balance in all areas of your life. This will help you minimize stress and stay motivated in your studies. .... ask yourself … : Where do my priorities lie? Are all aspects of my life (family, study, leisure, friends) receiving attention? What are the long-term outcomes of what I am doing? How does study form part of the total picture?*

The development of self-management skills suitable for survival in a megaclass is essential, yet virtually no studies have examined how students engage with a megaclass as part of their ongoing life, what habits they possess, and what self-management skills they employ (or not). Further, *metacognitive* knowledge and regulation processes that take place in a megaclass also have to be evaluated. Metacognitive *knowledge* includes knowledge about oneself as a learner and the factors that might impact performance as well as knowledge about available learning strategies and when to implement them. Metacognitive *regulation* includes planning activities, task performance, and evaluation of the efficacy of monitoring processes and strategies (Lai, 2011). Both have to be accounted for in view of the fact that in any type of a megaclass, students may feel reduced personal attention as an individual learner, yet be expected to apply successful learning strategies.

2.5 Social interaction and inquiry patterns

University classes can be viewed as social communities of students and educators. However, as class size grows, the number of opportunities for face-to-face interactions within the community normally decreases. Time pressures prevent teachers from answering many questions or allowing much class discussion. Given that they need to manage a larger crowd, they have to maintain tight control over interaction patterns. Consequently, students may be more likely to interact with

teaching assistants or tutors outside the reach of the lead instructor.

Fortunately, classes where students are connected online, including megaclasses where reliance on an online learning platform is often a necessity, enable the creation of alternate interaction patterns of various types (Schmid, 2013). Students can send queries to the teaching staff through multiple channels (e.g. per e-mail, or via class-related forum, discussion board or bulletin board), and, in our experience, increasingly expect rapid (almost real time) response. In addition, some online learning platforms such as *HighLearn* or *Moodle* enable students to post questions and receive answers either from the teaching staff, or from other students. Thus, a support community may emerge in a virtual space not fully controlled by teaching staff. Finally, in today's world where many people are members of social networks such as *Facebook* or *Google+* and others, students can voice their concerns or insights or ask questions about what is being learned without assuming any interaction with the teaching staff. We know of numerous cases where students set up a *Facebook* group of their own and created a vibrant learning community that has been exchanging ideas and providing ongoing support, completely outside the purview of the teaching team.

The above description, while not even covering all possible communication channels, suggests that students in megaclasses may simultaneously engage in multiple interaction and inquiry activities that are both vertical (i.e., with teachers and assistants) and horizontal (i.e., with their peers). These interaction patterns have of course existed even in traditional classes, but their scope and complexity may increase dramatically in a megaclass, much of it happening “under the radar”. Hence, many questions emerge regarding the nature of the discourse processes in megaclasses, and the contribution of vertical and horizontal interaction and inquiry patterns to the learning process in terms both of cognition and acquisition of knowledge and skills, as well as in terms of impact on attitudes and motivations.

2.6 Service satisfaction/quality and user experiences

Parts of our own academic work belong in the domain of service management (Ograjenšek & Gal, 2012). From this perspective, we believe that “quality” or “effectiveness” in a megaclass should be viewed not just from the traditional instruction perspective focused on academic outcomes (i.e., skills and knowledge) but also from the service management/marketing perspective. Such a perspective entails thinking both about “customer satisfaction/service quality” and “user experience”, since in a megaclass, students usually interact with multiple service providers (i.e., lead teacher, teaching assistants, tutors, helpdesk personnel) and a complex technology platform.

The notion of “customer satisfaction/service quality” is called for once we think of students as customers engaged in a prolonged relationship with a service providing system. Viewing students as customers is a controversial notion whose discussion would demand a paper of its own. However, this idea raises several issues that have been receiving much attention in the literature on service management/marketing. One research challenge lies in identification of dimensions that make up quality perceptions in a megaclass environment. Another targets factors that affect customer satisfaction with how complaints or queries are handled, which is a different issue that research shows to affect overall service satisfaction. For instance, Stauss & Seidel (2004) outline these dimensions underlying complaint satisfaction: (a) accessibility to the service provider (i.e., lead lecturer, teaching assistants), (b) quality of interaction (e.g., politeness, etc.), (c) speed and efficiency of handling a complaint (expected by the ‘customer’ almost in real time), and (4) fairness of the outcome (e.g., the final grade following a complaint).

The notion of “user experience” aims to address two different issues. The first is the “experience” aspect, i.e., emotional excitement of creating learners that are both engaged (Schmid, 2013) and satisfied. The second highlights the “user” aspect and builds on the idea of a smooth technology-based learning environment which does not

present usability barriers that detract from the learning experience. Examples for relevant dimensions are, e.g., ease of use, appearance, linkage, structure and layout, contents, reliability, efficiency, support, communication, and security (Santos, 2003).

All these topics nowadays receive ample attention from designers of (web-based) services. However, both entail related but different research questions that have hardly been explored in statistics education in general, and in a megaclass context in particular, e.g., to what extent can traditional course evaluations address aspects of the complex "servicescape" in a megaclass.

3. Discussion and implications for future research

The points raised with regard to the research areas in the previous segment, while brief, certainly imply that (introductory) statistics megaclasses present a complex arena within which planners, teachers, institutions, and students have to operate. Many useful ideas in this regard are raised in other IPS40 papers based on diverse case studies. Here we focus on research needs and related research toolbox emerging in light of our outlined ideas. Looking beyond each of the identified six specific research areas, we believe that the complexity in the megaclass arena calls for the use of wider range of research methods than is normally encountered in research on traditional college-level introductory statistics classes. A non-exhaustive range of possible approaches is briefly sketched below:

A. More mixed methods. Traditionally, statistics education research has split itself along traditional lines of using either quantitative methods (e.g., proficiency tests, attitude surveys, etc.) or qualitative methods (e.g., interviewing, qualitative analysis of students' responses in class exams, etc.). Such methods clearly have much merit for studying processes and outcomes of megaclasses, if properly applied. Yet they may not be sufficient or need to be augmented by additional designs or approaches. We believe that as more and more learners use interactive web-based learning and dissemination tools, researchers will increasingly need to employ mixed-methods designs that adapt the integrated use of qualitative and quantitative methods in a pre-planned way to suit particular research needs and increase the ability of the overall study to respond to complex research questions (Gal & Ograjenšek, 2010).

The use of mixed methods (Johnson & Onwuegbuzie, 2004) may be of particular interest when studying the interaction of cognition, emotions, social processes and outcomes in megaclasses, because of the existence of multiple types of interactions in such a setting, for example *relational* (student-to-student interactions and knowledge-sharing), *transformational* (both teachers, students, and technological entities seeking to change the behavior or knowledge of other students), *administrative*, *technical*, and so forth. Mixed methods are also useful for studying students' needs, attitudes, satisfaction and perceptions regarding what they are experiencing, because while quantitative studies can document levels of reactions or perceptions, they cannot shed much light on the *reasoning* or *motivations* behind them.

B. Data mining. Given the heavy reliance of many megaclasses on web-based platforms, it is essential that instructors apply modern web mining and log analysis methods to identify web usage patterns, e.g., how frequently their different learning resources are actually being accessed or downloaded, what parts of the web-based platform are visited more often or skipped, are resources being accessed in a timely manner, and so forth. In addition, data mining methods, now in use by virtually all large service providers, can be applied to connect web usage patterns to student performance data (e.g., test scores). This can help to develop deeper insights regarding the usage patterns of students with different achievement levels or with different learning needs (Romero, 2013) or to understand how students access discussion boards. These and other methods can help teaching teams to identify diverse areas for improvement in terms of content or web design, or suggest where and why existing resources need to be augmented, either by human contact or by other interventions.

C. Netnographic methods. Megaclasses tend to generate a vast number of discourses - by teachers and teaching assistants on the one, and especially within learner communities on the other hand. While standard content analysis could be employed to examine typical themes in students' questions or in teachers' answers, the understanding of the interactions from a holistic perspective and the progression of discourse that may occur along a timeline require additional tools. Netnography is defined by Kozinets (2002) as a contemporary form of an ethnographic study of virtual communities. Its underlying principle is simple: as the lives of this generation increasingly take place in the framework of virtual communities, so should the research. Netnography has been used in the fields of consumer behavior and marketing since the late 1990s (Kozinets, 2010) and will, in our opinion, gain recognition as a research tool on [statistics] education efforts in the years to come.

Obviously, each of the sketched approaches has its own merits. Which ones are ultimately used depends as much on the nature of the research project at hand as on the available resources – assuming the much harassed team of megaclass teachers and often overwhelmed megaclass students would be willing to cooperate.

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