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Editors:
Helen MacGillivray
Queensland University of Technology

Michael A. Martin
Australian National University

Brian Phillips
Swinburne University

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OZCOTS 2016 Paper Refereeing Process

Papers referred to in the proceedings as refereed publications were reviewed and accepted as meeting the requisite standards by at least two referees selected from a panel of peers approved by the OZCOTS 2016 editors.

The review process was "double blind" - identification of both authors and referees was removed from all documentation during the reviewing process. The Conference Committee took the view that the review of papers would give conference participants and other readers confidence in the quality of the papers specified as "refereed" in the proceedings. The refereeing process also provided a mechanism for peer review and critique and so contributed to the overall quality of statistics education research and teaching. While the refereeing process essentially relied on subjective judgments, referees were asked to compare the paper being reviewed against the accepted norms for reporting of research. It was expected that each accepted paper would represent a significant contribution to advancement of statistics education and/or the research processes in statistical education. Authors verified that the refereed published papers for these proceedings were substantially different from papers that have been previously published elsewhere.

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Designing Massive Open Online Courses for Educators around the World: The Case of Teaching Statistics

TRAN, Dung[1] and LEE, Hollylynne S.[2]
[1]Victoria University, Australia, [2]NC State University, USA
Dung.tran1@vu.edu.au

Statistics receives attention through global curriculum. Some have designed professional development for teachers to develop their statistical content and pedagogy, typically on a small local scale. Online courses can expand the number of teachers involved and create communities beyond school or district lines. For a "massive" and "open" course, there are many design challenges to meet the needs of participants with varied backgrounds in teaching statistics. We will share how a Massive Open Online Course for Educators (MOOC-Ed) designed in the USA, but offered and taken by educators from around the world, including Australia and New Zealand, presents design challenges for how to best impact teachers' learning and classroom practices. For this paper, we will focus on course design principles, the design and implementation of a framework for supporting students' approaches to statistical investigations and a task guide to assist teachers in evaluating, designing, and implementing worthwhile statistical tasks. We will share participants' engagement with the course and evidence we have collected suggesting impacts on their classroom practice.

Statistics receives attention through global curriculum (ACARA, 2012; CCSSM, 2010). Some have designed professional development for teachers to develop their statistical content and pedagogy, typically on a small local scale (cf. Darling-Hammond et al., 2009). Online courses can expand the number of teachers involved and create communities beyond school or district lines (Kim, 2015). Indeed, with advances in technology and interest in offering alternatives to traditional professional development, the number of online professional development opportunities has increased. The USA National Research Council (2007) claimed that: "Growing numbers of educators contend that online teacher professional development (OTPD) has the potential to enhance and even transform teachers' effectiveness in their classrooms and over the course of their careers." (p. 2)

MOOCs are designed and delivered to serve different target populations and provide diverse experiences for learners (Clark, 2013). For a "massive" and "open" course, there are many design challenges to meet the needs of participants with varied backgrounds in teaching statistics and working in different educational contexts. Capturing the potential for MOOCs to serve as large-scale professional development, teams have created MOOCs for Educators (MOOC-Eds) in the USA. As leaders of one of these teams, we designed a course focusing on teaching statistics to assist mathematics and statistics teachers in developing content understanding and pedagogical strategies for improving practice, and forming local and global communities of educators. This course was offered to and taken by educators from around the world, including those from Australia and New Zealand, presenting design challenges for how to best impact teachers' learning and classroom practices worldwide. Our question guiding this design and research is "*To what extent does a MOOC in teaching statistics offer opportunities for mathematics and statistics teachers to engage in professional learning and impact their teaching statistics practices*?" For this paper, we will focus on course design principles, the design and implementation of a framework for supporting students' approaches to statistical investigations and a task guide to assist teachers in evaluating, designing, and implementing worthwhile statistical tasks. We will share participants' engagement with the course and evidence we have collected suggesting impacts on their classroom practice.

Course Design Principles

MOOC-Eds are specifically designed to help educators meet their professional learning needs, so it is assumed that participants are motivated and self-directed. This MOOC-Ed was built using design principles of effective online learning and professional development (Kleiman, Wolf, & Frye, 2014) that emphasize: (a) self-directed learning, (b) peer-supported learning, (c) job-connected learning, and (d) learning from multiple voices. Most typical MOOC participants review material individually and some engage in discussion forums (Kim, 2015). We will highlight two of the design principles that

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address this challenge that makes MOOC-Eds different. For *peer-supported learning*, this MOOC-Ed made extensive use of discussion forums for encouraging participants to reflect, exchange ideas and resources, and engage in dialogue and debate to extend their understanding. We value the experience and expertise of the participants and design learning activities such that educators can share their knowledge to further the learning of others. There is also an emphasis on establishing professional connections among MOOC-Ed participants, who are identified by name in all their comments and projects; participants are not able to post or give feedback anonymously.

The course incorporated a number of opportunities to *learn from multiple voices*. MOOC-Eds are purposefully not designed around one or two experts who present online lectures; instead, they offer a rich set of perspectives presented within the context of activities and exchanges. As members of the design teams, we created our own resources and used existing open access resources written by other educators. Discussions that included well-known experts in the discipline were recorded and used throughout the courses. In these videos, the experts discuss relevant topics, share personal experiences and valued resources, and suggest strategies for implementing knowledge gained from research in everyday classrooms. Student voices were brought into the course through videos of teachers and students engaged in tasks in classrooms, and through animated videos based on actual student responses to research tasks. Multiple voices allow participants to learn about the perspectives of other teachers and administrators and those of students, researchers, and experts in the field

The discussion forums were designed for participants to post their thoughts about resources (readings, videos, tools) and discussion prompts, and interact with others. The design teams function as facilitators in forums; we encourage participants to share experiences and connect similar threads from different groups to offer multiple perspectives purposed to support richer discussions.

Statistical Investigation Learning Opportunities

The purpose of the course was for participants to think about statistics teaching in ways likely different from current practices in middle school through introductory statistics. A major goal was for teachers to view statistics as an investigative process (pose, collect, analyse, interpret) that incorporates statistical habits of mind and view learning statistics from a developmental perspective, aligned with guidelines from Franklin et al. (2007). We highlight our effort to design and implement a framework to support students' approaches to statistical investigation and a task guide to assist teachers in analysing, designing, adapting, and implementing worthwhile statistical tasks.

Design and implementation for a framework for supporting students' approaches to statistical investigations. We built upon the GAISE K-12 (Franklin et al., 2007) report by incorporating recent research on students' and teachers' statistical thinking and highlighting productive statistical habits of mind. The GAISE document is extensive (88 pages) with many illustrated examples. Our design challenge was to create useable artefacts and experiences that could communicate the essence and important messages within relatively brief comprehensible formats. Thus, we developed an adapted version of the GAISE framework we called supporting Students' Approaches to Statistical Investigations (SASI), and then designed learning materials to communicate the framework. Two brief PDF documents included statistical habits of mind and explicitly described the framework. We designed a graphic to communicate the investigative cycle, reasoning in each phase at each of 3 levels, and an indication of productive habits of mind for each phase. An interactive diagram was created so that details appear when an aspect is clicked (Figure 1). In a video, the instructor illustrated the framework using student work from research as supportive examples, and another video featured one of the experts illustrating the development of the concept of mean across levels of sophistication. The participants then discuss, in the forums, a task that allows for students to approach their work at varying levels of sophistication, video examples of students' work on the task, and how they could use such a task in their own practice. Participants were specifically asked to discuss how students' reasoning aligned with the SASI framework. Participants would again experience each of the phases of the investigative process when dealing with massive real data from the international CensusatSchool project. They experienced the statistical process as a learner and as a teacher who will teach the process to students. We explicitly highlighted the habits of minds in doing statistics, built upon previous general habits of mind in doing mathematics (e.g., Cuoco, Golden, & Mark, 1996) and statistical thinking frameworks (e.g., Wild & Pfannkuch, 1999). Educators were expected to discuss the habits of mind as they watched students engage in a statistical investigation with CensusatSchool data in the animated videos.

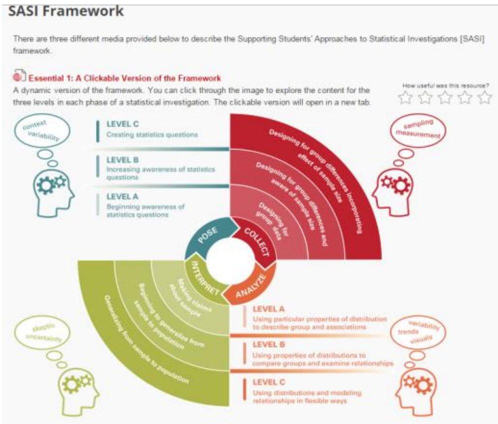

Figure 1. Learning resources for the SASI framework.

Task guide in evaluating, designing, and implementing worthwhile statistical tasks. Researchers have emphasized the roles of instructional tasks as catalysts for student learning (Stein & Lane, 1996). Therefore, we intentionally created learning opportunities around task analysis, adaption, and design. Two emphasised features included the difference between mathematics and statistics, and nature of worthwhile statistical tasks. Statistics educators (Franklin et al., 2007; Gattuso & Ottaviani, 2011) posit that uncertainty, the omnipresence of variability, and importance of context collectively distinguish statistics from the deterministic nature of mathematics. It is crucial for educators to realise the essence of statistical reasoning so that they could support students developing such thinking, which was underscored in the brief summary *Difference between Statistics and Mathematics* for participants to read. In this reading, we highlighted the role of context, measurement, variability and uncertainty to serve as a lens for educators to examine tasks that offer potentials for students to engage in statistical reasoning. We also developed a guideline for educators to examine why tasks are worthwhile in developing statistical thinking, how to improve the tasks, and what considerations need to be taken into account when implementing tasks in the *Considerations for Design and Implementation of Statistics Tasks* document. Participants then analysed tasks by mapping components of the tasks to the task guidelines.

Data Collection and Analysis

Data included registration and click logs of actions taken by participants (e.g., resources viewed, videos watched, forum viewed and posted). All dialogs generated in discussion forums, 5-star ratings of resources, and feedback surveys were collected. Descriptive statistics were generated based on demographic information, survey responses, and click logs. Open coding of forums and survey responses was used to develop themes related to impacts on practice, especially participants' understanding of statistical investigation and the use of an analytic frame to look at statistical tasks.

Engagement in the MOOCs

We will focus on the course offerings that occurred in Spring 2015. The course had 797 participants registered from 43 countries, with 597 (76%) registrants from the USA (see Figure 2 for the global reach for courses). Classroom teachers (64%) constituted the majority of participants, followed by about 10% of participants that worked in mathematics teacher education in university settings or other professional development roles. Interestingly, about two thirds of participants in the course held advanced degrees (masters or doctoral), which indicates that engaged learners in their discipline, valuing advanced educational opportunities were attracted to the MOOC-Eds.

Figure 2: Global enrollment in course in Spring 2015.

Participants were categorised into "no shows" i.e. entered the course after registration, "visitor" who logged into the course and engaged with some aspect of it four or fewer times, and "active participants" – the remaining participants (see Kleiman, Kellogg, & Booth, 2015 for more details). There is a large proportion of "no shows" participants (more than 1/3), and a large number (528) engaged somewhat and more fully. These numbers may not look impressive for a massively scaled course. However, in the context of professional development, a large number of participants are potentially taking the advantage of the learning opportunity offered in the course. Further analysis (see Kleiman et al., 2015) characterized the active participants according to how engaged they were throughout the course resources including videos, readings, tools, visiting, posting, and commenting on the discussion forums. This analysis showed that the 180 active participants had either declining activity (54%), or sustained high activity (46%). These high activity rates, through the final units in the courses, is much higher than typical MOOC completion rates (2-10%), but is aligned with completion rates when participants intend to complete a course (Reich, 2014).

As highlighted above about the peer-support learning in the MOOC-Eds, the course mainly accomplished through opportunities to interact with one another in discussion forums. There were about 33% of visitors and active participants who posted at least twice in the forums with either a new post or comment on a post of a peer. 308 (58.3% of the 528 visitors or active participants) participated in the forums with an average of 7.1 posts each with 930 discussions. There were also many more discussion views than postings, which were done by both active posters and non-posters. This suggests many saw discussion forums as an opportunity for learning, even by merely reading the posts of others. These "lurking" participants are present, but not visible; thus, exactly why they read discussions and what they have learned from them is unknown.

Impact of the MOOC-Eds on Educators' Practices

When asked, at the end of each unit, the extent to which activities supported the application of course content to their professional practice, 98% of participants agreed to some extent (i.e., selected "somewhat agree," "agree," or "strongly agree). As a follow-up question, 100% educators reported they had made changes in their practice as a result of the course. The ways they were applying their learning experience in the course to their practices include: (a) integrating new tools and strategies, (b) implementing course projects, and (c) using course content for instructional coaching and professional development, as indicated in the open-ended survey items.

Participants report positively on triggers for changing teaching statistics practices that were purposefully designed in the course. Participants (n=48 respondents) reported the course (a) strengthened their understanding of how to engage students in a statistical investigation process (97.8%), (b) improved their ability to use the framework to guide their teaching of statistical investigations to promote deeper data explorations for their students (93.7%), (c) improved their ability to use rich data sources to support investigations (95.8%), and (d) improved the ability to use dynamic tools to visualize and analyse data (91.6%). These four triggers also appeared as we examined the forum posts and open responses on surveys. For example, their open ended survey showcased an "overhaul" in their approach to the practice in relation to the use of real data in teaching statistics:

> Since starting the class, I have had my students use richer and messier data in their investigations and I have also put more of an emphasis on understanding the results and being able to analyze findings.

The MOOC-Ed participants appreciated being introduced to a more structured, comprehensive approach to teaching statistics. As a result of their engagement in the course, some participants described a shift in their overall approach to teaching statistics. In commenting on the value of the Supporting Students' Approaches to Statistical Investigations (SASI) Framework, one participant noted:

> The SASI framework was the most useful part of the course. It is incredible. I've been telling the teachers here about it because normally we teach the Intro to Stats class only procedurally, just calculations, with no sense of equations or interpreting. But that has changed now because of using the framework.

When analysing tasks as to whether they are worthwhile for teaching statistics or viewed examples of students' work on tasks, participants recognized four phases of the statistical investigation displayed in students' engagement in tasks or as they engaged in analysing statistical tasks:

> These activities were full of various levels from the SASI framework. Students were posing relevant questions checking the simulations to see what changed and then posing more questions. I love how they spent so little time on the actual calculations and so much time posing and seeking answers to relevant questions. Students were engaged and not frustrated with tedious calculations.

Participants discussed more on the first two phases of the investigation:

> I was more interested in the Television Time data because that data could be collected in far less class time through technology shared by multiple classrooms (Google Docs comes to mind). The data sets contained the actual data and allowed for exploration of variability, comparison of different ways to graph the same data, disaggregating the data, mean vs. median, and several others. Maybe I'm only valuing the variety of available analysis tools rather than a direct opportunity to *physically* collect data. I still think there's data collection concerns that can be addressed even with this activity: units of reporting, discrete vs. continuous, response bias, etc.

They also saw the potential of tasks in addressing different phases of statistical investigations and developing statistical habits of mind.

> I think there is a lot of merit to different statistical tasks that focus on only portions of the cycle. I think it's ok to maybe have a day to brainstorm how to just pose a question. Then another task the just focuses on how to gather data. The other two tasks were mostly analysis, but there is certainly merit in having some tasks that only analyze data as well. Of course we should have some tasks that integrate all 4 parts of the cycle, but I would argue that we cannot make every task that way. So if the goal is to teach the analysis of the data, the other tasks are just fine. If the goal is to engage in more of the cycle, then Coke vs Pepsi does that, but it still lacks the whole cycle. I like that this task uses real world data rather than made up numbers.

Educators also reported wanting to use all four phases of a statistical investigation, rather than their past heavy emphasis on the analysis phase.

> I have changed my planning process for statistics. I will use more technology in my teaching and spend more time on the first 2 phases of the investigative cycle. I will encourage statistical habits of mind and movement through the levels of the SASI framework.

While some of the comments indicate how teachers have already changed, or will change, their practices with their own students, other comments show how elements of the course are impacting how participants encourage their colleagues to change their practices.

Discussion

While the number of participants does not look massive like other MOOCs, in the context of professional development, at least 528 participants take advantages of our purposeful designs in Spring 2015 (the course has been offered 3 additional times with many more participants and a growing global community). The design includes general principles in development of MOOC-Ed, as well as specific productive practices of teaching statistics. These serve as catalysts for self-reflection and change in practice. The research-informed practices in teaching statistics were highly valued and appeared to assist participants in viewing the learning and teaching of statistics more conceptually and comprehensively that focuses on developing statistical thinking and habits of mind. Participants also seemed to be able to shift their perspectives from viewing the importance of teaching and learning statistics as reliant on algorithms or procedures, to a view of statistics as more of a process that has nuanced conceptions that must be developed with extended experiences.

Results show that our MOOC-Ed provided participants the opportunity to engage in professional development to strengthen their content and pedagogy in areas *they personally were interested in improving*. We continue to learn about the affordances and constraints of this model of professional learning for mathematics teachers and are interested examining the long-term impacts on practice. How could such MOOC-Eds sustain the trigger to continuing practices of educators in their jobs? How would participants engage, and would professional learning networks emerge? Furthermore, we would like to explore the possibility of international collaboration in the design of future courses that closely address more specific demands (such as the Australasia education system) and the possibility of offering smaller scale modules that are continuously available.

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