ELECTRIC DREAMS
30th ascilite Conference, 1-4 December 2013
Macquarie University, Sydney

Piloting an online mathematics and statistics tutoring service

Jim Pettigrew
Mathematics Education Support Hub
University of Western Sydney
Donald Shearman
Mathematics Education Support Hub
University of Western Sydney

In early 2013 the Mathematics Education Support Hub at the University of Western Sydney launched a tutoring service to support students' mathematical and statistical learning in an online environment. Until the end of its pilot implementation in mid 2013, the service operated at all times as a moderated question and answer forum located within the University's Learning Management System (a version of Blackboard Learn known as vUWS). It also featured a 'virtual classroom', which allowed students to interact with mathematics and statistics support staff in a web conferencing space equipped with a wide range of digital communication tools. This paper refers to the service as it was offered in discussing a range of general issues and questions associated with its pilot implementation. Particular attention is given to the issues of pedagogy in a purely online teaching and learning context and communicating asynchronously and synchronously using mathematical language and notation.

Keywords: Online tutoring, asynchronous, synchronous, mathematics and statistics support

Introduction

As part of a suite of initiatives to mark the full-scale operation of the Mathematical Education Support Hub (MESH) at the University of Western Sydney (UWS), the online mathematics and statistics tutoring service was introduced in early 2013 to a small cohort of first level students enrolled in quantitative units. The service's launch followed a period of investigation of suitable service models and research studies examining similar support offerings and their various teaching and learning and technological dimensions, as well as experimentation with asynchronous and synchronous communication technologies that would underpin the UWS offering. This paper puts forward for consideration some of the discoveries made and challenges encountered throughout these preparatory implementation stages.

Issues

Among a range of operational and technical issues affecting the use of the online tutoring service, the authors have chosen two for discussion in this paper – pedagogical considerations and the use of mathematical notation in asynchronous/synchronous teaching and learning spaces. The pedagogical opportunities and constraints enjoyed by teachers working with quantitative learners in purely online spaces are manifold. In this section a contextualised account of some of the peer-reviewed discourse addressing this broad topic is given, followed by a reflection on the authors' practical experience.

Pedagogy

Alongside the technical elements of the development of the tutoring service, an important element was preparing the service's teaching staff for the extraordinary pedagogical issues that moderating a discussion forum or 'virtual classroom' might present. This involved considering the similarities and differences between conventional face-to-face teaching and learning dynamics and those experienced through asynchronous and synchronous online communication. Once identified, these were used to motivate discussion about how to translate pedagogy from the conventional to the online setting in the case where similarities existed, or transform it in the case where differences were found.

A range of recent studies investigating online teaching and learning practice were used as a starting point and inspiration. Some of these examined pedagogical issues in both asynchronous and synchronous spaces, while others focused only on the latter.

In their paper 'Virtual Spaces: Employing a Synchronous Online Classroom to Facilitate Student Engagement in Online Learning', McBrien et al. examine various teaching and learning issues in a synchronous higher education teaching space (McBrien et al., 2009). They use Moore's notion of transactional distance to frame their discussion in terms of three theoretical elements: Dialogue, Structure and Leaner autonomy (see Moore, 1993).

In the case of Dialogue, they note the advantages of synchronous environments with regard to improved student participation:

> Many students linked dialogue to important pedagogical considerations… such as increased participation and increased time to reflect before responding. Perhaps most importantly, the synchronous online platform allowed students, particularly shy students, to feel more comfortable expressing their opinions. This indicates the power of a synchronous online system to empower students in conversation and expression. Many of these students may never initiate comments in a traditional classroom. In such cases, the transaction distance enables such students to formulate their ideas and receive responses to them, thus increasing their learning potential. (p. 13)

But they also note that that this can come at the expense of students feeling 'confused' by over-exposure to simultaneous, multi-channel communication systems. With regard to Structure, the authors note that 'students revealed the need for clear and consistent structure, expectations, and roles in virtual classroom sessions to reduce their experience of distance' (p. 14). And with Learner Autonomy, they suggest that technical complications can be a strong force for student disengagement.

These themes are echoed in Michael Jopling's review of one-to-one online tuition in schools and higher education (Jopling, 2012). Using 17 'core studies' and a grounded theory approach, the author identifies four dimensions of 'next practice pedagogies' that epitomise innovation in online tuition.

The first of these, 'relevance', concerns teaching approaches that weave digital literacy instruction into the curriculum, in addition to providing opportunities for authentic learning (using external professional mentors, for example), the growth of trusting, possibly informal, relationships with students and the expert use of paralinguistic and non-verbal online communication. The second, 'co-construction', considers approaches that allow students to 'lead, negotiate and own their learning' (p. 315). Sub-themes are the promotion of learner autonomy and empowerment via self-directed enquiry or peer-to-peer tutoring. The third, 'learner-tutor mix', covers issues relating to teachers' changed (or even threatened) status and identity in learning environments that lend themselves to facilitated collaboration, integrated (student-teacher) digital expertise, lesson negotiation and skill enhancement. The last dimension, 'in and out of school/HE contexts', concerns 'pedagogies that seek to remove the boundaries between learning in and out of school, university, and other educational contexts, and support the learner in making connections between different learning experiences' (p. 316). An important sub-theme here is the need for dedicated and reliable technical support for teachers and students, 'particularly outside their educational institution' (p.317).

A number of pedagogical challenges in the synchronous setting are discussed from the tutor's perspective in 'Web conferencing for synchronous online tutorials: Perspectives of tutors using a new medium' (Kear et al., 2012). Issues examined include: the unpredictability of real-time teaching and learning environments (where teachers need to 'adapt their responses to learners' responses and needs' (p. 954), and where, crucially, this is not always aided by non-verbal communication; the difficulty of adapting material prepared for face-to-face tuition to lessons suitable for synchronous online instruction; enabling and encouraging students to speak during web conferencing sessions, and striking the right balance between the spoken contributions of the tutor and that of their students; participants' ability to input and edit mathematical notation while maintaining the flow and momentum typical of well-functioning face-to-face interaction; and negotiation of complex, multimodal interfaces.

Due to the relatively small-scale nature of the pilot discussed in this paper, the experience of the authors, who were the sole moderators of MESH's online tutoring system, was limited to use of only part of the system: the asynchronous discussion forum. (It is expected that, with the inclusion in the program of many thousands more students in the second half of 2013, the synchronous part will soon play an important role.) This forum was open to all students enrolled in at least one of five first level mathematical and statistical units; and it was designed in such a way that it could articulate with a 'virtual classroom' if students required real-time assistance beyond – or as a substitute for – their delayed-time interactions with its moderators. A selection of questions and issues that arose for the moderators is given below:

- In what ways does the delayed-time interaction in a vUWS discussion forum affect the character and quality of the teaching and learning process? Due to the html-based nature of the vUWS (i.e. Blackboard Learn) discussion tool, some effort was required to ensure that posts were not overly 'text dense', and that, in particular, they had a well organised, readable and visually appealing or instructive style. This usually involved the use of embedded graphics files or photos of handwritten calculations or diagrams. A disadvantage might be the lack of interpersonal dynamism and conceptual 'wayfinding' that often characterises real-time interaction. Serendipitous discovery and opportunities for socially-constructed learning might also be compromised in the absence of instant or immediate two-way communication, as might opportunities for 'nipped-in-the-bud' correction of learners' misconceptions. Advantages might include the fact that delayed responses allow teachers and students to properly digest information given to them and to carefully craft replies. Peer involvement in the question and answer process might also be more manageable and rigorous (from the moderators' viewpoint) in cases where moderators have time to intervene and correct or extend 'solutions' volunteered by students;
- How should the moderator position themselves in the asynchronous space? Should they be discipline experts or 'final arbiters' who provide definitive advice on matters of content? Or should they occupy the space 'lightly' and allow room for informal, experimental or speculative modes of instruction? And in what ways is the nature of the dialogue between teachers and students affected in each of these cases? (One of the authors admits to having felt some pressure to make every response to student questions authoritative and mathematically precise, knowing that an unseen audience of learners might be reading them.);
- What expectations might the students have with regard to turnaround time for their posted problems? How should these be managed in cases where students require rapid resolution under threat of their query becoming irrelevant (e.g. where they require help with an impending assessment task) or the need for reasonable levels of instructional continuity and steady or well-paced development towards a satisfactory answer?
- Should students be provided with a complete 'one off' answer to their query or might their asynchronous learning be more productive in the case where the moderator uses prompts, hints, partial or parallel answers in order to offer a gradual unfolding of the solution? In the very early phase of the pilot, one of the authors adopted the former approach, while the other adopted the latter. Both eventually agreed that dialogue-driven or cued interaction with students was preferable pedagogically – though the question of how the learning materials generated might be reused in an FAQ or searchable repository remains open.

Mathematical notation

In 'Communicating Mathematics on the Internet: Synchronous and Asynchronous Tools', the authors highlight the challenges associated with displaying and manipulating mathematical notation on the internet. They cite studies that posit these challenges as the reason why 'mathematics courses have been less prevalent than courses from other content areas to move online' (see e.g. Engelbrecht & Harding, 2005). Hodges (2009) refers to the difficulty of communicating online with mathematical notation, noting that – to borrow Hodges' and Hunger's phrasing (Hodges & Hunger, 2011, p. 40) – this is 'severely hindered by the state of the tools available to author such content'. Various mark-up systems are cited as solutions to this problem, including MathML and LaTeX via specialised graphical user interfaces that minimise the need for code-based editing.

The authors of 'Diagrams and math notation in e-learning: growing pains of a new generation' refer to the 'extraneous cognitive load' imposed by 'unnecessary steps in the communication process' that are caused by insertion of special mathematical symbols into online postings (Smith & Ferguson, 2004, p. 682). They also note the need for online instructors to be able to put maths notation directly into threaded discussions (rather than as file attachments or links) and to be able to draw 'quick conceptual sketches' without losing the thread of a discussion (p. 683). An interesting distinction is drawn between MathML notation which 'retains its semantic mathematical meaning' (and can therefore be used as input text for graphical or scientific applications) and other rendering modes, such as the Java-based WebEQ, which cannot readily serve this computational purpose (p. 685). A solution to the problem of disjointed 'symbol-insertion' methods of mathematical communication is a virtual whiteboard that allows for combined use of symbols accessible via graphical user interface menus and freehand text rendered via a text or pen tool.

This paper's authors anticipated that many students would use standard keyboard characters to denote mathematical or statistical elements in their vUWS discussion posts – even though the Blackboard Learn discussion tool offers a comprehensive selection of special characters such as Greek letters and cups and caps for set union and intersection. Hence moderation of the forum required facility with 'shorthand' characters denoting operations such as multiplication (* in place of ×) and mark-up such as subscript and superscript (x_1 and e^2 in place of x_1 and e^2). Students were directed to a web resource that itemised these and other such shorthand denotations. Where relevant, the authors embedded image (jpg), Word or LaTeX (PDF) files to fully furnish diagrams or calculations with annotated text.

In preparing for use of the 'virtual classroom', the authors explored the various whiteboard tools within the web conferencing system Blackboard Collaborate. While the synchronised, multi-user facility of the whiteboard allowed for 'collective' student interaction (Lissaman et al., 2009, p. 219), and enabled seamless integration of 'diagrams, formulas/math notation and text' (Smith & Ferguson, 2004, p. 684), it was awkward to write or draw on using ordinary computing technology such as a mouse or laptop touchpad. (Both authors made use of graphical tablets which significantly improved their dexterity with the whiteboard tool.)

Questions and issues that arose for the moderators are given below:

- What expectations can teachers have with regard to students' confidence and competency in using shorthand characters to denote mathematical symbols or widgets, interfaces, applications or tools that enable the use of sophisticated mark-up? How should students lacking skill in this area be inducted into online mathematical communication?
- Are there any mathematical language conventions or modes of expression that are qualitatively different in an online setting as compared to a face-to-face setting, and how can these be organised and made uniform and/or rigorous?

Conclusion

By considering the research base relating to (mostly) higher educational applications of asynchronous and synchronous communication technologies, the authors prepared themselves for the implementation of an online mathematical and statistical tutoring service. The pedagogical and mathematical notation issues examined in this paper informed the development and delivery of this service and acted as a useful reference against which the early implementation experience could be contrasted and compared.

References

Hodges, C.B. (2009). Developing web-based content containing mathematical expressions. In M. Simonson (Ed.), *31st Annual Proceedings of the Association for Educational Communications and Technology, Volume I* (Vol. 1, pp. 99-103). North Miami Beach, FL: Nova Southeastern University.

Hodges, C.B. & Hunger, G.M. (2011). Communicating Mathematics on the Internet: Synchronous and Asynchronous Tools. *TechTrends*, 55(5), 39-44. https://doi.org/10.1007/s11528-011-0526-4

Engelbrecht, J. & Harding, A. (2005). Teaching Undergraduate Mathematics on the Internet Part 1: Technologies and Taxonomy. *Educational Studies in Mathematics*, (58)2, 235-252.

Jopling, M. (2012). 1:1 online tuition: a review of the literature from a pedagogical perspective. *Journal of Computer Assisted Learning*, 28(4), 310-321. https://doi.org/10.1111/j.1365-2729.2011.00441.x

Kear, K., Chetwynd, F., Williams, J. & Donelan, H. (2012). Web conferencing for synchronous online tutorials: Perspectives of tutors using a new medium. *Computers & Education*, 58(3), 953-963.

Lissaman, R., de Pomerai, S. & Tripconey, S. (2009). Using live, online tutoring to inspire post 16 students to engage with higher level mathematics. *Teaching Mathematics and Its Applications*, 28(4), 216-221

McBrien, J. L., Jones, P., & Cheng, R. (2009). Virtual Spaces: Employing a Synchronous Online Classroom to Facilitate Student Engagement in Online Learning. *International Review of*

Research in Open and Distance Learning, 10(3), 1–6. https://doi.org/10.19173/irrodl.v10i3.605
Moore, M. G. (1993). Theory of transactional distance. In D. Keegan (Ed.), *Theoretical principles of distance education.* New York: Routledge.
Smith, G.G. & Ferguson, D. (2004). Diagrams and math notation in e-learning: growing pains of a new generation. *International Journal of Mathematical Education in Science and Technology*, 35(5), 681-695. https://doi.org/10.1080/0020739042000232583

Author contact details: Jim Pettigrew,j.pettigrew@uws.edu.au

Please cite as: Pettigrew, J. & Shearman, D. (2013). Piloting an online mathematics and statistics tutoring service. In H. Carter, M. Gosper and J. Hedberg (Eds.), *Electric Dreams. Proceedings ascilite 2013 Sydney*. (pp.706-710). https://doi.org/10.14742/apubs.2013.1433