PROMOTING AUTONOMOUS LEARNING IN STATISTICS AMONG UNDERGRADUATE MEDICAL STUDENTS

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For many educators, the idea of autonomous learning in statistics among undergraduate medical students may seem too much of a utopia to be worth pursuing. This unhappy scenario can place undue pressure on teachers of statistics to assume the rôle of instant service provider. Furthermore, tomorrow's doctors need to make informed judgments among competing sources of evidence, including statistical findings, in order to gain an accurate perspective on best practice. As teachers of statistics, we therefore have a responsibility to pursue strategies for turning the autonomy dream into a reality. Here, I seek to encourage educators through providing examples of such strategies based on successful teaching practise and findings from recent educational literature. In so doing, I take a multidisciplinary approach to statistics education and recommend ideas for integrating these strategies with teaching activities within existing medical programmes.

AUTONOMOUS LEARNING AS PERSONALIZED LEARNING

The educational literature is replete with alternative interpretations of what is meant by autonomous learning (Benson & Voller, 1997). More extreme interpretations of this notion are based on the idea of the individual being resistant to external influence at all stages of their learning. Ironically, in such extreme cases, an autonomous approach to learning can lead to *subversion* of the learner's capacity to construct their own meaning within a particular disciplinary setting. The refusal to reflect on the views of their peers and their educators can lead to failed opportunities to sharpen and fully personalize their own views through debate, correction and shared experiences. Autonomous learning, as intended in this paper, is by contrast a form of learning whereby the learner is able to take ownership of their personal learning journey in terms of identifying and searching for appropriate learning resources for problem solving activities whilst employing social interaction with other learners to improve their critical thinking skills and accepting ultimate responsibility for their management of time, the conclusions they draw and the impact that these conclusions will have on their educational performance. Here, social interaction can serve to cultivate learner autonomy rather than undermine it, provided the views of others are used to develop more advanced ways of thinking rather than taken as sacrosanct. Within the domain of learning statistics, relevant activities might include differentiating between good and poor statistical practice within the medical literature, selecting appropriate statistical methodologies for investigating clinically-based problems and employing sound statistical reasoning in the critical analysis of study findings. For simplicity, I choose to assume in this paper that *self-directed learning* is synonymous with autonomous learning as defined above.

THE IMPORTANCE OF AUTONOMOUS LEARNING

But why, as teachers of statistics to non-specialists, should we be concerned about cultivating learner autonomy? Taking the perspectives of the educator and the learner into account, strategies to improve learner autonomy may evolve both out of practical necessity and through recognition of their value to the quality of the student learning experience.

A practical necessity

Within undergraduate medical curricula, the competition for curriculum space to allow the educator to have their slice of the cake is very intense. Partly due to the failure of regulatory bodies to acknowledge statistics in defining their learning outcomes for tomorrow's doctors, teachers of statistics may be particularly disadvantaged here. Frequently, this is reflected by severe shortages in trained statisticians amongst teaching staff and the neglect of prior learning in statistics in early years. Medical students may therefore fail to recognize the value of statistics to their learning and to clinical decision making in the workplace until opportunities arise in senior years to embark on clinically related research. Here, the skills of choosing the appropriate statistical procedure and

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interpreting data soundly may feature for the first time, if at all, amongst course learning outcomes. Moreover, supervisor expectations may run unrealistically high, particularly where student projects are viewed as an opportunity for a research publication. On being parachuted into this environment, the teacher of statistics must redeem themselves from their paternal instincts; otherwise, the limitations of time, and student preparedness and the desire to please will inevitably conspire to undermine educator self-efficacy and effectiveness in enhancing student learning.

The added value to student learning

The idea that aspects of autonomous learning are central to effective engagement with the learning process is well-recognized (see, for example, Ramsden, 1992; Bryson & Hand, 2007). The sense of authenticity which is derived from autonomous learning as defined above contributes to this process by liberating the learner to view their *own* perspectives as valid and to embark on a personal learning journey whereby these perspectives must change over time. These benefits are likely to prove particularly valuable in the supercomplex world of clinical practice. Here, statistical thinking must be interwoven with the perspectives of a range of subject specialists in arriving at the optimal care pathway for the patient and the interpretation of best practice is regularly open to revision. Furthermore, the range of possible interventions from which to choose continues to expand based on the rapid turnover of research publications of varying statistical quality. (Altman, 2002) For the practising physician there is often no escape from the needs to "judge" rather than "comply", based on a range of competing sources of evidence and to decide for oneself which of these sources, including statistical findings, is of direct relevance to a particular patient problem. (McKee, 2002)

STRATEGIES FOR CULTIVATING AUTONOMOUS LEARNING

Given the predicament of the educator and the needs of tomorrow's doctors, it makes sense to explore available strategies for cultivating autonomy in the learning of statistics among undergraduate medical students. The strategies suggested have arisen out of the author's personal experience of teaching undergraduate medical students involved in short-term research projects and through her investigation of the educational literature on promoting student autonomy.

Ensure that the student maintains ownership of their own project or problem solving activity

In 1993, the General Medical Council (GMC), which is the regulatory body responsible for the medical profession in the UK, proposed the use of Student Selected Components (SSCs) within undergraduate medical curricula (GMC, 1993). The intention here was to ensure that each Medical School in the UK devoted between a quarter and a third of their undergraduate medical curriculum to components where students could exercise choice in areas of specialisation. In practice, the majority of students choose their SSC projects from an available list of clinically related projects, although in some cases the student may self-propose the topic of the project and approach a clinician who is considered to have considerable expertise in the corresponding field. They may also choose to carry out their project work outside their normal place of study. The GMC has placed an emphasis on the unique capacity of these projects to allow students to have greater control over their own learning and become more autonomous learners. Nevertheless, whilst these projects provide manifold opportunities for developing statistical skills, one cannot assume that the quality of student autonomy is automatically transferable from the chosen clinical field of study to the learning of statistics.

Indeed, without some early guidance, students, more out of naivety than indolence, can expect to arrive for their first consultation armed with the solitary question – here is my data; how do I analyse it? In making this query, the student is already assuming that the statistical component of their project is a separate entity to be tagged onto their project proper and that the imagination of the statistician may prove an asset in putting the final icing on the cake when the project report is presented for assessment.

In this common scenario, the fledgling teacher of medical statistics may be confronted with a plethora of powerful forces enticing them to meet the student's perceived need. At this stage, it is extremely tempting to offer suggestions as to meaningful associations to test for and effective and

efficient means of presenting relationships graphically. If student autonomy is to be realized, this temptation is best eliminated by a pragmatic approach rather than conquered by mere will power.

The author has developed a *structured electronic booking form* with individual sections for students to complete when requesting their first appointment. By means of these sections, the student is invited to specify their own support needs (thus requiring them to consider in advance what they anticipate getting out of their appointment). They are also advised to provide a comprehensive project summary, specifying their key objectives and hypotheses. The success of this intervention has been enhanced by the inclusion of an exemplar request form within the system. The electronic form, which has been developed with the support of an experienced Learning Technologist, is designed to arrive via email as an MS Word document and thus in a suitable format for future updating and editing by the statistician during consultations. On submission of the form, the student also receives an automatic reply providing them with their personal electronic copy.

The statistician is then in a position to advise the student in advance of their appointment if further information is required or if the style in which the project details have been presented is inadequate for a meaningful discussion. Furthermore, the project details provided are often an indicator to the statistician as to which eLearning resources the student can engage with in advance of their first appointment, thus making the student *accountable* for their own learning at the earliest possible stage. The scene is therefore set for a productive first session in which the student can be encouraged to set the agenda regarding the subject matter and priorities for the meeting, including addressing any issues which may have arisen during their preparatory work, and the statistician is less likely to be coerced into defining or redefining the project for the student.

The above intervention also equips the medical student with lifelong learning skills in preparing for statistical consultations within contexts where there is a need for the input of a professionally trained statistician.

Make use of readiness for autonomous learning inventory to assess the preparedness of students for self-directed learning

For multifarious reasons, students vary considerably in their individual degrees of self-direction (Pratt 1988). There is a corresponding need to assess the level of pedagogical groundwork that requires to be performed to successfully direct the learner towards greater autonomy.

The Self-Directed Learning Readiness Scale (SDLRS) was designed in 1977 (Gugielmino, 1977) as a mechanism for quantifying adult readiness for self-directed learning. Since then, its construct validity has been confirmed through numerous studies involving a wide variety of cohorts of adult learners and different statistical techniques (MacDougall, 2008). The score forthcoming from this inventory is categorized into five classes from low to high, relating to the readiness of the individual for self-directed learning. Based on prior research, it is also regarded as a measure of preparedness for activities involving a high degree of problem solving, creativity or change. The SDLRS can serve as a diagnostic test for the educator to identify students who are likely to exhibit resistance or disorientation when confronted with a learning programme which requires a high or even moderate level of personal self-management. Within this context, SDLRS scores ought to be used as a basis for staff-student discussions on the rationale behind autonomous learning. Such discussions can help in erasing any misconceptions, often based on cultural and prior educational norms, that the student may have regarding the responsibilities of the educator.

The need for adaptations to the SDLRS in assessing readiness of medical students for self-directed learning in statistics is implicit from Little's observation that 'the learner who displays a high degree of autonomy in one area may be non-autonomous in the other.' (Little, 1991) Furthermore, based on studies involving Exploratory Factor and Principal Components Analyses, there have been some more recent concerns expressed as to what construct the SDLRS is actually measuring and in particular, whether its specificity is sufficiently high to distinguish between the attributes of openness to learning and readiness for *self-directed* learning. Also, with a view to avoiding acquiescence bias, some of the inventory items have been designed so that response categories are reverse scored. However, there is evidence to suggest that this feature of the inventory is producing a method factor which can in turn cause the final scores to be inaccurate. (Hoban et al., 2005) There is therefore a tension between avoiding acquiescence bias in responses

and method variance in the measured score which invites a more thorough investigation in re-designing this inventory. Moreover, it has been observed elsewhere that "the ability and motivation to be self-directed varies with the context of learning". (Greveson & Spencer, 2005) Therefore, to optimize the use of such a scale in improving student learning it is advisable to ensure that it is itemized to capture the specific types of task to be performed (for example, defining the study questions for a research project or identifying what extra information is required for responding to a simulated patient scenario presented in a Problem Based Learning (PBL) session). It is important, however, that the level of specificity of the inventory is not so high as to preclude its utility beyond the level of an individual institution. These observations point to the scope for collaborative research between educators with a view to designing a revised version of the SDLRS specifically for use in the teaching of undergraduate medical students.

Involve the student in the design of online resources

In preparing statistical eLearning resources to meet the multifarious interests of undergraduate medical students, there is likely to be a need for ongoing expansion of these resources. This is particularly so within the context of programmes involving students as researchers, given the individuality of each student project. There is therefore a corresponding need to compartmentalize these learning materials in such a way that the inexperienced learner is able to filter out relevant material. A possible solution is the use of FAQ knowledgebases. However, even where these are neatly subdivided according to topic, there is still great scope for knowledge overload if the learner is insufficiently well-versed in statistics to know why the resources they require ought to fall under particular topics. In turn, student autonomy may be severely impaired by the need for the learner to consult the statistician for detailed instructions mapping their study questions to the appropriate resources. Thus, if online knowledgebases are to serve their original purpose of allowing the educator to use their time more efficiently, more work needs to be done to assist the student along the pathway towards more autonomous learning.

Such observations have prompted the author to lead an initiative at the University of Edinburgh (henceforth "Edinburgh") to develop an online searchable indexing system for use within EEMeC (Edinburgh Electronic Medical Curriculum), which is the web-based virtual learning environment for the Edinburgh Undergraduate Medical Programme. The index is designed for use with several online statistics resources which she has designed, including sections on *How to Get Started* with statistics and *Frequently Asked Questions on Statistical Design and Analysis*. Students are able to input their own queries through key word searches and to receive in return a window of URLs to address these queries. The search engine is not restricted to listed terms but also facilitates free text searching for alternative terms. Free text searching generates a corresponding window of URLs provided that during the design of the index, these terms have already been specified as being related to one or more of the listed terms. However, students are also encouraged to regard the index as being mutually constructed by the educator and the learner. In particular, free text search options are linked to an automatic reply message for failed searches encouraging the learner to specify terms they would like to see added to the online lists of index terms. By way of ensuring that student activities serve as a basis for the design of this index, records of failed searches are also automatically stored by the indexing system and subsequently used by the author of this paper to update the existing list of search terms.

The need to fine-tune the FAQ system and the searchable indexing system to enhance student autonomy is most apparent as students approach their submission deadlines. A common student problem here is that of knowing how to translate statistical jargon into a meaningful evidence base to answer clinical research questions. Thus, links to tutorials including instructions for applying statistics and related software in problem solving ought to be complemented with clinically contextualized examples which distinguish between statistical and clinical significance and highlight the importance of confidence intervals in pinpointing the accuracy of study findings. It should then be possible for the learner to draw suitable analogies for use with their own clinical problems without the additional input of a 'translator'. More generally, questions sent via email by students can be viewed as an opportunity for educator creativity in identifying clinically meaningful scenarios for presenting statistics. Thus, where time allows, the author also redesigns existing eLearning resources to integrate the enquirer's own research topic with a corresponding

FAQ in statistics. This approach ought to pay dividends in empowering future students to explore and choose possible approaches to solving their own clinical problems. Moreover, through pointing existing students to the updated resources, the educator can remind them implicitly of the expectation to rely on these resources, thus preventing an overflow of inappropriate requests by email, particularly as students approach the finishing line.

Strive to negotiate for curriculum innovations

The credibility of the statistician's recommendations to students to exercise autonomy in the learning of statistics is typically challenged by the fact that the study of statistics is not likely to be of interest to aspiring clinicians on entry to Medical School. Undergraduate medical students do, however, have a keen interest in learning outcomes, particularly since these are perceived as an indicator of likely assessment criteria and of the competencies which define the successful practitioner. It is therefore critical for teachers of statistics to work with clinical teachers in ensuring that course learning outcomes give precedence to developing autonomy in statistical skills when stressing the need for critical thinking in medicine. Furthermore, as is the case at Edinburgh, the Learning and Teaching Strategy for the Medical School as a whole ought to explicitly acknowledge the skills of critical appraisal, experimental design and statistical analysis which the statistician is endeavouring to cultivate. Opportunities for progress in these areas are most likely to occur where teachers of statistics are involved in collaborative educational research with course organizers in the evaluation of assessment and learning methodologies across the curriculum. Within medical schools, there is considerable pressure from regulatory bodies, such as the GMC, to maintain "high standards of medical education" whilst ensuring that students develop strong critical appraisal skills and the ability to critically analyze clinical data (GMC, 2009). Correspondingly, curriculum managers are required to deliver concrete evidence for justifying their choices of teaching and assessment methodologies. Statisticians ought to recognize these needs as openings for developing strong partnerships with clinical teachers and curriculum managers through the design and application of new statistical methods for evaluating clinical courses. Opportunities can then arise more naturally for recommending how statistical learning can be incorporated throughout the curriculum to enhance students' critical thinking skills.

Corresponding ideas for curriculum innovation ought to provide opportunities for cultivating skills in autonomous learning in early years. For example, group learning activities within existing PBL courses can serve as an opportunity for fully integrating statistical and clinical learning. Online communities of learning can then be used as an impetus for students to engage with statistical resources as a means of identifying how best to tackle the clinical cases that have been presented to them in classes.

Through more active participation in these communities in early years, the teacher of statistics has considerable scope for nurturing students into the process of learning the language of statistical discourse. Relevant areas include defining research questions and hypotheses with adequate precision and tackling statistical terminology in publications which students have themselves retrieved on researching the literature. The value of such communities in conquering anxiety towards statistics has also been recognized elsewhere within the context of teaching statistics to social scientists. (Macheski et al., 2008) Tackling obstacles, including linguistic and psychological barriers, in the learning of statistics in early years ought to improve student readiness for autonomous learning in later years. Moreover, the student-centered educator ought to view the above activities as opportunities for identifying common conceptual misunderstandings among and for adapting resources accordingly in anticipation of these problems recurring with future students.

In order to engage students optimally at this stage it is necessary to design resources which involve a more interactive approach to learning statistics than that which might be possible through the use and application of statistical knowledgebases alone. Therefore, in addition to the eLearning resources discussed above, the author has led several funded projects over a number of years to develop eLearning materials to meet this need. The new resources include modules on confidence intervals, summary statistics and a wide range of topics relating to Evidence-Based Medicine and the interpretation of patient risk. The modules include interactive learning objects and clinically contextualized examples and exercises as formative assessment with immediate feedback to students. All modules are subdivided into chapters to support future mapping of the contents to

statistical learning outcomes in each year of the undergraduate medical curriculum. Module content has been informed by the author's research into the statistical learning needs of undergraduate medical students, including dyslexic students (MacDougall, 2009a) and needs she has encountered through her teaching. (MacDougall, 2009b)

Future curriculum innovations will rely on feedback from clinical staff and students on the relevance of these materials to clinical learning within the Edinburgh undergraduate medical curriculum and to working practices of graduate physicians across a wide range of specialities.

CONCLUSION

Ironically, autonomous learning does not take off autonomously but rather, is dependent on the initiative of the educator. Within the context of teaching statistics to undergraduate medical students, there is incredible scope for addressing the mismatch between students' prior experiences in learning statistics and the role of the educator as a facilitator. However, the teacher of statistics ought to pursue opportunities to collaborate with programme managers in multidisciplinary educational research projects so as to take a more informed and effective approach to raising the profile of statistics throughout the undergraduate medical curriculum.

REFERENCES

Altman, D. G. (2002). Poor-quality medical research: What can journals do? *Journal of the American Medical Association, 287*, 2765-2767.

Benson, P., & Voller, P. (1997). Introduction: Autonomy and Independence in Language Learning. In P. Benson & P. Voller (Eds.), *Autonomy and Independence in Language Learning*. London and New York: Longman.

Bryson, C., & Hand, L. (2007). The Role of Engagement in Inspiring Teaching and Learning. *Innovations in Education and Teaching International, 44*, 349-362.

GMC (1993). Tomorrow's Doctors: Recommendations on Undergraduate Medical Education. London: General Medical Council. Online: www.gmc-uk.org/education/undergraduate/GMC_tomorrows
_doctors.pdf.

GMC (2009). Tomorrow's Doctors: Outcomes and Standards for Undergraduate Medical Education. London: General Medical Council. Online: www.gmc-uk.org/static/documents/content/
TomorrowsDoctors_2009.pdf .

Greveson, G., & Spencer, J. (2005). Self-directed learning: The importance of concepts and contexts. *Medical Education, 39*(Editorial).

Gugielmino, L. M. (1977). *Development of the Self-Directed Learning Readiness Scale*. University of Georgia: Doctoral Dissertation.

Hoban, J. D., Lawson, S. R., Mazmanian, P. E., Best, A. M., & Siebel, H. R. (2005). The Self-Directed Learning Readiness Scale: A Factor Analysis Study. *Medical Education, 39*, 370-379.

Little, D. (1991). *Learner Autonomy: Definitions, Issues and Problems 1*. Dublin: Authentik Language Learning Resources Ltd, Trinity College.

Macheski, G. E., Lowney, K. S., Burhmann, J., & Bush, M. E. L. (2008). Overcoming Student Disengagement and Anxiety in Theory, Methods, and Statistics Courses by Building a Community of Learners. *Teaching Sociology, 36*, 42-48.

MacDougall, M. (2008). Ten Tips for Promoting Autonomous Learning and Effective Engagement in the Teaching of Statistics to Undergraduate Medical Students Involved in Short-Term Research Projects. *Journal of Applied Quantitative Methods, 3*(3), 223-240.

MacDougall, M. (2009a). Dyscalculia, Dyslexia and Medical Students' Needs for Learning and Using Statistics. *Medical Education Online, 14*(2).

MacDougall, M. (2009b). Statistics in Medicine: A Risky Business? *MSOR Connections, 8*(4), 11-15.

McKee, A. (2002). Evidence-Based Practice in Health Sciences. *Exchange, 3*, 19-20.

Pratt, D. D. (1988). Andragogy as a Relational Construct. *Adult Education Quarterly, 38*, 160-181.

Ramsden, P. (1992). *Learning to Teach in Higher Education*. London and New York: Routledge.