Peter Samuels and Gareth Williams

Developing students' self-efficacy through mathematical study skills resources

Peter Samuels
sigma Centre for Excellence in Mathematics and Statistics Support
Coventry University
p.samuels@coventry.ac.uk

With a contribution from Mary Deane
Centre for Academic Writing, Coventry University

Gareth Williams
Mathematics and Statistics Department
The Open University
g.r.williams@open.ac.uk

1. Introduction

Many academics in higher education (HE) are faced with the challenge of providing students with supplementary support beyond the learning and teaching material associated with a module or course. There are various reasons why students benefit from learning development that is connected with, but provided outside of their modular studies. For example:

1. ***Some students appreciate the stimulation of extra learning material, particularly if they aspire to achieve high grades at university;***
2. ***Some students benefit from material that takes a different approach or gives more detailed guidance, particularly when they are struggling with particular aspects of a course; and,***
3. ***Many students whose first language is not English value additional resources to guide them in adopting the discourse and conventions associated with their chosen discipline.***

This article describes a case study of the development of mathematics support study skills resources by **sigma** and The Open University which has resulted in the provision of twelve single-page leaflets now freely available from the **sigma** website (see section 5.5 for details).

The article begins by exploring the concepts of self-efficacy and study skills in mathematics. It then examines the key characteristics of contemporary tertiary level learners and explores the provision of learning resources in the UK HE sector. The resources produced by **sigma** and The Open University and their production methodology are then examined. Finally, key issues and future directions for resource development are identified.

2. Mathematics self-efficacy and study skills

The availability of resources to support students in HE has increased significantly in recent years [1]. This arguably reflects a growing demand, particularly in relation to the range of academic literacies tertiary level students are expected to acquire [2]. In particular, adaption to contemporary learners' preferences has led to a shift from textbooks to more accessible resources such as web pages, downloadable leaflets and video clips [3]. It has been recognised that developing learners' literacies can help to reduce dependence on learning support tutors, and that instruction in critical thinking is most effective when grounded in the relevant contexts [4].

This article reports on a collaborative development between **sigma** and The Open University of contextualised, accessible resources mathematics study skills [5]. The

purpose of providing mathematics study skills support is to develop learner self-efficacy. Mathematics self-efficacy has been defined as "individuals' judgments of their capabilities to solve specific math problems, perform math-related tasks, or succeed in math-related courses" [6]. Several research studies have indicated that an effective route to improving self-efficacy is by teaching specific learning strategies [7], although the authors are not aware of any specific research into the connection between mathematics self-efficacy and mathematics study skills support.

3. Characteristics of contemporary tertiary learners

The characteristics of contemporary learners in HE are here described in two ways. Firstly, Prensky coined the term Digital Natives to describe contemporary learners born after about 1980 [3]. He describes Digital Natives in the following way:

Today's students – [from primary school to university] – represent the first generations to grow up with this new technology. They have spent their entire lives surrounded by and using computers, videogames, digital music players, video cams, cell phones, and all the other toys and tools of the digital age. Today's average college grads have spent less than 5,000 hours of their lives reading, but over 10,000 hours playing video games (not to mention 20,000 hours watching TV). Computer games, email, the Internet, cell phones and instant messaging are integral parts of their lives.

It is now clear that as a result of this ubiquitous environment and the sheer volume of their interaction with it, today's students think and process information fundamentally differently from their predecessors. These differences go far further and deeper than most educators suspect or realize.

Secondly, according to a summary of recent research studies carried out by the Join Information and Systems Committee [8], the main characteristics of contemporary learners' approaches to new technologies are:

Learning in a digital age - Using technologies in all aspects of their studies, today's digital learners rarely see e-learning as a separate or special activity. They are adept at blending personal and institutionally owned technologies with traditional approaches to learning in ways that are unique to them.

Communication and networking – Technology supports a continuum of social interaction, increasing learners' ability to network with their peers and communicate with their tutors.

Concerns – Some learners find difficulties with asynchronous communication, others indicate a need for more assistance with the technologies they use in assignments, and the digital divide remains a potent concern.

Benefits – Learners also find significant advantages in using technology. These differ according to the individuals' perspectives, but increased choice, ease of access to information and control over when and how they learn are highly valued.

Whilst not all learners can be characterised as Digital Natives, most teaching and learning interventions are not designed with Digital Natives' needs in mind. It is therefore believed that there is significant scope for designing study skills resources which attempt to cater for them. In particular, short multi-media accessible online resources are promoted as being more appropriate than textbooks for contemporary learners.

Student demographics mean that The Open University has a relatively lower proportion of Digital Natives than traditional, face-to-face, institutions. Yet the remote nature of study with The Open University demands that resources should be accessible and in as many formats as possible, to cater for individual student needs.

4. Mathematics study skills resources

A recent naïve Google [9] search for the term "study skills" by one of the authors produced in excess of fifty million results. Taking a more traditional route, entering the same phrase in The Open University's library catalogue system [10] generated 416 results. These simple searches indicate that there is a wealth of resource, readily available to learners at all stages of their education.

Much of these resources are devoted to skills which are relevant to study in a generic sense. One of the most popular is by Martin Greenhow of Brunel University [11]. There is sage advice ranging from preparation of a suitable environment for study to time management, from exam technique to note-taking in lectures. However [4] makes the argument for contextualised study skills resources - that is, material written with a specific academic discipline in mind.

For the academic discipline of mathematics, contextualised study skills resources do exist, but are far less common than their generic study skills counterparts. Texts such as [5] and [12] offer contextualised study skills support in mathematics, and are being supplemented by online resources, such as The Open University's mathematics study skills website [13]. Yet typing "mathematics study skills" into the Google search engine [9] produces, typically, links to handouts from mathematics departments of individual Higher Education

Institutions (HEIs), for instance [14]. These naturally discuss material relevant to the appropriate HEI (for instance, supervision arrangements) but are less relevant to students elsewhere.

There exist various online resources to support students of mathematics and other numerate disciplines. Often these are available freely, and are viewed as highly accessible by many students. Table 1 presents a selection of some such resources.

5. sigma's collaboration with The Open University

5.1 History and rationale

Inspired by some process-orientated academic writing support leaflets produced by Coventry University's Centre for Academic Writing [20], **sigma's** initiative to develop contextualised accessible, mathematics study skills resources began in 2007 by identifying existing mathematics study skills websites in UK HE (given in Table 1) and contacting the site authors or named contacts along with other known researchers and developers in the field with a view to establishing a small development community (which later took the form of an informal steering group). This led to a dialogue with several academics at The Open University which developed into a formal **sigma** secondment proposal. The secondment involved the two authors working together on a matched time basis.

The collaboration between **sigma** and The Open University came into being to serve a dual purpose. Firstly, it was an attempt to supplement the widely available content-based resources with contextualised study skills resources, accessible to HE entry-level students of mathematics or other numerate disciplines. Secondly, it was an attempt to promote self-efficacy in these students, so that they may become successful independent learners. In particular, a student's study can often be interrupted when he or she encounters difficulty at a time when a tutor is not available to provide physical support. By developing associated study skills, it is hoped that the resources resulting from the collaboration will help to overcome this barrier.

5.2 Identification of topics

In collaboration with the author of [5], areas of particular student difficulty were identified. A 'broad spectrum' approach was chosen in order to cater for university entry students (i.e. both foundation and first year), both mathematics specialists and non-specialists. About a dozen suggestions for leaflets resulted which evolved into the list below.

- Creating examples;
- Taking mathematics apart;
- Proof – what is the game?;
- Unpacking symbols;
- Writing mathematics well;
- Assessment;
- Learning to do algebra;
- Using diagrams;
- Handling your emotions;
- Approaching numeracy as an adult;
- Mathematical problem solving;
- Getting to grips with statistics;
- Mathematical reading; and,
- Using technology.

The first eleven leaflets were produced by the authors. The leaflet 'getting to grips with statistics' was commissioned and developed by David Bowers from University Campus Suffolk. The final two leaflets are yet to be produced.

5.3 Content and aims of leaflets

Each resource produced was subject to the aims below:

- contained on a single sheet of paper and also in an online format (pdf);
- focussed on associated study skills, and not on specialised mathematical skills;

Institution	Description	Reference
University of Cambridge	A pdf document on mathematics study skills specifically relating to the University context.	[14]
University of Hull	A repository of resources which are mainly downloadable and printable and mainly content orientated but including leaflets on maths phobia and maths study skills.	[15]
London School of Economics	A single page website with advice on studying mathematics.	[16]
The Open University	This site focuses on some core skills needed to succeed in studying mathematics (rather than focussing on mathematical content itself). The site is freely available but is aimed at Levels 2 and 3 mathematics undergraduates, without provision for lower level students.	[13]
mathcentre	A comprehensive site with sections for staff and students, feely available material including leaflets, booklets, exercises, video clips and external links. Material is largely focussed on mathematical content rather than associated study skills, and is aimed at post-16 mathematics help.	[17]
mathtutor	Strongly linked to [15], this site aims to bridge the gap between school and university, and offers video tutorials. These are available in DVD format or can be viewed (freely) online. The site also contains some resources for use with iPod technology. Again, material is largely focussed on mathematical content.	[18]
University of Southampton	A single page website on mathematics study skills divided into 10 sections.	[19]

Table 1 - Some UK HE online mathematics support resources

- grounded in context, with examples to demonstrate points being made;
- accessible to independent learners with activities to stimulate engagement; and,
- to promote accessibility, each leaflet follows the same format, with visual icons to identify areas containing advice, activities, and examples. Fig 1 illustrates the style.

In Fig 1, an example is provided to demonstrate that students need to answer the question to succeed in assessed work. The example consists of some mathematics (a combination of Pythagoras' theorem and elementary trigonometry). This serves to provide context, allowing students to see where their study skills must be applied. The resource does not attempt to teach students how to use Pythagoras' theorem or trigonometry.

Fig 2 shows another typical feature of the resources: the use of activities to engage the student. The resource makes no attempt at teaching differential calculus to the student, but provides an example in the context of differentiation. Moreover, in case some students are de-motivated by calculus, the activity encourages the student to try the same thing with work of their own.

Fig 3 shows a resource making students aware of the different styles of mathematical problems, and goes on to discuss skills for solving each. The resource aims to help students identify which skills to apply, appropriate to the style of problem, even if on a first reading they do not understand the mathematical content of the problem.

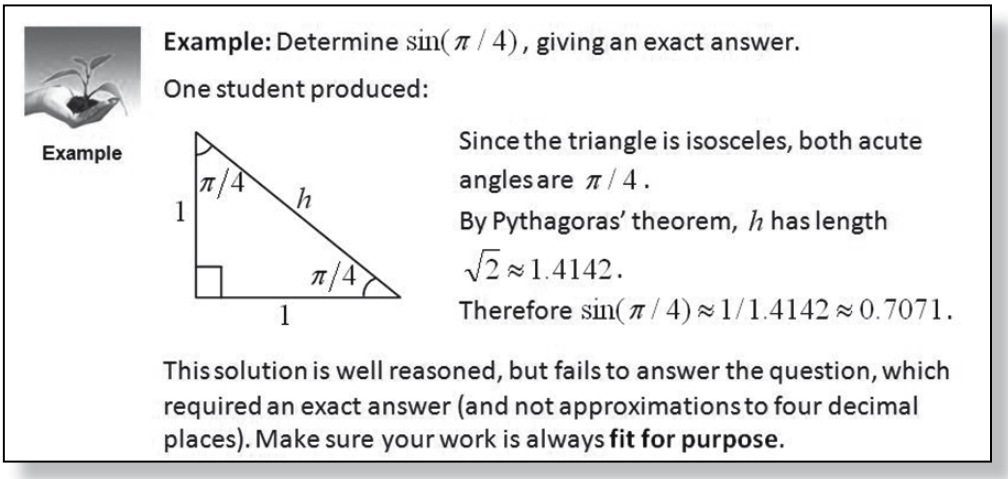

Fig 1 - Extract taken from the *Assessment* resource

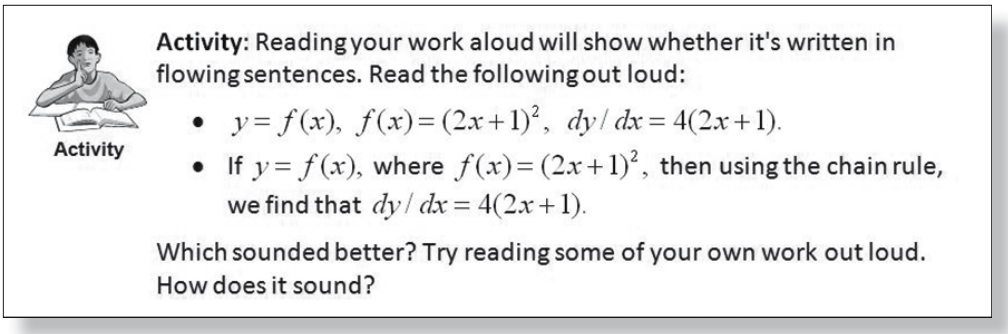

Fig 2 - Extract taken from the *Writing mathematics* well leaflet

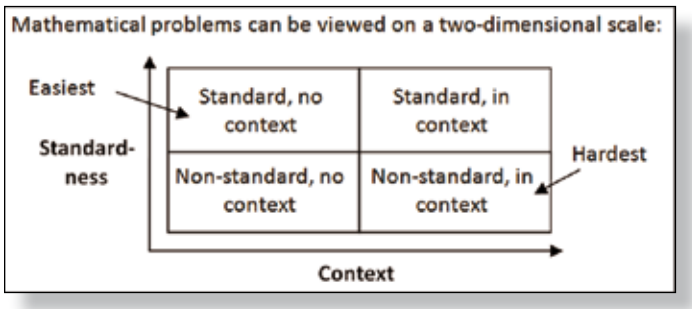

Fig 3 - Diagram taken from the Mathematical problem solving leaflet

5.4 Production and trialling of resources

The authors found the most productive way of writing the resources to be several short but intense face-to-face collaborations. Working in this way, each leaflet required approximately eight hours of concentrated effort. A sample of students at Coventry University was exposed to a selection of the resources in 2008. Feedback was generally positive, in particular:

- Students are unaware of the importance of contextualised study skills and hence may struggle to overcome associated barriers;
- The visual icons were well received by some students but the majority did not feel strongly about them. Accordingly, their inclusion appears harmless; and,
- Students resisted engaging with the activities, but when pressed to do so, found they made valid points which the students had not previously considered. This serves to reinforce the importance of engaging activities, and also highlights the challenge of persuading students to engage.

5.5 Availability and future directions

The study skills resources are currently available via the **sigma** website (http://www.sigma-cetl.ac.uk – choose Resources from the top menu then select Maths Study Skills Leaflets).

The future plans are to produce the remaining two leaflets (on mathematical reading and using technology), trial out the leaflets further and produce short (approximately 5 minute) video clips covering each leaflet.

6. Conclusions

This article has described the need for providing mathematics study skills resources and has analysed samples from a range of resources produced by **sigma** and The Open University to enhance students' self-efficacy in studying mathematics.

The aim of this provision is to encourage students to reflect upon how they approach academic work in order to become more effective in managing their time and resources and become more proactive in approaching tertiary level study.

The resources which are now freely available cover a broad spectrum of topics and levels. They have the potential to assist the mass of students in need of mathematics study skills support in UK HE.

References

1. MacArthur, C. A., Graham, S., and Fitzgerald, J. (2008), Handbook of Writing Research, London: Guilford Press.
2. Lea, M. and Street, B. (1998), 'Student Writing in Higher Education: an Academic Literacies Approach.' Studies in Higher Education, 23(2): 157-72.
3. Prensky, M. (2001), Digital Natives, Digital Immigrants, On the Horizon, 9(5): 1-2.
4. Gottschalk, K. and Hjortshoj, K., (2004), The Elements of Teaching Writing: A Resource for Instructors in All Disciplines, Boston: Bedford/St. Martins.
5. Kahn, P. (2001), Studying Mathematics and its Applications, Basingstoke: Palgrave.
6. Betz, N. E., and Hackett, G. (1983), The relationship of mathematics self-efficacy expectations to the selection of science-based college majors, Journal of Vocational Behavior, 23: 329-345.
7. Margolis, H., and Mccabe, P. P. (2006), Improving Self-Efficacy and Motivation: What to Do, What to Say, Intervention in School and Clinic, 41(4): 218-227.
8. JISC (2007), "In Their Own Words: Exploring the learner's perspective on e-learning", HEFCE, Bristol.
9. Google. Available via: http://www.google.co.uk [Accessed 26 October 2009].
10. The Open University: Voyager [Open University Library catalogue]. Available via: http://voyager.open.ac.uk/ [Accessed 26 October 2009].
11. Greenhow, M. (2009), Study Skills Online website. Available via: http://people.brunel.ac.uk/~mastmmg/ssguide/sshome.htm [Accessed 26 October 2009].
12. Northedge, A., Thomas, J., Lane, A. and Peasgood, A. (1997), The Sciences Good Study Guide, Milton Keynes: The Open University.
13. The Open University: Mathematical Study Skills website. Available via: http://maths-study-skills.open.ac.uk/ [Accessed 26 October 2009].
14. University of Cambridge: Study Skills in Mathematics [online pdf document]. Available via: http://www.maths.cam.ac.uk/undergrad/studyskills/text.pdf [Accessed 26 October 2009].
15. University of Hull: Study Advice Service website. Available via: http://www.hull.ac.uk/studyadvice/MathsResources/index.html [Accessed 26 October 2009].
16. Anthony, M, London School of Economics: Study Skills for Mathematics and Statistics website. Available via: http://www.maths.lse.ac.uk/studyskills.html [Accessed 26 October 2009].
17. mathcentre website. Available via: http://www.mathcentre.ac.uk/ [Accessed 26 October 2009].
18. mathtutor website. Available via: http://www.mathtutor.ac.uk/ [Accessed 26 October 2009].
19. University of Southampton: Study Skills for Mathematics website. Available via: http://www.soton.ac.uk/maths/currentstudents/csstudy.html [Accessed 26 October 2009].
20. Coventry University: Centre for Academic Writing website. Available via: http://www.coventry.ac.uk/cu/caw [Accessed 26 October 2009].

Editorial comment:

We would like to the make MSOR Connections readers aware that the Maths, Stats & OR Network is providing funding and support for the development of a maths-focus to the Martin Greenhow study skills website mentioned in the article. For more info on the proposed developments, please visit:

http://mathstore.ac.uk/index.php?pid=172

The Network has also recently released a study skills leaflet for undergraduate students which has also been written by Martin; for further details please visit:

http://www.mathstore.ac.uk/index.php?pid=276