MATHS BY EMAIL: AN AUSTRALIAN INITIATIVE TO IMPROVE STUDENTS' ENGAGEMENT IN MATHEMATICS

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Maths by Email is a free fortnightly email publication, published since March 2010 by Australia's premier scientific research organisation (CSIRO: the Commonwealth Scientific and Industrial Research Organisation). (See Endnote 1.) While the publication is directed in the first instance at students aged 9-13 years, who are considered to be in their formative years regarding future career directions, it has also been constructed to inform mathematics teachers, future mathematics teachers and undergraduates about the nature and significance of mathematics. *Maths by Email* (*MbE*) is sent to direct email subscribers only; subscriptions are not limited to residents of Australia. The publication was sponsored initially by the Australian Mathematical Sciences Institute (a consortium of mathematics departments in research universities) and the federal Australian Government Department of Education, Employment and Workplace Relations (DEEWR). Australian curricula over all years of schooling routinely include the study of statistics every year as part of the mathematics curriculum for almost all students; accordingly, in 2011, the Australian Bureau of Statistics also become a sponsor and the publication changed title to *Maths and Stats by Email*, although this paper focuses on the first year of operation, for which data are available.

A major rationale for the initiative was in response to increasing concerns in Australia that students are not attracted to careers involving mathematics and other areas requiring substantial mathematical study at the college level. Similar concerns have been apparent in other western countries, including the UK and the USA, for many years, which has lead to serious shortages of adequately qualified secondary school mathematics teachers in many countries. So the principal aim of MbE is described by the publishers as "to communicate that mathematics is making a valuable contribution to the community, is relevant, beautiful, interesting and enjoyable and provides many employment opportunities." This aim is clearly concerned with affecting the attitudes of subscribers towards mathematics in several ways. The main target audience comprises students aged 9-13, spanning primary and secondary school, with extension ideas provided for more advanced students where appropriate. It is recognised that other audiences might also benefit from the newsletter, including older students, parents and mathematics teachers. (See Endnote 2.) It was anticipated that parents and teachers might subscribe on behalf of students, and use the content with them at home or at school, as this is a common practice with *Science by Email*, a similar newsletter by the same publisher that has been published for more than ten years now.

The technology involved in the newsletter is generally restricted in the first instance to email and web browsers, which together are sufficient for reception of and engagement with the newsletter, including associated activities and resources, and are widely available in both

homes and schools in Australia. The mathematical content spans a wide range, including recent events with a mathematical character, although at a level suitable to a general audience. The newsletter includes hands-on practical activities involving mathematical ideas, developed to be accessible to middle and high school students, and thus of likely interest also to mathematics teachers, student teachers and teacher educators.

Maths by Email newsletters typically comprise several components: a short article about mathematics (maths in the news, news from the maths world or other content); a hands-on activity related to maths, using equipment from around the home and/or game boards and pieces provided in PDF format; web links to maths-related online content from other organisations as well as links to other mathematical content from sponsors; a brainteaser or puzzle; short maths 'facts'; events, competitions and sometimes other relevant information.

Although the main purpose of the evaluation was to provide independent feedback to the editors and publisher of the *Maths by Email* initiative to potentially improve the service and to inform decision-making regarding future plans for the service, this paper enlarges on that purpose, by summarising some evaluative information about this initiative to a wider audience. Specifically, the paper draws from the larger evaluation study to provide information regarding: who is using *MbE* and how it is being used; the effectiveness of the various components of *MbE* newsletters; use of the *MbE* newsletters by teachers; and the extent to which *MbE* is meeting its stated aims.

Literature review

The story of the first year of *Maths by Email*, as described in this evaluative paper, is situated (contextualised) across at least two disciplines (mathematics education and evaluation), and germane to perhaps as many as three distinct research literatures within maths education: informal or popular mathematics (e.g., Franklin & Peng, 2008; Kissane, 2009); attitudes and beliefs about mathematics and its relevance and roles in society (e.g., Aiken, 1976; Ercikan, McCreith, & Lapointe, 2005; Hannula, 2002; Hemmings, Grootenboer, & Kay, 2010); and, the delivery of mathematics education via "new media" (e.g., Fisch, 2004; Franklin & Peng, 2008). Although a comprehensive review of these literatures, and the ways in which they overlap relative to *Maths by Email*, is clearly beyond the bounds of this short paper, we nevertheless think some points drawn from these disciplines and their literatures are noteworthy, and perhaps helpful in framing and contextualising this work.

First, we are of the view that evaluation and research are different (Levin-Rozalis, 2003; Scriven, 1994) in the following important way (among others). The core business of research is to generalise, most often framed within the context of a conceptual or theoretical framework. Thus, the external validity of research (applicability of the study's findings to other similar situations) is of high importance. In contrast, the business of evaluation is to make judgements about merit (intrinsic value) and/or worth (value in context) of a particular product, project, program, policy or initiative against agreed-upon evaluative criteria, in large measure guided by the needs of the evaluation project's client. Issues associated with external validity are much less important than in conducting educational or social research

(Fitzpatrick, Sanders, & Worthen, 2004; Levin-Rozalis, 2003; Scriven, 1994). In keeping with these general parameters and purposes of evaluation, we designed the program evaluation to be responsive to our client's needs, and largely without a "theoretical framework" in the conventional research sense. That being said, however, the relevance of this evaluation's findings for mathematics educators, students and other stakeholders is in our view, hardly diminished. Indeed, Silver & Herbst (2007, p. 45) used some studies related to attitudes in mathematics to observe that "scholarship in our field includes some research that can be legitimately justified on the basis of the connection between practice and problems."

Second, a substantial corpus of research, developed over at least four decades, exists on learners' attitudes toward and beliefs about mathematics (e.g., Aiken, 1976; McLeod, 1992). From this expanding body of work it is clear that affective domain constructs such as attitudes and beliefs continue to be seen as important, in considerable part because of their longstanding empirical relationship as predictors of maths achievement, and by extension of future career opportunities (Ercikan, McCreith & Lapointe, 2005; Hemmings, Grootenboer, & Kay, 2010). Additionally, it is well established that "many people (children and adults) have negative attitudes towards mathematics, and these attitudes are seen as hindering mathematical learning and engagement" (Hemmings, Grootenboer, & Kay, 2010, p. 2). Importantly, in relation to the goals held for the *Maths by Email* initiative, it is also well established that attitudes are not simple or easy to change, and that at the group or class level, efforts to foster positive attitudes have generally been unsuccessful (Hannula, 2002). Additionally, the late elementary and early secondary school years have been cited as most critical to the sustainable development of positive attitudes toward maths (Aiken, 1976). It is clear that ameliorating attitudes towards mathematics is no easy matter.

Third, we readily acknowledge that mode of delivery typically makes a considerable difference in learners' perceptions in terms of enhancing or diminishing their views on the attractiveness and relevancy of any given subject matter (Fisch, 2004). Put another way, in the exploding use of new media (CDs, DVDs, software, internet, mobile devices, and most recently, smart phones) over the past 15 years, the medium has most certainly been an important part of the message. In the current case, for example, the newness of the initiative combined with its mode of delivery may have influenced subscribers' views about the service, and hence about maths. Nevertheless, in accordance with Fisch's (2004) advice and with client needs, both format and content issues were examined in this evaluation study.

Methodology

The evaluation of *Maths by Email* drew upon both analytical and empirical data sources. The empirical data comprised subscriber responses to two online surveys during the first calendar year of operation of the newsletter. These surveys (in the form of questionnaires) were designed to obtain information about matters of interest, including the novelty of the material and the accessibility of the material to the intended 9-13 year old audience. The first survey was conducted after only five issues had been distributed, to provide early feedback to the editors. The second survey was conducted later in 2010, and is the main data source here.

The surveys used on both occasions were similar, although small changes were made to the initial survey to produce the second survey. The most significant changes were concerned with capturing better the impressions of respondents to the various views about mathematics encapsulated in the newsletter's stated aims. It was recognised that there was insufficient information captured in the first survey, as it was likely that many subscribers already held positive attitudes towards mathematics.

The surveys were made available online at Murdoch University, Western Australia, via Murdoch's Institutional Research and Evaluation Services, and newsletter subscribers were invited to respond to them through a brief note in an edition of *Maths by Email*. In the first survey, there were insufficient responses to the invitation to respond to the survey in the two weeks immediately following the invitation so it was agreed that the deadline would be extended for another week, with the request to participate inserted again into the following edition, and that the publishers would send an email reminder of the request to participate to all subscribers. The effect of these actions was to generate sufficient responses by the end of May, 2010 (n = 586) for the survey to be closed. A matching process was followed in October/November, 2010, precisely mimicking the earlier time lines and methods of encouraging respondents, resulting in n = 902 responses.

All responses to the surveys were anonymous, with a mechanism in place to prevent more than one response coming from any one computer, so that it is assumed that each response represents the views of a single volunteer *MbE* subscriber, self-identified. It was anticipated that a suitably large sample would provide a range of feedback from various audiences likely to inform the evaluation, although it is also recognised that the sample unavoidably comprised volunteers and thus is not a strict random sample of subscribers. As identifying data were not sought, for reasons of confidentiality, it was not possible to compare directly individual subscriber responses to the two surveys; rather, the second survey is regarded as providing the more reliable data, since it is likely to be based on more published issues and a longer subscription period, and hence is less likely to include novelty effects.

Results

The results reported here are extracted from the final evaluation report, which is available for download from ERIC (Kissane & McConney, 2010). Space precludes a full treatment of questions of interest, so that data that provide some descriptive information as well as some aspects of subscriber responses have been selected for the present purpose.

Respondents. In all, 902 subscribers to *Maths by Email* responded to the invitation to complete the second online survey, out of a total subscriber base of 8122 at that time. Tables 1 and 2 summarise some demographic characteristics of respondents. As expected, the main respondents were teachers; in addition, about a quarter of parent respondents were home schooling parents, who also have a teaching role. While a plurality of respondents were most interested in the target age range, even more were interested in the secondary years, reflecting the original expectation for a wide audience.

Table 1. Self-reported primary roles of respondents

Teacher	Parents	Student	Other
52%	16%	16%	16%

Table 2. Respondents' levels of schooling reported to be of most interest

Upper Primary (age 9-12)	Early Secondary (age 12-14)	Upper Secondary (age 14-16)	Other	Total
346 (38.9%)	204 (22.9%)	217 (24.4%)	122 (13.7%)	889 (100.0%)

Respondents resided in all six Australian states and two territories, as well as overseas. (See Endnote 3.) A plurality of respondents (30%) reported living in Victoria, with somewhat smaller proportions in New South Wales (23%) and Queensland (18%), respectively. Yet smaller proportions live in South Australia, Western Australia and the Australian Capital Territory. Notably different from the other states and territories, for Victoria and to a lesser degree for Queensland, teachers appeared to outnumber non-teachers as respondents to the second survey and therefore also likely as subscribers. The proportions of survey respondents were essentially consistent with the proportions of subscribers in each state and territory as well as overseas, with two exceptions: survey respondents from Victoria and New South Wales over-represent their respective proportions in the subscribership, both by 6%. However, we are confident that the views of all subscriber groups, according to the region in which they live, were represented in the survey findings.

Newsletter components. Survey respondents were asked to indicate the component of *Maths by Email* newsletters they like most. Three of the components dominated responses to this question. Of the 789 subscribers who responded to this question, a plurality (33%) indicated their preference for the hands-on activities included with each newsletter. (See Endnote 4.) This was particularly so for those respondents who had indicated being most closely affiliated with upper primary schooling. The newsletter components second- and third- most liked were feature articles (30%) and brain teasers (24%), respectively. Here it is notable that, different from other groups, the component most liked by those affiliated with upper secondary schooling was the feature article.

Use of MbE by teachers. Some survey questions were restricted to teachers only to determine the extent to which they had used *Maths by Email* in educational contexts. A majority of teachers (51%) reported using the newsletter with others, *sometimes*. A further 31% of teachers overall reported using it with others *usually*, while 6% reported doing so *always*. A higher proportion (about 4 out of 10) of upper primary teachers reported using MbE with others *usually*, as compared to only about 3 out of 10 teachers associated with the other levels of schooling.

When asked to describe further the ways in which they used *Maths by Email* with other people, 214 teachers responded. The most common kind of use (129 responses) involved discussion with others (such as colleagues and students), with a further 78 responses describing how they used the subscription to pass on information in different ways (using

media such as email, noticeboards or school newsletters). While many teachers chose not to refer explicitly to particular components of the newsletter that they had used with other people, some did do so; of these, the most frequent reference was to the hand-on activities, followed by the brain teasers and the feature articles.

Specific advice was sought from teachers regarding their use of the hands-on activities. Just over half of the teachers reported that they 'sometimes' used the hands-on activities in their classrooms, and about half that many used them more frequently. Hands-on activities were more likely to be used with younger students (for whom they were designed by the newsletter editor).

Teacher respondents were also invited to elaborate on use of the newsletter with their students, with the following prompt question: "Please describe briefly a specific example of your use of *Maths by Email* with students, including your impressions of how it went." This question generated a wide range of responses, with varying levels of detail provided, so that it is not always explicit which components of the newsletter were used, the age of the students concerned, the duration of the example, and so on. Of the 113 responses that did include an evaluative comment, however, 21 were interpreted as 'very positive', 83 as 'positive' and the remaining nine as 'mixed'.

Meeting the goals of MbE. As noted on the first page, the principal aim of the newsletter was to communicate positive messages about various aspects of mathematics, and thus to positively affect attitudes about mathematics, particularly (but not only) in the target audience of middle years students. The survey data from the first questionnaire were mostly positive in these respects, but did not tap sufficiently well the nature of subscriber-respondents' attitudes before and after subscription to *Maths by Email*. The later survey was adjusted to provide more information of this kind, which is reported here in some detail, in view of the significance of the issues involved.

Maths-related careers. Table 3 summarises reported opinions regarding maths-related careers of respondents prior to subscribing to *Maths by Email* and at the time of the second survey. The subscription duration involved for individuals is not known, but is at most about seven months.

Table 3. Respondents' opinions on maths-related careers before *MbE*, and currently.

Opinion on maths-related careers before *MbE*	Opinion on maths-related careers currently (October 2010)			Total
	more negative	not changed	more positive	
Negative	1 (6.7%)	4 (26.7%)	10 (66.7%)	15 (100%)
Neutral	2 (0.9%)	99 (46.3%)	113 (52.8%)	214 (100%)
Positive	2 (0.4%)	315 (59.4%)	213 (40.2%)	530 (100%)
Total	5 (0.7%)	418 (55.1%)	336 (44.3%)	759 (100%)

The row percentages suggest that very few opinions seemed to be negatively impacted by *MbE*, while 44.3% of respondents reported a more positive view about careers related to maths by October 2010 than they did prior to subscribing. While data are not available, it seems reasonable also to infer that a substantial proportion of the 59.4% of respondents whose views were positive, and did not change to be more positive, results from their views being so positive at first that there is little room left for change (i.e. a ceiling effect).

The relevance of maths. Table 4 summarises reported respondent opinions regarding the relevance of maths prior to subscribing to *MbE* and at the time of the survey. For this survey question, fully 85% of subscriber-respondents reported positive views on the relevance of mathematics prior to their subscription to *MbE* (no doubt accounting in part for the decision to subscribe). Despite the large proportion of initially positive views, however, more than 5 of 10 (53%) respondents overall also perceive that their opinions regarding the relevance of maths became more positive as a result of *MbE*. Another 46% reported no change in their opinions on the relevance of maths. In addition, 86% (all but 2 out of 14) of respondents whose initial opinions regarding the relevance of maths were negative experienced a more positive change as a result of *MbE*. Additionally, three out of four respondents whose opinions were initially neutral and one of two respondents whose opinions were initially positive, experienced more positive changes resulting from their *MbE* experience.

Table 4. Respondents' opinions on the relevance of maths before *MbE*, and currently

Opinion on relevance of maths before *MbE*	Opinion on relevance of maths currently (October 2010)			Total
	more negative	not changed	more positive	
Negative	1 (7.1%)	1 (7.1%)	12 (85.7%)	14 (100%)
Neutral	0 (0.0%)	23 (23.0%)	77 (77.0%)	100 (100%)
Positive	5 (0.8%)	327 (50.9%)	310 (48.3%)	642 (100%)
Total	6 (0.8%)	351 (46.4%)	399 (52.8%)	756 (100%)

Overall, it is not surprising that a substantial majority of subscribers held positive opinions about the relevance of mathematics before subscribing; nevertheless, the newsletter's influence has generally been toward more positive or unchanged opinions for essentially all subscribers. Only 6 out of 756 respondents to this survey item reported views about the relevance of maths that were more negative than before experiencing *Maths by Email*.

The beauty of maths. Third in this sequence of questions, survey respondents were asked to rate the influence of *MbE* on their opinions regarding the beauty of maths. In this case, as detailed in Table 5, of 754 respondents to this survey question, about 7 in 10 (68%) reported positive views regarding the beauty of maths before their *MbE* experience. Overall, 28% reported initially neutral views about the beauty of maths.

By October 2010, however, about 6 of 10 (59%) respondents overall perceive that their opinions regarding the beauty of maths are more positive having experienced *MbE*. Another 40% reported no change in their opinions on the beauty of maths. All but three of the 21

respondents whose initial opinions regarding the beauty of maths were negative experienced a more positive change as a result of *MbE*. Additionally, six out of ten respondents whose opinions were initially neutral and a similar proportion of respondents whose opinions were initially positive experienced positive changes resulting from their *MbE* experience.

Table 5. Respondents' opinions on the beauty of maths before *MbE*, and currently.

Opinion on the beauty of maths before *MbE*	Opinion on the beauty of maths currently (October 2010)			Total
	more negative	not changed	more positive	
Negative	0 (0.0%)	3 (12.5%)	21 (87.5%)	24 (100%)
Neutral	2 (0.9%)	85 (39.7%)	127 (59.3%)	214 (100%)
Positive	0 (0.4%)	217 (42.1%)	299 (57.9%)	516 (100%)
Total	2 (0.3%)	305 (40.5%)	447 (59.3%)	754 (100%)

Overall, as might be expected, most *Maths by Email* subscribers held positive opinions about the beauty of mathematics before subscribing. Only a small proportion of subscribers initially held negative views about the beauty of mathematics, and only two of 754 respondents experienced a negative change. Generally, therefore, the newsletter's influence has been toward more positive or unchanged opinions for essentially all subscribers.

Interest in maths. Last in this sequence of items about the influence of *MbE*, respondents were asked to rate its impact on their interest in maths. In this case, as shown in Table 6, of 760 respondents to this survey question, nearly 9 in 10 (87%) reported positive interest in maths before subscribing to *MbE*.

Table 6. Respondents' opinions on interest in maths before *MbE*, and currently.

Interest in maths before *MbE*	Interest in maths currently (October 2010)			Total
	more negative	not changed	more positive	
Negative	0 (0.0%)	1 (5.0%)	19 (95.0%)	20 (100%)
Neutral	1 (1.2%)	15 (18.5%)	65 (80.2%)	81 (100%)
Positive	4 (0.6%)	274 (41.6%)	381 (57.8%)	659 (100%)
Total	5 (0.7%)	290 (38.2%)	465 (61.2%)	760 (100%)

By October 2010, however, about 6 of 10 (61%) respondents report a more positive interest in mathematics, having experienced *MbE*. Another 4 in 10 (38%) reported no change in their interest in maths. Fully 95% of respondents (all but one) whose initial opinions regarding interest in maths were negative experienced a positive change after subscribing to *MbE*. Additionally, 8 out of 10 respondents whose opinions were initially neutral and 6 out of 10 respondents whose opinions were initially positive experienced positive changes resulting from their *Maths by Email* experience. Overall, as might be expected, a strong majority of *MbE* subscribers held positive interest in mathematics before subscribing. Despite this, however, the newsletter's influence has clearly been toward more positive interest in maths for the majority of subscribers. Only 5 of 760 respondents to this item reported more negative interest in maths having experienced *MbE*.

Recommendation to others. As an indicator of subscribers' overall view of *Maths by Email*, survey respondents were also asked whether they would recommend the newsletter to others. Respondents were overwhelmingly positive in response to this question, with almost 95% reporting that they would recommend the newsletter to others. This was almost the same figure as for the first survey. Additionally, this high endorsement for the newsletter was observed across all three levels of schooling identified as most relevant to survey respondents.

Discussion

While acknowledging that survey data from this study involve anonymous volunteer respondents from subscribers, it seems clear that the newsletter is achieving its goals for this group, and it seems reasonable to suggest that it might be of wider interest as well. Although it is generally regarded as difficult to affect attitudes towards mathematics, responses from subscribers suggest that this sort of initiative offers some promise, at least over the relatively short time for which it has been available to date. The extent to which such effects persist over a longer period are unclear of course, and are ultimately dependent on the continuance of the service (which at the time of writing was not guaranteed). In particular, the extent to which *MbE* will encourage students to pursue mathematics into college is also unknown, although the indications to date from the available data show some promise.

In addition to the mathematical nature of the newsletter, its manifestation as a regular email might also contribute to its positive reception. An email may appeal to a modern generation attuned to the use of ICT for information, entertainment and inspiration, as well as being coherent with modern busy lifestyles. Unlike other educational experiences, a newsletter of this kind can be used autonomously and asynchronously, allowing readers of all kinds to engage with it to a depth, at a time and in a place of their own choosing. Unlike other disciplines, it seems relatively rare for opportunities in mathematics to present themselves in these ways, as Kissane (2009) noted. Mathematics is often less evident to young students in their everyday world, with very few regular magazines, television programs, movies or other forms of media regularly offering windows into the world of mathematics.

Conclusion

Maths by Email has been well received by subscribers in its first year of operation. Although it seems that, traditionally, attitudes to mathematics are difficult to change for the better, this new practice of publishing a regular email newsletter related to mathematics appears to show some early promise, suggesting informal and external curriculum supplementation of this kind is worthy of closer study.

Endnotes

1. In Australia, mathematics is commonly abbreviated in speech and informal discussion to 'maths' rather than 'math', as in the USA.
2. Students in Australia are in school for twelve years; the first six or seven years of school are referred to as 'primary' school, rather than elementary school; the final five or six years of school are referred to as 'secondary' school, rather than high school.

3. Australia comprises six states and two federal territories, each with their own education system; recently, a national mathematics curriculum has been agreed upon, but not yet implemented in full.
4. Although back copies of *Maths by Email* are not available, the hands-on activities are archived, with a broad classification, at http://www.csiro.au/MathsbyEmail

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