Maths Apps index #maths4us

Project Report

This report provides an overview of the Maths Apps index project led by the Association for Learning Technology (ALT) as part of the maths4us initiative during 2012/13.

Contents

Maths for everyone, everywhere... (Executive summary)

From measuring ingredients to planning a holiday, maths and numeracy skills are essential to helping each and every one of us succeed in everyday life. The Maths4us initiative, led by NIACE, the National Institute of Adult Continuing Education, aims to raise awareness of the importance of maths as well as to tackle some of the challenges in this area.

The overall initiative brings together innovative and engaging projects all about helping us improve numeracy and maths skills for everyone. Some examples of what the initiative is about include:

- Maths4Families, Fun Activities to Support Children With Maths;
- Baking with Friends, which is about helping people to become more confident with computers - and with maths - in everyday settings, getting people measuring ingredients, adding up calories, dividing portions - and using computers to help along the way;
- National Numeracy Challenge, helping adults learn the maths needed for everyday life;
- Women and Maths, WEA's resources, links and ideas to support development of the Women and Maths.

The Maths Apps index is a small part of the overall initiative and is about helping you find apps that you can use online, on a mobile device such as a smartphone or tablet or on a desktop computer, for improving your numeracy and maths skills. There are also apps for helping with everyday activities such as calculating your BMI, planning your finances or converting kilograms into ounces.

An app is a piece of software that can take a lot of different forms. There are apps that work like a calculator, apps that you can play like a games, apps that can help you find information you are looking for and apps that can show you videos for example, of how to calculate a percentage. There are millions of apps and many thousands of apps for improving your maths skills. So how do you know which ones will work for you?

The Maths Apps index helps learners and teachers find apps that are right for a particular task, currency conversion for example, and provides you with a review written by a teacher, learner or developer who has experience in using it. It also provides additional information such as whether the app is free to use and what devices it will work on. It helps you find apps that are useful for you - but if you cannot find what you are looking for and you come across an app that isn't yet included, you can register as a reviewer and add a new app to the index. You can add a review online in a few minutes and also rate apps that are already included.

The index also enables you to share apps that you find useful with others via social media and send links to others via email. As the index grows you can search for apps either by keywords, platform (i.e. Android or iOS), everyday tasks (baking) and in other ways to make finding and using the right app to improve your maths skills easier.

http://maths4us.alt.ac.uk

Apps have great potential to improve adult numeracy in particular as they can be used independently and wherever needed. Most are free to download and can provide a quick, easy way for individuals and teachers to access the information that is needed. With many new apps being released every day, apps are a growing resource for learners and teachers everywhere and the Maths Apps index will contribute to their use in improving maths skills.

The Apps4us developed as part of the initiative which will be launched in September 2013 on the Maths Apps index will be the first new app developed for adult learners learning maths on the index and will, together with the other resources from across the initiative, further promote usage of apps for improving numeracy and maths skills.

About the project

The main aim of the project was to develop the Maths Apps index at http://maths4us.alt.ac.uk/ hereafter referred to as “the index”. The index was part of the technology strand of the overall initiative, aimed at supporting a wide range of activities to raise awareness of the importance of maths as well as tackle some of the challenges help adults improve their maths skills.

The development of the index was based on the Community-led Evaluation and Dissemination of Support Resources pilot system developed by ALT. You can access the report of the project via the ALT Open Access Repository.

The main aim of the index is to encourage and support the use of technology, and more specifically, both web-based and mobile apps to help adults improve their maths skills in a number of contexts including learning led by a teacher or tutor, self-study and practical applications such as travel, helping children with their homework, budgeting and so forth.

With a plethora of apps available to users, finding the right app isn’t straightforward. The index contains reviews written by individuals with expertise in using apps for maths teaching and learning thus enabling users to find and evaluate apps best suited to their context. Users can subscribe to the RSS feed on the site in order to get notified when new reviews are added.

The index enables users to search for apps:

- using a taxonomy based on maths terms, using the terminology used for the National Numeracy campaign as a basis, including words like ‘algebra’, ‘calculus’ or ‘whole numbers’;
- using a taxonomy based on every terms, such as ‘budgeting’, ‘calculator’ or ‘mental maths’;
- by platform (e.g. web and mobile devices);
- by access type (e.g. free, paid for).

Users looking for apps used for teaching maths can also search for apps:

- by how interactive it is;
- by what kind of learning it is most suitable for (e.g. teacher-led, self-study);
- by who the intended end-user is (e.g. teacher of student).

Registration on the site is free and open to all. Registered users can submit reviews of apps and rate those already included using a star system.

While the index has been launched and is fully functioning, work to add further content and support the involvement of a broader community continues.

Lessons learned

Part of the work undertaken by ALT was a reflection on the maths index project as a whole both within its context and also from the point of view of the type and scope of a project of this size and complexity.

Importance of maths skills and numeracy
The first result, clear from the work, its reception and the attitudes of partners and third parties is that mathematics and the need for mathematical skills and numeracy in the UK really matters and that the lack of in depth skills leads to significant issues for individuals, organisations and the UK as a whole. The relevant skills are often related to financial understanding and ability and it is perhaps unsurprising that a lot of things included in the index have some financial underpinning, at least in part. The aim of the initiative and its partners is therefore addressing a key issue for learners, particularly adult learners, across the UK.

To give three examples of why numeracy and maths skills are key to success in everyday life and which we have tried to address in part by the resources in the index - many individuals find it difficult to compare rates of interest charged for personal loans on offer and as a result cannot choose the best option for them; similarly, it can be a common problem not to be confident when calculating change in shops and elsewhere both at home and when travelling abroad; and a further example is planning a budget for instance an overseas holiday involving several currencies or a large purchase such as a car, especially when tax is included. Yet other family activities such as baking and following recipes also draw on numeracy and maths skills.

Thus there is an ongoing need for major attitudinal change that needs to be further addressed, although the initiative has helped to identify it. For further discussion, particularly in relation to helping teachers improve the teaching and learnings of maths skills, see the Royal Society report “Visions for science and mathematics education” (http://royalsociety.org/education/policy/vision/) and links thereform - which addresses the important areas of accountability and teacher training as well as the need for resources and for understanding adults and parents.

Technology can help across different contexts
While the development of the Maths Apps index only forms a small part of the overall initiative it does aim to directly exploit the potential of technology to improve maths skills. Apps can make maths and numeracy learning tools available to a broad audience and importantly, can make this available across different platforms and thus places. For example, the index includes apps that can be used both on the web and on mobile devices. Many TV sets now enable users to access the internet and apps have the potential to becoming an important channel to deliver maths teaching both at home and on the go.

Working in partnership is key

While the Maths Apps index project only drew on a small number of partners from across the initiative, the project could not have been successfully completed without their input. The partner list below is diverse and one key outcome of the project has been for partners who had similar aims to spend time to get to understand one another's values and motivators, sharing past experiences and coming together to address national issues in relation to numeracy and maths skills. The overall approach of the initiative to foster partnerships and reflect on their effectiveness helped to facilitate effective collaboration and promote sustainability plans which are being implemented in order to build on the developing partnerships across different parts of the initiative. In relation to the Maths Apps index, the sustainability plan provides a framework which should ensure that work such as updating and continuing to add new resources as well as strengthening relationships with partners who are contributing. Several partners have already agreed to an ongoing involvement in its development in the medium-term.

Community involvement and uptake

Due to the short timeframe of the project, there was only limited scope to build community involvement and promote usage of the index within different communities. This is a key aspect on which the sustainability plans focuses and will continue to be addressed. The index is open to users and reviewers, enabling teachers and learners to find and add resources on an ongoing basis. The index will be promoted widely in an ongoing way in relevant places and via partners. Dissemination will also take place via the ALT annual conference and NIACE conference later this year with specifically focused sessions and presentations.

While we will continue to promote engagement with the Maths Apps index and the apps that it provides access to, it is important to acknowledge that this project only forms a small part of the overall initiative, which reaches to broad engagement with families and adult learners across the UK.

Research and further reading

The emphasis during the development of the Maths Apps index has been on research that informs the development and use of apps for numeracy and maths skills. We aim to add to this over time using research with a focus on adult learning and maths learning outside of formal contexts and welcome further contributions in this area.

Mathematics education research over last couple of decades demonstrates that one of the most significant challenges in learning mathematics relates to their abstract nature that engages only a fraction of students who in their majority still often receive traditional one-way instruction. It is mostly a problem, therefore, of motivation. Such findings are discussed further in several national and international reports (e.g. European Commission, 2007; Eurydike, 2011) who often call for identifying ways to introduce students to "interesting, stimulating and challenging applications of mathematics which are relevant to their world" (JMC, 2011).

A response to this call comes from the research in Technology-Enhanced Learning in Mathematics and the general appreciation around the fact that mathematical environment provide opportunities for making the abstract concrete and manipulable (c.f. Noss and Hoyles, 2006; Forbus, Feltovich, 2001) and a chance to engage both groups and individuals. There are at least two related (but also diverse) perspectives; a constructionist approach — to put it simply the idea that we learn by making tangible objects and that can include computer representations of those -— and the game-based learning perspective — the idea that well-designed educational games can promote learning — both of which attempt to spark students' motivation by promoting a more stimulating problem-solving experience or simple practice skills that connect with one's interests and experiences.

The response to this call is welcome and there is a vast amount of national and international research that looks into the potential and effects of digital technologies in mathematics (see a summary in JMC, 2011). The field however has also recognised that there is a proliferation of so-called mathematical games designed to provide intrinsic or extrinsic reward for effectively doing drill and practice in arithmetic in well-designed contexts full of graphics and avatars. This is also often backed up by research (e.g. the reward games in Zondle were inspired explicitly by neuroscience research on uncertain rewards that poses that at the junction between the question answering and the uncertain possibility that you'll get to play some game there is a lot more dopamine flowing through your synapses, motivating you to continue and helping encode what you've just thought about in your long-term memory).

The index contains a good selection of related games. And although some examples are starting to appear that make authentic use of mathematics within the digital environment and can help demonstrate that mathematics and the various procedural skills one needs to develop are a means to an end and not only the end itself, more would be welcome. Such approaches of course require considerably more investment both in their design and application and from the user to master. Games, such as Lure of the Labyrinth, where the mathematics become alive, wrapped into an appealing narrative game and through math-based puzzles challenge students, adults or whole families to think like mathematicians may well be the answer to this.

Feeding the exact right proportion of food to a group of very hungry monsters might not be what mathematicians do but may well be the way to stimulate students' interests and begin the process of unlocking their potential. Another example, going back to the learning by making mentioned above, and perhaps the most prominent one, Scratch, is not strictly an app but a simple programming language that allows for creating from interactive stories and animations with cartoon-like characters to simple games and simulations. While Scratch is often perceived only as tool for learning programming in recent years Scratch has been used to help both young students and adults relate their personal interests with a design processes that requires and helps develop both mathematical and computational literacy. There is of course the danger that such programmes will still be interesting only to some who already enjoy problem-solving as an end to itself and to learners who would have responded anyway to the traditional approaches but the evidence suggests that with good pedagogy, teacher training and appropriate time

allocation (e.g. with the use of blended learning scenarios), it is possible to make significant steps towards making mathematics education more stimulating.

Development of the index (technical specs)

As part of the Community-led Evaluation and Dissemination of Support Resources pilot, a number of recommendations were made in the final report highlighting the affordances of the open source WordPress platform for a community review site. In particular it was highlighted that this solution would allow the easy input of reviews, filtering based on a controlled taxonomy and integration of additional community features such as review star rating.

Having selected WordPress, a review was undertaken of the WordPress Plugin Directory and existing documented solutions for similar functioning sites. As part of this, the following open source plugins in Table 1 were identified. In addition the open source Sampression Lite theme was selected. The primary reason for selecting this theme was it provides a responsive design framework suitable for a range of screen sizes including for both desktop and mobile devices.

Plugin	Description
GD Star Rating	Used to add community star rating to reviews Version 1.9.22 | By Milan Petrovic | Visit plugin site
Google Analyticator	Adds the necessary JavaScript code to enable Google's Analytics. Version 6.4.4.2 | By Video User Manuals | Visit plugin site
Google XML Sitemaps	This plugin generates a special XML sitemap which will help search engines like Google, Yahoo, Bing and Ask.com to better index the site. Version 3.2.9 | By Arne Brachhold | Visit plugin site
Jetpack by WordPress.com	Enables a number of additional features including Wordpress.com Stats, social sharing buttons and extra widgets. Version 2.2.5 | By Automattic | Visit plugin site
TDO Mini Forms	This plugin allows the addition of custom posting forms for submission of reviews by registered community members. Version 0.13.9 | By Mark Cunningham | Visit plugin site
Theme My Login	Enables customised registration and login forms and email notifications. Version 6.3.6 | By Jeff Farthing | Visit plugin site
WP SMTP	Used to send emails via SMTP server (added to help prevent emails being incorrectly detected as spam). Version 1.1.5 | By BoLiQuan | Visit plugin site

Table 1: Plugins used in the index

Site design

The site homepage includes a number of ways for finding and searching for resource reviews highlighted in Figure 1. These include category filtering, taxonomy clouds and site search.

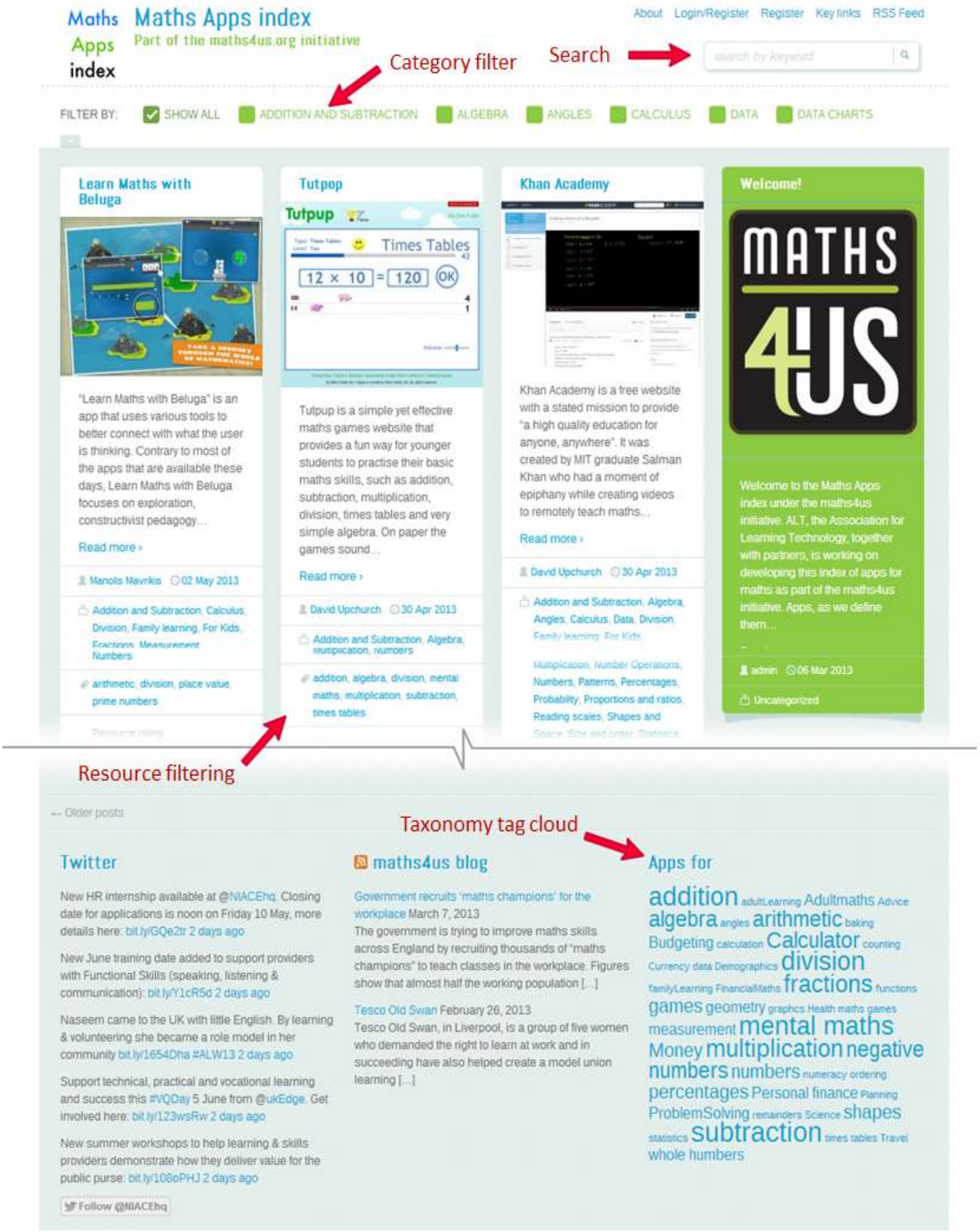

Figure 1: The index homepage

http://maths4us.alt.ac.uk

Navigating to an individual resource review the page contains a number of additional ways for finding relevant and related resources. In particular the Additional Information (shown in Figure 2) contains links to allow the user to filter the index for items with the same field property.

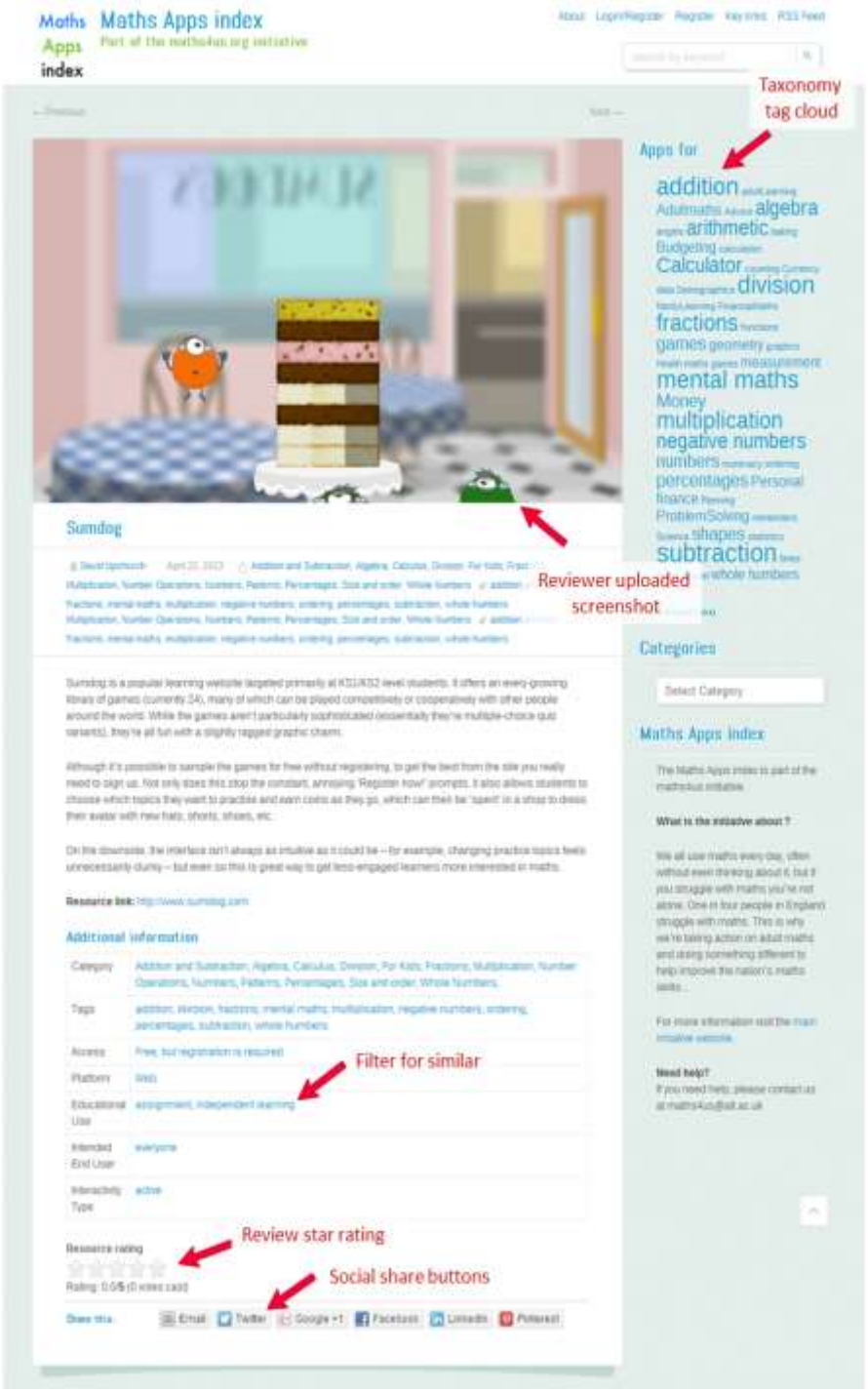

Figure 2: Individual resource review page

Within each resource there are options for anyone to provide a star rating of the review. These are encoded in such a way that they will be included on Google Search rankings. Currently there are no public pages that allow users of the index to see our search for top rated resource reviews, but this data are available to the sure administrators and this functionality would be easy to add to public pages at a later date once more star ratings had been collected.

Individual resource review pages are also integrated with social network sites. Buttons are provided at the bottom of each review to directly share resources with a number of social networks including Facebook, Twitter and Google+.

Usage tracking

Two levels of tracking are used in the index. Course grain data is collected by the Wordpress.com Stats tool which is party of the jetpack plugin. This records the number of page views for individual resources. Additionally the tool provides data about which link, if any, the user used to arrive at the site and if via a search engine the search term they used. In addition to this Google Analytics are used for more fine grain tracking. This includes more detailed demographic data (country/city of origin, browser capability, social network referral and more). Currently this data isn't used beyond a general overview of traffic but it may be used in the future to identify and highlight popular resources, or at a diagnostic level to improve site design.

Metadata and resource discovery

To aid search and discovery as part of the review, submission reviewers are required to enter additional data about the resource they are reviewing. Identification of these fields was based on requirements identified by the project team as well as properties from the Learning Resource Metadata Initiative (LRMI) specification (see Appendix 1).

Figure 3: Example review with LRMI/Schema.org encoding

In line with emerging best practice the review metadata in incorporated into the index using microdata techniques outlined in Appendix 1. Figure 3 illustrates how this is achieved within a resource review.

In addition to this the index uses the Sitemap XML plugin to generate a machine readable site map of all the reviews. This sitemap conforms to industry standards and allows search engines like Google to efficiently index the site and display results in its search rankings. It is worth noting that although the site had only been public for a couple of months it already has almost 200 search hits in Google.

Review workflow

Before a resource review can be submitted, the reviewer must be registered. Registrations are purposefully designed to be lightweight requiring only a chosen username and email address. The administrators of the site immediately receive an email notification of all registrations. When registrations are approved, users receive an email notification with their password and general instructions (these instructions can easily be changed by administrators via the backend interface). As part of these instructions reviewers are given a link to a review submission form which they are encouraged to bookmark. An outline of the review form and details of the textfields is shown in Figure 4.

Review Form

Review Title (Required): [TEXTFIELD]
Review Text (Required): [TEXTAREA]
Helptext: Each review should give a sense of what the app can be used for, who it was developed by or how and some idea of why it is included.

Tags: [AUTOCOMPLETE TEXTFIELD]
Helptext: (separate multiple tags with commas: calculation, currency, science - use everyday words that describe what this app is for/about) :

Resource link (Required): [TEXTFIELD]

Access is [SELECTLIST] [free, free, but registration is required, paid]

Platform [SELECTLIST] [web, mobile (Android), Mobile (iOS), mobile (other), other]

Learning Resource Type: [SELECTLIST] [Current list in Appendix 2]

Educational Use: [SELECTLIST] [assignment, groupwork, independent work]

Intended End User Role: [SELECTLIST] [learner, teacher, everyone]

Interactivity Type: [SELECTLIST] [active, mixed, expositive]

Upload Screenshot: [FILEUPLOAD]

[SUBMIT]

Figure 4: Review form outline

When a reviewer finds a resource they would like to submit to the index, details can be entered in the field of the review form. The form includes a number of fields which uses a mixture of free text, controlled taxonomies and auto-completed options. The reviewer also has the option to upload a screenshot of the resource.

When a review is submitted, the administrators receive an email notification. The details can then be reviewed in the site administration panel and if suitable approved.

Whilst there is currently no internal system for allocating and administering the assignment of resource reviews to registered users the WordPress platform includes a user search function which could be used to find the email address of a potential reviewer.

Site Accessibility

The Maths Apps index has been tested using the WebAIM WAVE web accessibility evaluation tool (http://wave.webaim.org) which is designed to support developers in "implementing HTML-related principles and techniques for those seeking WCAG 2.0 conformance". Using WAVE the Maths Apps index homepage has been validated as containing no markup or accessibility errors. Further to this Craig Mill, owner of Assist-I.T. and a recognised expert in accessibility has tested the Maths Apps index for structural and keyboard navigation issues. Testing conducted personally by him has revealed no issues and the site is deemed to be accessible to the widest possible audience, including readers using assistive technology or accessibility features.

Thanks and authors

The authors of the report are:

Maren Deepwell, Chief Executive, Association for Learning Technology;
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John Slater, Director of Development, Association for Learning Technology.

This report also contains contributions from Michael Belcher, Wolfram Research, from partners involved in the project and Craig Mills.

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Partners

The following partner organisations have contributed to the development of the index:

E-Learning Foundation
Institute for Learning
Institute of Education
Jisc
Jisc CETIS
Learning Unlimited
National Institute of Adult Continuing Education
UKOnline Centres
UnionLearn
Unison
Sparkloop
UCISA
Wolfram Research

Further information

For further information, please visit the Maths Apps index site http://maths4us.alt.ac.uk .
You can watch a webinar about the Maths Apps index and download the presentations used via the ALT Open Access Repository.

Appendix 1 Review and learning resource metadata

There is a general trend in webpages away from hidden metadata (keywords, descriptions contained in the header of a page) towards structured markup. This is in part a move by search sites to prevent the manipulation of search ranking by using hidden metadata. The solution has been to move towards combining human-oriented resource description and machine readable metadata.

An example of this is used in the Creative Commons embeds information about licenses in webpages. Using their 'license chooser' tool it generates extra HTML code for you to include in your distributed work. As well as the human readable icon and/or text the machine readable markup includes the `rel="license"` attribute shown in Figure 1.

```
<a rel="license" href="http://creativecommons.org/licenses/by-sa/3.0/us/">
Creative Commons Attribution-Share Alike 3.0 United States License</a>.
```

Figure 1 Example of RDFa markup used in Creative Commons license

The inclusion on `rel="license"` allows search engines to identify that a resource might be released under a specific license, this information being used as a means to facet search results.

Schema.org

A development in this area of particular significance is schema.org, an initiative involving Google, Yahoo, Yandex and MS Bing that aims to:

"… improve the web by creating a structured data markup schema supported by major search engines. On-page markup helps search engines understand the information on web pages and provide richer search results." (schema.org, 2013)

There are two aspects to schema.org; a syntax for encoding parts of a page to identify additional metadata, and a shared schema of item types and their properties to make it easier for search engines to consistently index information.

Learning Resource Metadata Initiative (LRMI)

The Learning Resource Metadata Initiative (LRMI) is working to extend the controlled vocabulary used in describing educational resources which is compatible with schema.org and other systems. This will mean search engines will be able to understand the information on web pages describing learning resources and make it easier for users to find them.

Table 2 is an extract from the LRMI Draft Specification version 1.0 and describes the metadata that can be included.

Table 2 LRMI Draft Specification version 1.0

Property	Description
educationalAlignment	An alignment to an established educational framework.
educationalUse	The purpose of the work in the context of education. ● Ex: "assignment" ● Ex: “group work”
intendedEndUserRole	The individual or group for which the work in question was produced. ● Ex: "student" ● Ex: "teacher"
interactivityType	The predominate mode of learning supported by the learning resource. Acceptable values are active, expositive, or mixed. ● Ex: "active" ● Ex: "mixed"
isBasedOnUrl	A resource that was used in the creation of this resource. This term can be repeated for multiple sources. ● Ex: "http://example.com/great-multiplication-intro.html"
learningResourceType	The predominate type or kind characterizing the learning resource. ● Ex: "presentation" ● Ex: "handout"
timeRequired	Approximate or typical time it takes to work with or through this learning resource for the typical intended target audience. ● Ex: "P30M" ● Ex: "P1H25M"
typicalAgeRange	The typical range of ages the content's intendedEndUser. ● Ex: "7-9" ● Ex: "18-"
useRightsUrl	The URL where the owner specifies permissions for using the resource. ● Ex: "http://creativecommons.org/licenses/by/3.0/" ● Ex: "http://publisher.com/content-use-description"

Because it was perceived as unrealistic for a reviewer to supply data like educationalAlignment as part of reviews it was opted to use a subset of the LRMI data which was incorporated into the review form of:

- educationalUse
- intendedEndUserRole
- interactivityType

Appendix 2: Learning Resource Type

Controlled taxonomy of learning resource types:

- Algebra
- Angles
- Calculus
- Data
- Data charts
- Division
- Family learning
- For Kids
- Fractions
- Functions
- Geometry
- Graphs and Charts
- Measurement
- Multiplication
- Natural Sciences
- Number Operations
- Numbers
- Patterns
- Percentages
- Planets and the Universe
- Probability
- Problem Solving
- Proportions and ratios
- Reading scales
- Risk
- Shapes and Space
- Size and order
- Statistics
- Symbols
- Using Calculators
- Whole Numbers