Evaluating solutions to process, view and listen mathematical formula within an accessible context

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Project "Recursos docentes accesibles" —accessible teaching documents— is an action within the Teaching Improvement and Innovation Program at University of Barcelona, whose broad objective is providing templates for the creation of most widespread teaching documents, and easy procedures to create alternate versions of them. Those alternate versions will include changes in colour, fonts or other presentational attributes and also conversions to different digital formats, thus promoting inclusive education in the university by the integration of alternative formats in everyday contents.

Within the mathematics context, this broad objective imposes specific requirements for mathematical notation/formulae. Most word processors process mathematical notation/formulae through a proprietary codification system or, even, through graphical formats procedures, so they are not suitable for assistive technologies like screen readers or screen magnifiers (JAWS). This situation imposes a severe barrier for blind and low vision students when using learning resources within mathematics area. People with dyslexia or ADHD could also benefit from screen readers or changes in presentation when reading mathematical notation/formulae in order to understand them better –even when, for those groups, this solution is not essential.

For a long time, solutions oriented to generate Braille formats have been considered the most convenient for visually impaired students to access the mathematical content, and, specifically, the mathematical expressions (Pontelli & Palmer 2004, and surveys of Jayant in 2006, and Karshmer, Gupta & Pontelli in 2007 which have not been formally published yet). Lately, these solutions have been questioned, as in (Sources & Ferres 2012), which consider them "an expensive and/or slow technology". Alternative solutions help produce renderized audio of electronic documents. For low vision students, most effective solutions focus on expression magnifiers.

1 Methodology

A testbed was designed with two main components:

- A selection of 139 different formulae, with a good coverage of symbols and expressions, based on the formulas offered by LibreOffice Math 3.3.2, which distinguishes 11 different sets of formulae.
- A selection of three text processors with specific capabilities for processing mathematical notation: MS Word 2007 (12.0.6661.5000) SP3 MSO (12.0.6662.5000)

and LibreOffice Math 3.3.2, for office documents; and Latex MiKTeX 2.9 TeXnicCentre 1.0, for Latex documents. The selection was based on the results of a survey on the tools commonly used by faculty members in the Department of Mathematics of University of Barcelona.

All the formulae were processed within the editors, in order to obtain evidences of capability and quality on viewing them and listening to them. In the case of MS Word 2007, formulae were tested both on a regular version of the editor, and on an empowered version with MathType 6.0c., from Design Science, a formula editor that allows the creation of mathematical notation for inclusion in desktop and web applications.

Once all the formulae were processed with the three editors, results were converted into MathML, in order to view and listen to them on different internet browsers. All converted formulas were tested on Firefox (on Windows), Opera (on Windows) and Safari (on MAC), which have native support for MathML. After this first test, LibreOffice was discarded as an option. Further tests were done with MS Word and LaTex on IE with MathPlayer plugin.

The test was performed during November 2012, when presentational results were gathered and, in the case of MathPlayer, also results of listening. The evaluation of results involved two different indicators: quality of displays for user visualization and quality of reading for user audition. For the first indicator, values were: not acceptable display; acceptable display; and best display. For the second indicator, values were: MathPlayer doesn't read the formula; MathPlayer reads the formula partially; MathPlayer reads the formula correctly. In this second indicator, the listening was carried out by choosing Spanish language and "reading for the blind" setup option. We have also conducted tests in other languages (e.g. English) and for different settings (e.g. low vision and dyslexia), which are not reflected in the final results.

Results of the tests have been consolidated in an Excel table. Values for indicators are represented both through textual expressions and chromatic codes.

2 Results

Results show that MS Word empowered with MathType is the best solution in terms of number of symbols correctly interpreted; quality of displays for visualization; and quality of readings for audition.

Even when 6 of the selected mathematical expressions were not covered by MSWord+MathType, this last solution provides better displays than LibreOffice. It's worth noting the high quality in visualization of big operators (\sum, \prod, \coprod…) and resizable delimiters.

LaTex MiKTeX 2.9 can't process 11 of the selected mathematical expressions. By default LaTex exports formulas in a nonstandard typography which hinders understanding in viewing and in Mathplayer listening, but this can be corrected in the conversion process.

As for browsers, visualization on IE+MathPlayer of expressions processed by MSWord+MathType is the best solution, although Firefox alone gives better results in comparison with any other browser without plugins.

Opera shows the worst results in recognizing expressions which have been processed by Math LibreOffice 3.3.2 and MS Word 2007, and also in rendering symbols, especially in the cases of accents and delimiters. Only for expressions processed by LaTeX MiKTeX 2.9, the results obtained with Opera are better than those obtained with Firefox.

Results in viewing with Safari are quite good, as only 13 expressions processed with MS Word 2007+MathType generate not acceptable displays, and 9 expressions processed with LibreOffice-Math generate not acceptable displays. The overall negative aspect that should be noted is that expression accents are too distant from letters, and they don't resize when it's needed.

Concerning the quality of reading for user audition, tests on MS Word 2007+MathType and LaTeX MiKTeX 2.9 (both on IE+MathPlayer) give the results shown in the following table.

Table num. 1: Results of tests on reading for user audition

	Formulas not supported by the editor	MathPlayer doesn't read the formula	MathPlayer reads the formula partially	MathPlayer reads the formula correctly
MS Word 2007 + MathType	6	6	11	116
LaTeX MiKTeX 2.9	11	66	33	29

As you can see, results are far better for the combination MS Word 2007 + MathType. Dysfunctions focus on expressions that include small fractions (e.g., a/b 4/3 ...) and expressions that include symbols | I {} as delimiters.

3 Further work

Test results will allow us to deliver evidence-based advice to the University professors (and, specially, to the Department of Mathematics) on best options for accessible mathematical formulas within teaching resources. Also, we will advise blind or low vision students about the best options for optimum viewing and listening resources containing mathematical formulas. In addition, some models devoted to mathematical formulae will be included in the catalogue of accessible materials for teachers within the University and advice on how to convert Latex formulas and how to create formulas with MathType will be disseminated.

Next steps in our project envisage developing solutions to make mathematics manipulation processes accessible, further than processing, viewing and reading of mathematical expressions, in inclusive education contexts (Tsonos et al. 2009) (Alajarmeh et al. 2011).

A final point is that we are planning to provide access to result data for external querying and operating.

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References

ALAJARMEH, Nancy – PONTELLI, Enrico – SON, Tran. From "Reading" Math to "Doing" Math: A New Direction in Non-visual Math Accessibility. In *Universal Access in Human-Computer Interaction. Applications and Services: 6th International Conference, UAHCI 2011, Held as Part of HCI International 2011, Orlando, FL, USA, July 9-14, 2011, Proceedings, Part IV*. Berlin; Heidelberg: Springer, 2011. s. 501–510.

ARCHAMBAULT, Dominique – STÖGER, Bernhard – BATUI, Mario – FAHRENGRUBER, Claudia – MIESENBERGER, Klaus. Mathematical working environments for the Blind: what is needed now? In *Workshop on Advanced Learning Technologies for Disabled and Non-Disabled People (WALTD) at The 7th IEEE International Conference on Advanced Learning Technologies (ICALT 2007) July 18-20, 2007, Niigata, Japan*. Available in URL <http://ftp.informatik.rwth-aachen.de/Publications/CEUR-WS/Vol-357/paper1.pdf>.

BERNAREGGI, Cristian – ARCHAMBAULT, Dominique. Mathematics on the web: emerging opportunities for visually impaired people. In *W4A '07 Proceedings of the 2007 international cross-disciplinary conference on Web accessibility (W4A)*. New York, NY: ACM, 2007. s. 108-111.

FERRES, Leo – FUENTES SEPÚLVEDA, Jose. Improving Accessibility to Mathematical Formulas: The Wikipedia Math Accessor. In *W4A '11 International Cross-Disciplinary Conference on Web Accessibility Hyderabad, Andhra Pradesh, India, March 28 - 29, 2011*. New York, NY: ACM, 2011. Available in URL <http://dl.acm.org/citation.cfm?id=1969294&dl=ACM&coll=DL&CFID=240526309&CFTOKEN=97867479/>

PONTELLI, E. – PALMER, B. Translating between formats for mathematics: Current approach and an agenda for future developments. In *Computers Helping People with Special Needs: 9th International Conference, ICCHP 2004, Paris, France, July 7-9, 2004. Proceedings*. Berlin; Heidelberg: Springer, 2004. s. 627–627.

TSONOS, Dimitrios – KACCORI, Hernisa – KOUROUPETROGLOU, Georgios. A Design-For-All Approach Towards Multimodal Accessibility Of Mathematics. In *Assistive Technology From Adapted Equipment To Inclusive Environments*. Amsterdam: IOS Press, 2009. s. 393–397.