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ABSTRACT

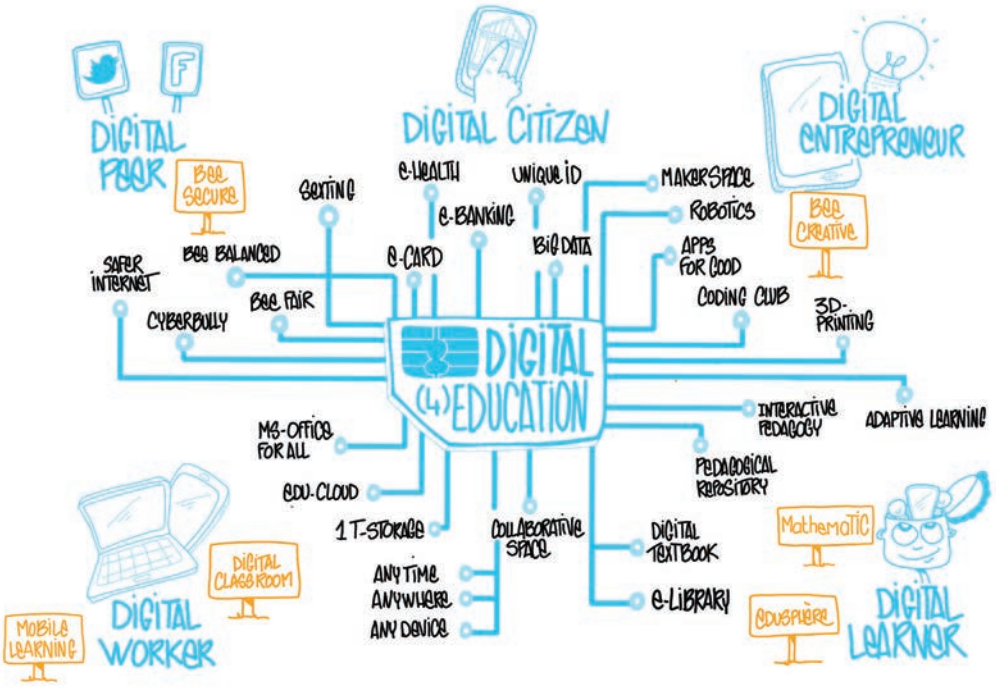
Counting almost 45 per cent of foreigners among its residents, Luxembourg holds the record in Europe for the proportion of students who do not speak the language of instruction at home, the number of foreign languages taught at school and the number of hours dedicated to the teaching of these foreign languages. This multilingual tradition influences equity in learning at school and significant performance gaps are observed between students from various socioeconomic backgrounds, between those of native and foreign origin who do not speak the language of instruction as well as between boys and girls. In response to its growing heterogeneous school population, the Ministry of National Education, Children and Youth (MENJE) introduced MathemaTIC in September 2015. This is a project whereby 10–11 year-old students in grades 5 and 6 can choose to learn mathematics in any of four languages in an adaptive digital environment. The aim is to take advantage of technology to adapt the learning of mathematics to individual student needs while giving a fairer chance to those who have a lower command of the language of instruction and whose achievement would be hindered when the language becomes a barrier to understanding the mathematical text. This article will briefly present the potential of MathemaTIC to improve learning, address the conditions necessary for its success, outline the strengths and challenges encountered during its implementation after a one-year pilot phase and touch upon the first lessons learnt to inform the next steps of the project.

LUXEMBOURG LOW-STAKES STUDENT ASSESSMENT FOR STUDENT SUCCESS: A PERSONALISED LEARNING ENVIRONMENT IN MATHEMATICS TO RAISE ATTAINMENT AND TACKLE INEQUITY

The education system in Luxembourg is distinguished by its multilingual tradition where the teaching and learning of languages occupies a central place in the school curriculum. This diverse context stems from the national one where a striking 44.5 per cent of Luxembourg residents are foreigners [17 per cent and seven per cent being Portuguese and French respectively] (MENJE, 2014). In addition, on a daily basis Luxembourg receives around 155,000 cross-border workers from France, Belgium and Germany. This growing cultural heterogeneity is clearly reflected at school entry where two-thirds of the students enrolling in preschools (MENJE, 2016) do not speak the national language – Luxembourgish (closely related to German). As Luxembourgish is the main language of communication at school and German is the main language of instruction in fundamental, or primary, schools and lower secondary public schools (MENJE, 2015a), this growing proportion of foreign young children are faced with the daunting task, in grade 1, of learning to read and write at school in their third language from the early age of six. French is then taught as a subject at the end of grade 2 onwards, Mathematics is taught in French from grade 7 (age 12 onwards) and the language of instruction is progressively replaced by French in the upper secondary classes.

Being multilingual in a globalised world is undeniably considered as a tremendous asset for employability and it is even considered a drawback for a job-seeker to speak only one language (OECD, 2012). But for Luxembourg, the European country with the highest proportion of students who do not speak the language of instruction at home, with the highest number of foreign languages taught at school and the highest number of hours dedicated to the teaching of these foreign languages (Eurydice & Eurostat, 2012), the effects of language learning at school on educational attainment and equity has been a subject of heated debate for decades.

Furthermore, evidence from the PISA studies since 2000, and the national standardised tests since 2008 (Martin, Ugen & Fischbach, 2014), have consistently drawn attention to the performance gap between students from various socioeconomic backgrounds, between those of native and foreign origin, as well as between boys and girls. In PISA 2012 (MENJE, 2013), overall results for reading, mathematics and science literacy showed that students who spoke Luxembourgish or German at home fared on average better than those who spoke French, Portuguese or a Balkan language. In addition, students from a lower socioeconomic background lagged two years behind in their learning when compared to those from a higher socio-economic background. Not surprisingly, performance in Mathematics and science are thus influenced by reading proficiency, the language chosen to write the PISA test (as in Luxembourg students may choose either German or French), the



language of instruction as well as socioeconomic status.

Furthermore, the national school monitoring results of 2014 (Martin, Ugen & Fischbach, 2014) show that 17 per cent of grade 3 students have repeated at least one school year, this figure rising to almost 50 per cent by the time students reach grade 9 in secondary school. In particular, roughly three out of four of these grade repeaters are non-German speakers with a migrant background and low socioeconomic status. Moreover, over 40 per cent of grade 3 students do not attain the minimum standards for German as defined in the national curriculum, while 25 per cent do not achieve the minimum standards for mathematics. This situation gets gloomier by grade 9 where just under 50 per cent of 15-year-old students succeed in mathematical problem-solving tasks. All these statistics confirm the continued disparity in attainment between students and highlight the need for the Luxembourg education system to cater for the learning needs of a particularly heterogeneous population in terms of socioeconomic, migrant and language origins.

In its efforts to respond to the diversity of teaching and learning needs, the Ministry of National Education, Children and Youth (MENJE) has introduced numerous initiatives since 2000 in order to raise attainment and tackle inequity in schools. Understandably, the crucial issue was to find ways of changing language learning – from being a barrier to opening up opportunities for students to succeed in school. The Language Education Policy Profile (MENJE, 2007), established in 2007 for Luxembourg, recommended promoting a high level of multilingualism for all students while at the same time considering their individual abilities. Other measures and initiatives have been introduced which include: a definition of teaching and learning standards within a skills-based approach; measures to reduce grade repetition; the formalisation of a national monitoring framework for measuring student performance; and placing emphasis on increasing school autonomy and self-evaluation in order to improve the school's quality and improve student performance.

In this article, we will present MathemaTIC, a budding pilot initiative introduced in September 2015 and hence still in its early infancy. It has the ambitious aim of using technology to offer a relatively 'language-free' solution

to raise attainment in numeracy while simultaneously enabling teachers to better support the learning needs of an increasingly heterogeneous classroom of 10-11 year-old students in grades 5 and 6 of fundamental schools. We will first explain the rationale for believing in the success of this project, the choices that were carefully weighed before high-stakes decisions were taken and the potential of MathemaTIC to transform learning, raise numeracy levels of students and tackle inequity. We will also point out the pre-required conditions necessary to support the successful implementation of MathemaTIC, which were considered right at the start of the project. Next, we will highlight the successes and challenges we encountered during the first year of the pilot phase and finally relate how we plan to accordingly adapt and pursue the next steps in the short and medium term. We hope that sharing the lessons we have learnt so far will prove useful to other countries embarking on similar learning adventures.

WHY MATHEMATIC?

In 2014, the Luxembourg government launched the national "Digital Lëtzebuerg" (Conseil de Gouvernement Luxembourg, 2014) initiative within the framework of the EU Horizon 2020 research and innovation programme to promote digital awareness among its citizens. The purpose was to affirm the new face of Luxembourg as a smart nation, modern, open, highly connected and ready to embrace a digital society. Acknowledging at the same time the potential of the digital revolution to revitalise the notion of pedagogical innovation, in May 2015 MENJE launched its strategy "Digital (4) Education" (MENJE, 2015b). This has a dual role. First, 'digital education' aimed at preparing young people to live and work in a 21st century global world ruled by new technologies. Second, 'digital for education' aimed at exploring ways of incorporating technology as an integral component of quality teaching and learning, so as to offer students and teachers wider access to learning resources. It also sets out to provide all learners, irrespective of their social origin, access to quality information and pedagogical resources. This would bridge the digital gap and enable the diversification of teaching and learning strategies to meet the different learning needs and paces of students.

The "Digital (4) Education" strategy is itself structured into 4 pillars: the 'Digital Peer' which focuses on the prevention of cyber bullying and the safe use of the Internet; the 'Digital Worker' which provides free access to the technological tools that students will use in their future job; the 'Digital Learner' where technology is used to enhance learning; and the 'Digital Entrepreneur' which fosters the entrepreneurial spirit in a digital world. MathemaTIC is a personalised adaptive learning environment under the umbrella of the 'Digital Learner'. It contains digital mathematical resources in German, French, Portuguese and English, created using state-of-the-art interactive pedagogies and tailored to the Luxembourg national curriculum (with reference to no particular textbook). It is custom-built for 10-11 year-old students in grades 5 and 6 of fundamental, or primary schools, offering them an opportunity to learn mathematics in an engaging and intuitive way and receiving online feedback in real-time. Students have 24/7 access to MathemaTIC on any mobile device, including computers, laptops, tablets, and smartphones, at school and at home. It is intended that such an adaptive learning environment will transform future classroom dynamics in the teaching and learning of mathematics.

MENJE decided to invest considerable resources in a project such as MathemaTIC in response to international and national recommendations with regards to raising school performance in a heterogeneous multilingual population. Indeed, research findings on German-French bilingual students in Luxembourg suggest that arithmetic significantly relies on language, especially in complex computations (Van Rinsfeld, Brunner, Landerl, Schiltz

& Ugen, 2015) and that the language of mathematic instruction influences the arithmetic performance of bilingual students (Van Rinsfeld, Schiltz, Brunner, Landerl & Ugen, 2016).

MathemaTIC thus firstly contains the multilingual resources to offer a relatively language-free space to learn mathematics, an incredible benefit to learners who struggle with languages and yet need to master them to succeed. It is hoped that neutralising the language factor in the learning of mathematics will enable all students, irrespective of their origin and command of the instruction language, to become more proficient in mathematics.

Secondly the integrated system of continuous feedback in the adaptive environment delivers real-time online individual tips and strategies adapted to the individual needs of students. Remedial help assists students who are falling behind while more advanced tasks help faster learning students to move on, all at their own pace. The teacher is able to follow the progress of each student online, to identify difficulties early on and provide supplementary explanation or exercises to exactly whom and where they are needed. This gain in time is precious for teachers who understandably complain that the overloaded curriculum leaves them no space for supporting the heterogeneous demands of the class. Thirdly, MathemaTIC also provides students with a platform to both master routine mathematical tasks and to tackle problem-solving tasks. Recommended for use in the classroom by teachers and students, or for independent use at home, this multilingual platform serves the pedagogical objectives of differentiation, individualisation and personalisation while meeting the wide range of students' needs irrespective of their migrant, language and social origins.

A fourth enticing element of MathemaTIC for schools is that this immediate low-stakes feedback is brought about while the learning occurs rather than after learning has occurred as in the case of adaptive testing. Through a variety of tasks, the environment thus offers opportunities to students and teachers to use formative assessment data for improving learning as well as summative assessment data at the end of a learning unit. MathemaTIC therefore clearly brings advantages to classroom learning as compared to annual national computer-based assessments in Luxembourg, that are more useful for system-level monitoring (but which teachers consider as less useful for the classroom).

Fifth, MathemaTIC, being a digital environment, comfortably finds its mark in the minds of today's 'digital native' learners where technology takes up a great proportion of their time awake. Research in the USA (Robb, 2016) indicates that a typical teenager's day includes up to nine hours of texting, gaming, watching videos, and posting on multiple social networks. Indeed, MENJE took the opportunity of such technology addiction and the national digital strategy to identify an appropriate learning medium for the students.

Teacher buy-in is the sixth reason why MENJE was confident of the potential of MathemaTIC. Indeed, teachers from 10 schools, where improving the teaching and learning of mathematics was already part of their existing school development plan, were invited to test the environment for some weeks. They not only voluntarily joined and stayed on board with the project but they even reached out to their peers in other schools. Today a total of 40 schools, over 100 teachers and 1,700

students are voluntarily and eagerly contributing to build MathemaTIC as their own powerful learning environment.

Lastly, but very importantly, MENJE is privileged to benefit from international expertise making MathemaTIC a collaborative development model designed by teachers, researchers and curriculum specialists from Luxembourg and France, with the pedagogical and technological design expertise from Canada. The technological component includes interactive exercises with mastery-based pedagogies and algorithmic assessments with adaptive engines.

WHY IS MATHEMATIC UNIQUE?

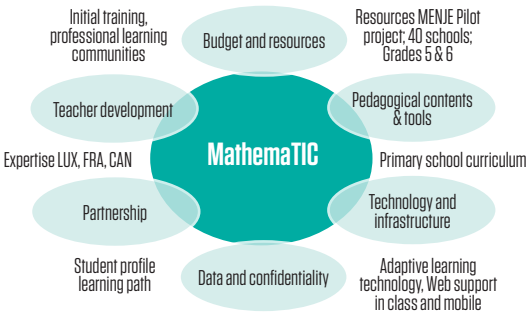
In opting for MathemaTIC as a potential solution for schools, MENJE weighed the pros and cons of other similar tools or platforms that seemed equally adequate. A strong reference was made to "The quality principles for digital learning resources" (Becta, 2007), illustrated left, which address both pedagogic and design principles, all incorporated as an inherent part of MathemaTIC. Much emphasis was placed on the fact that MathemaTIC provided the technology which would enrich the core mission of the school, which is to foster teaching and learning.

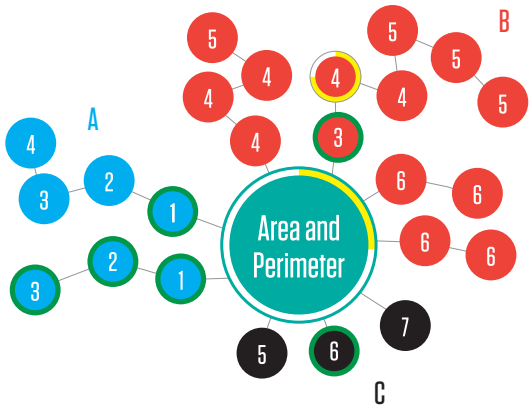
Becta's core pedagogic principles consider inclusion and access to resources where students create and learn anytime and anywhere (with teachers, students, or in the community) and hence bridge the digital divide to enhance: equity; learner engagement for improved motivation; effective personalised learning; assessment to support individual learning; robust summative assessment at the end of learning; and an innovative easy-to-use environment which matches the intended curriculum, instruction and assessment.

Becta's core design principles include: the robustness of the environment and the support provided with it; the human-computer interaction which considers user-centred design, usability and user experience; the quality of contents; accessibility to ensure that all learners benefit from the resource irrespective of their access requirements or preferences; interoperability between alternative platforms; the testing and verification process to ensure the environment is suitable and appropriate for its audience; and effective communication which relates to how the information about the environment is made available to its users.

In considering the cost of developing, implementing, maintaining and adapting the platform, MENJE opted for a commercial solution whose advantages outweighed the costs of an open-source one. In the absence of highly technical expertise to create, rapidly modify and adapt the environment, simply relying on the goodwill of the open-source community would not have enabled MENJE to set up a permanent maintenance system and be as reactive to the fast changing requirements of classrooms and the algorithms calculated as learning occurs. The contractual obligations with the commercial partner include extreme flexibility of adaptation, a strong foundation of interoperability with other learning platforms as well as clear ownership of intellectual property rights.

Furthermore, MENJE clarified that MathemaTIC was a unique solution custom-made 'by Luxembourg for Luxembourg'. Contrary to other tools, it is not an online learning management system, nor a digital interactive textbook. It is neither a simple automatic generator of online exercises nor a general learning platform of miscellaneous exercises and videos. As a multilingual adaptive digital learning environment, MENJE is not only financing a technological environment based on the national curriculum but is investing in an international, collaborative and flexible solution that contains other





A. Discovery Phase
B. Recognition and Comprehension Phase
C. Application and Analysis Phase

components of the package, namely project management, resource creation, teacher development and evaluation of the impact of the whole project.

HOW DOES MATHEMATIC WORK?

The MathemaTIC interface is divided into a student view and a teacher view, both accessible to the teacher. Students sign in using a personal identifier, and access a powerful, multilingual and engaging interface containing interactive, visual, audio and video mathematical items or exercises – all divided into six national curriculum learning modules. According to student success in solving the items, access to some items might be completely locked, to others partly unlocked, and other items may have been successfully completed. Each learning module begins with a 10-minute diagnostic test to determine the initial individual knowledge related to the content. The results then determine the sequence of items proposed to the learner while navigating through a learning unit at his/her own pace. Additional activities on similar topics may also be proposed by the teacher. MathemaTIC may be used collectively in the classroom alongside the textbook, as part of a group discussion, or students may work alone to revise or complete homework. Graphical tracking of student performance and progress over time enables both the teacher and the student to visualise the unique learning paths in real time. Teachers gain extra time to offer individual support to students and hence optimise lesson time and maximise impact on teaching and learning. At the end of each learning module, MathemaTIC proposes a 10-minute summative test that the teacher can administer to the class as a whole.

As shown in the figure to the left, there are three types of items: discovery items (blue), recognition and understanding items (red) and application and problem-solving items (black).

The first item of a branch – there can be multiple branches of the same colour – is always unlocked. Further items might be unlocked right away depending on the result of the diagnostic test. Upon successfully completing an item with a predefined success rate (80 per cent), the progress bar turns to green and the next item of that branch is unlocked; otherwise the progress bar is yellow and the student must rework different exercises of the same type and difficulty level before proceeding in that branch. In addition, a central overall progress bar for each module serves as a learning indicator giving quick feedback about the student's progress. Comparing the results of the summative test to the initial diagnostic test indicates a measure of learning for that module and helps identify and reduce gaps in learning. Support may then be given to ultimately raise achievement.

The teacher can (un)lock the diagnostic test and the summative test when the module is dealt with in class and can follow in real-time the learning progress at classroom, student and item levels, irrespective of whether learning occurs in class or at home.

Detailed information about student answers to each item in the learning module may be printed and shared with the child and the parents to track learning progress against expected standards. Each module comes with detailed didactical guidance suggesting to the teacher different ways of combining the MathemaTIC exercises with other problem-solving activities. Learning mathematics is not reduced to virtual learning only.

Acting like an intelligent tutor to

assist students and teachers with rich data, MathemaTIC therefore offers great potential for raising attainment in mathematics in comparison to traditional textbook learning methods. Its adaptive nature assists teachers to better manage classroom heterogeneity by automatically identifying the knowledge and skills acquired by students according to tracked responses in real-time. Students are recommended a corresponding learning pathway of activities in a preferred language according to their individual learning profile. Very importantly, MathemaTIC provides continuous access to a pool of multilingual mathematical resources, created by local teachers, for all students. Learning mathematics becomes fairer, interactive and fun for all.

WHAT CONDITIONS ENABLE MATHEMATIC TO BE A SUCCESS?

The success of MathemaTIC depends on the fulfilment of certain critical conditions or pre-requirements as illustrated below.

MENJE's financial commitment was subject to confirmation, through a test-run, that at least 20 per cent of schools were willing to engage in using MathemaTIC in the classroom. The initial schools participated voluntarily as they were already committed in their current school development plan to improve student performance in mathematics. The bottom-up approach for schools to join the project, coupled with the perceived added value of MathemaTIC for students and teachers gave the project a successful initial take-off.

MathemaTIC is enriched through the creation, addition and adaptation of new pedagogical resources. These include the co-construction of items or exercises by experienced mathematics teachers, the content types and formats being different from those found in the school text-books. These technology-enhanced learning items are innovative, adaptive and aligned to the national mathematic standards for Grades 5 and 6 of the primary school curriculum. Through local and international collaboration, particular attention is paid to the mathematical culture and pedagogical approach of different origins (German, French and Anglo-Saxon) while respecting all intellectual property rights. Great care is taken during the translation process of the multilingual items to ensure coherence in the meaning and sequence of the items and to avoid bias across languages.

To bridge the digital divide and enhance equity of learning across local areas and schools, MENJE plans to support the upgrading of the technological infrastructure for wider implementation of MathemaTIC. Proper access to high-speed internet, strong Wi-Fi networks and the presence of technological and pedagogical staff increase engagement in learning. The pros and cons need to be explored further regarding the choice of personal computers, tablets and operating systems for schools, the number of devices per school and class, the technology restrictions required and the real cost and added value of such investments.

Another vital factor that underlies the successful implementation of MathemaTIC relates to the management and effective use of the 'big data' generated from the formative assessments, the tracking of student learning and the creation of automatic student profiles. Important though this may be to monitor learning, the national policies related to personal data protection often define (and restrict) the access to these data for parents, teachers and researchers. In the case of MathemaTIC, the primary use of data is for the teachers and students in order to raise attainment. Parents can only access the data related to their child. Confidentiality of data is treated with utmost concern and MENJE only has access to anonymised data to allay the fear of schools that information may be used for the purposes of sanctioning. Data used for the purposes of research and analysis may only be obtained subject to authorisation from the National Commission for the Protection of Data.

The volume of data generated by MathemaTIC itself to inform learning is huge and initially may not make much sense to the teachers and students if

they are not cleaned, filtered and well-structured, a fastidious process in itself. A data evaluation team thus reviews all the data generated and MENJE offers training sessions to assist the teachers in interpreting and using the student and class feedback to guide teaching and learning. Without this support, the added value of receiving real-time data only remains hypothetical.

Resources, technology and data by themselves count for very little if MathemaTIC does not become an integral part of the daily teaching and learning process. Continuous compulsory and optional teacher development sessions and adequate school support are provided by MENJE – an indispensable factor to respond to the demands of schools and monitor the satisfaction of the users. The close collaboration of teachers and international expert partners combines with a pool of pedagogical, psychometric, research, technological and project management expertise. The MathemaTIC team also reaches out through international networking and participation in relevant conferences and workshops.

The teacher development sessions are intended to trigger a progressive shift in the pedagogy, especially in terms of the use of time and space for learning, the strategies for learning, the relationship between teachers and students and the context in which learning takes place. Technology is viewed only as a means to allow the diversification of teaching and learning methods and to provide access to various types of access to knowledge content. It leads teachers to acknowledge they are not the sole provider of knowledge and hopefully to initiate the required transformation of classroom activities. Assessment practices are also automatically reshaped – because the assessment no longer aims at sanctioning but instead monitors student progress throughout learning – it is both an assessment for and of learning. Since there is no boundary between teaching and learning in school time and 'outside school', the model of the flipped classroom implicitly comes into play.

The content of teacher development fosters an optimal use of MathemaTIC and seeks to collect and share teachers' experiences through lesson observation, informal conversations and sharing of stories with respect to working with MathemaTIC. Such sessions address the new roles of teachers and suggest different ways they can facilitate and guide student learning so as to dismiss the reported uneasiness that teachers may be replaced via virtual or online learning. The accompanying didactical notes provided to teachers recommend ways to integrate the exercises in MathemaTIC into broader teaching.

The MathemaTIC project offers MENJE a new approach to addressing the content of mathematics and facilitates the validation of standards defined in the national curriculum. An experimental phase on a voluntary basis allows the gradual introduction of innovative pedagogy. Items created in the database represent a lasting investment as MENJE has access to the corresponding technology 'source code' and perpetual licenses which allows it the flexibility to use the interactive MathemaTIC items on other compatible interoperable digital platforms.

In the long run, MENJE may share this environment with educational publishers of mathematics to develop innovative solutions that accelerate learning by better targeting the needs of every student. Such a solution offers Luxembourg the ability to build the contents of a Luxembourg Mathematics Manual for subsequent publication, both in the digital format or on paper. All along the project, MENJE has attempted to consider all the conditions mentioned above in order to maximise the chances of raising attainment and tackling inequity in mathematics for all students in the participating schools.

MATHEMATIC EXPERIENCES AFTER ONE YEAR

Being a new initiative, MENJE piloted MathemaTIC during 2015-2016 in 40 volunteer schools, to be followed by an evaluation of the pilot phase and

finally a roll out to all schools, still on a voluntary basis. As it stands in July 2016, MathemaTIC is currently used by approximately 25 per cent of Luxembourgish children aged 10–11 and it is far too early to assess its real impact. Used on a regular basis, it will hopefully modify the way these students view and learn mathematics in a multilingual environment rather than only in German – the official instruction language. Already, MathemaTIC gives MENJE a deeper insight into the way a series of related exercises are solved and provides data about the strategies used and the level of understanding acquired by the participating learners. Besides, the final tests of the different modules will offer a large dataset containing large-scale, computer-based, low-stakes assessment data, which can then be compared to the annual national standardised tests.

First experiences reveal a high level of enthusiasm, general satisfaction of teachers and students, an increasing demand from other primary and secondary schools to join the project and the willingness to pursue their journey in MathemaTIC if it is offered in other grades. Yet, a few hurdles still need to be addressed. There is room to increase the variety, complexity and quality control of the MathemaTIC content by taking on board the feedback and contributions during teacher development sessions. Though this is quite time-consuming, the long-term benefits of a rich national learning environment cannot be undermined. Filtering out the relevant and useful data from the mass generated by each user click is laborious but transforming this data into a readable and useful form for teachers and policy makers is critical to evaluate the impact and return on investment.

Evaluating the functioning and the effects of MathemaTIC is also a taxing component of the project, to examine the extent to which schools will have efficiently integrated MathemaTIC into classroom learning to raise attainment. This evaluation consists of: a constant review of the item creation process; the definition of the implementation protocols to be followed by teachers, support staff, observation teams; the elaboration of the evaluation framework of the project; and the psychometric validation of assessment and learning tools. The evaluation framework defines the expected results, identifies the indicators and criteria, describes the measuring instruments and fine-tunes the strategy of data collection and analysis. To measure whether students succeed better when using MathemaTIC, evidence of learning will be linked to other student performance data, the effect of the multilingual environment on student learning, student motivation, teacher development, the change in teaching methods, the overall satisfaction of students and teachers, the involvement of parents in learning and how the digital environment bridges the gap in learning.

One first common practical challenge encountered is striking the balance between the short-time frame which defines the political agenda and the longer time period required to create, effectively use and integrate the environment into schools. Another challenge is the extent to which MENJE needs to be prescriptive or directive in its approach to ensure that certain optimal conditions of use of MathemaTIC are respected. Experience shows that even if didactic guidance is provided, this does not in any way imply an efficient use of MathemaTIC or that effective learning will ensue.

CONCLUSIONS

MENJE launched the MathemaTIC project as such an adaptive learning environment for mathematics would be in line with its plans to modernise and diversify its educational resources, content and digital services in order to raise attainment in schools. Adapting learning materials to the curriculum and specific needs of students clearly implies reducing educational and social inequalities, promoting inclusive education and in turn decreasing early school drop-outs. In addition, the multilingual aspect of MathemaTIC and its power to offer diagnostic, formative and summative tools with real-time feedback

are elements that have served to directly motivate both students and teachers to view mathematics learning in another perspective. To keep the momentum high, MENJE moreover mobilised a pool of local and international expertise which continuously injects know-how on the pedagogical, methodological, technological, teacher development, evaluation and quality management aspects of the project.

Claiming at this very early stage, without conclusive data, that MathemaTIC will indeed raise attainment and tackle inequity, would obviously be premature. MENJE is nevertheless confident that creating the right conditions early on for the success of learning can only contribute to increasing the motivation of students and teachers to increase performance. Already, the initial enthusiasm, satisfaction and willingness to pursue the project are all positive signs that MathemaTIC has gained acceptance in the participating schools.

The experience gained so far also reminds MENJE of the necessity to maintain close dialogue with the schools and to continuously collect feedback and react in a timely manner. Teacher development has begun to raise awareness of the changing role of teaching, the first fundamental stepping stone to gradually changing the mindsets of teachers. Subject to the availability of financial and human resources and demand from the schools, MathemaTIC may be extended to (younger) grade 3 students and lower secondary students in future.

LESSONS LEARNED AND NEXT STEPS

Within the national 'Digital Lëtzebuerg' initiative, MENJE envisions MathemaTIC as a unique education initiative, specific to the local context, which makes Luxembourg an international front-runner in digital learning. Nevertheless, at this early stage there is no doubt that teacher motivation, buy-in and empowerment rank highest in promoting the success of the project. Focusing on this priority is in line with the European recommendation (European Schoolnet, 2013) for countries to build capacity for ICT pedagogical expertise through sustained investment in teachers' professional development. The Digital (4) Education enterprise needs to reach out to schools and translate its policies, which in turn feed into school improvement measures. MENJE should continue investing in both adequate infrastructure and pedagogical expertise (including ICT co-ordinators) in all schools. As an effective organisational means of supporting successful innovations, teachers will gradually be guided to work in professional learning communities to custom-build MathemaTIC and identify themselves as part of the sustainable Luxembourg solution to raise numeracy levels. Yet again this can only happen if students, teachers and policy-makers are able to take advantage of the new, objective feedback mechanism, that is, the data generated by MathemaTIC. MENJE needs to build expertise in learning analytics and educational data mining to make sense of the 'big data' that helps inform us on how different students learn. To address inequity, research using these data would enlighten us on which student actions are associated with better learning and higher grades, for whom, as well as what features (for example, the multilingual aspect) lead to better understanding or indicate engagement or satisfaction. MENJE also plans to collaborate with researchers to investigate the human-computer, user-centred design of MathemaTIC in its effort to improve usability and the user's learning experience. Medium and long-term planning to potentially extend the item creation process, in collaboration with other European countries, is envisaged. Sharing the results of MathemaTIC and the valuable experience gained will continuously be undertaken through networking and research conferences on education.

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