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| EIEi2c | **Programme de soutien à la valorisation et au transfert (PSVT)** |

**Rapport final**

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| **Date de remise :** 30 Janvier 2015 |  |
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| **Titre du projet :**  Developing Foundational Skills in Quebec Students: *Orienter la réussite des mathématiques émergentes* (ORME) software |
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### Programme de soutien à la valorisation et au transfert (PSVT)

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| GRILLE DE PRÉSENTATION |
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| Selon l’échéancier prévu, le projet pour lequel vous avez obtenu une subvention se termine sous peu. Ainsi qu’il est précisé dans la convention de subvention, un rapport final attestant de la réalisation des travaux doit être fourni. Pour ce faire, veuillez suivre la grille de présentation suivante. **Pour être valide, le rapport final doit être signé à la page 1**. |
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| **1. Résumé du projet**As a result of multi-year funding from MDEIE, the ORME project team has planned, designed, developed, and researched *Orienter la réussite des mathématiques émergentes (ORME),* the latest web-based tool accessible from the Learning Toolkit. Members of the multi-disciplinary ORME team consisted of researchers, subject matter experts, instructional designers, developers, pedagogical consultants, teachers and graduate students from the Centre for the Study of Learning and Performance, LEARN, CTREQ, Commission scolaire Pointe-de-l’ile, Commission scolaire des Affluents, Commission scolaire de la Beauce Etchemin and Commission scolaire English Montreal.The result is the completion of ORME (ver.1), a comprehensive evidence-based interactive tool designed to teach foundational mathematical concepts to young learners. ORME consists of three modules: Student, Teacher and Parent. The Student module contains an array of engaging instructional activities that are designed to help early elementary students develop their number sense, increase their proficiency in mathematics, and reduce their anxiety in mathematics. The Teacher module consists of a teachers’ Manage section that provides a reporting feature on students’ progress in the activities, along with an opportunity to customize use of ORME for different ability levels of students, and a Teachers’ Resources page that provides access to a host of multimedia material, including 100 lesson plans designed to facilitate use of ORME in the classroom. The Parent module provides an overview of ORME, along with tips on how to help develop proficiency in mathematics in the home environment.A field test of ORME conducted in the fall of 2014 involved 12 teachers and 234 grade-one students. Six experimental teachers taught their students (N=114) with the aid of ORME, while six control teachers relied on their usual approach in teaching their students (N=120). The outcomes of this short-duration field test revealed that the use of ORME showed significant promise in increasing student mathematics abilities and decreasing mathematics anxiety and boredom. Specifically ORME students demonstrated higher gains than their control peers in mathematical skills including adding, subtracting, pattern recognition, etc. as measured by the customised CAT-4 math sub-test, a standardized test of mathematical ability. In addition, experimental students reported less boredom and anxiety in learning mathematics than students in control classes.Additional funding provided by the Max Bell Foundation will enable further development and researching of the software. |
| **2. Description détaillée du projet****Original Objectives**: Le projet consiste à concevoir et développer un outil intitulé Orienter la réussite des mathématiques émergentes (ORME) destiné à développer les compétences de base en mathématiques. L’outil, axé sur le premier cycle du primaire, répondra aux besoins des élèves, de leurs enseignants et de leurs parents et se déroulera dans trois commissions scolaires. La plateforme internet sera interactive et gratuite.Le projet, d’une durée de 30 mois, poursuit les objectifs suivant : 1. Augmenter la proportion d’enfants qui atteignent le niveau 3 en numératie;
2. Augmenter la proportion des enfants qui atteignent le niveau de plus haut niveau en numératie ;
3. Diminuer la proportion d’enfants qui souffrent d’anxiété en mathématiques.

Cet outil, développé à partir de données scientifiques validées, a pour objectifs de: * augmenter de la proportion d'enfants qui atteignent le niveau 3 en numératie ou supérieur (maîtrise de l'utilisation d'outils mathématiques, la capacité à reconnaître les situations qui nécessitent l'utilisation d'outils mathématiques, la capacité de choisir des outils mathématiques, aptitude à comprendre l'information présenté en termes mathématiques, etc)
* augmenter la proportion des enfants qui atteignent le niveau de numératie supérieur à leur compétence initiale;
* diminuer la proportion d'enfants qui souffrent d'anxiété en mathématiques.

La structure organisationnelle sera composé de deux équipes pour mener à bien les différentes parties de ce projet: Une équipe de projet pluridisciplinaire (chercheurs, concepteurs pédagogiques, directeur créatif, gestionnaire / coordinateur du projet, les étudiants diplômés, et les conseillers pédagogiques) et une équipe de conception et le développement (directeur artistique, concepteur pédagogique, développeur).**Design and Development****A. Student module**Twenty-five online activities in two themes: *Number Concept* and *Additive Triads* have been developed. Each of these themes has been broken down into ideas, with each idea further sub-divided into a number of activities each building in their level of complexity and abstraction. Thus each “Theme/Idea” introduces a mathematical concept, through a sequence of activities that moves the student from concrete images and physical actions to mental images and abstract symbolic representations. The design allows for the teacher to observe how each student is performing an activity, and determine whether the student understands or is performing tasks in a rote manner. Each concept has been broken down into a multi-step sequence to allow for differentiation based on current knowledge as well as ability. For example, initially a student is asked to count by performing the equivalent of touching the image of each object, then by generating a mark corresponding to each object being counted, and finally by counting in their head and reporting that count using number symbols. This journey emulates mankind’s historical development (counting sheep by marking each one uniquely, counting sheep by putting small stones in a pile, one for each sheep, and counting sheep and recording the number). Following a similar sequence should provide each student with support, a fall‑back resource or method so to speak, if at any stage they become unsure of how to perform a task.For each activity, students are presented with a puzzle. This puzzle has a number of missing puzzle pieces. Each missing puzzle piece represents a set, or repetition, of the activity. Completing the set earns the student that puzzle piece. The activity is completed once the student gains all the missing puzzle pieces.In order to make some activities more manageable for students, they were broken down into multiple phases. In other words, students will provide an answer for the first part of an activity then click OK to check their answer. If it is correct, they move on to the second part of the same set. Only when a student has completed all the phases, he/she will gain the corresponding puzzle piece.A demo was created for each activity. Each video shows students the technical steps involved in completing the activity. Receiving information for the whole activity all at once might overwhelm students, so we present demos corresponding to each phase. All activities have a ‘help’ button at the bottom right of the screen to provide built-in just-in-time support. This help generally consists of a brief audio instruction followed by visual cues, and is context sensitive, dependent upon which phase the student is doing in the activity.A summary of the quantities of each of these features is provided below.

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| --- | --- | --- | --- | --- | --- | --- |
| **Theme** | **Idea** | **Activity** | **Number of Phases** | **Number of Demos (EN)** | **Number of Demos (FR)** | **Number of Context-sensitive *Help***  |
| Number Concept | Count | 1 | 1 | 1 | 1 | 3 |
| 2 | 1 | 1 | 1 | 2 |
| 3 | 2 | 2 | 2 | 4 |
| 4 | 1 | 1 | 1 | 3 |
| 5 | 1 | 1 | 1 | 2 |
| Compare | 1 | 3  | 2 | 2 | 9 |
| 2 | 3 | 3 | 3 | 9 |
| 3 | 3 | 3 | 3 | 9 |
| 4 | 3 | 2  | 2  | 8 |
| Add | 1 | 2 | 2 | 2 | 4 |
| 2 | 3  | 2 | 2 | 4 |
| 3 | 3 | 3 | 3 | 8 |
| 4 | 1 | 1 | 1 | 2 |
| Subtract | 1 | 2 | 2 | 2 | 4 |
| 2 | 2 | 2 | 2 | 8 |
| 3 | 3 | 3 | 3 | 9 |
| 4 | 3 | 3 | 3 | 5 |
| 5 | 3 | 3 | 3 | 5 |
| Decompose | 1 | 1 | 1 | 1 | 4 |
| 2 | 4 | 4 | 4 | 12 |
| 3 | 2 | 2 | 2 | 4 |
| 4 | 1 | 1 | 1 | 4 |
| Additive Triads | Combine Sets | 1 | 2 | 2 | 2 | 6 |
| 2 | 2 | 2 | 2 | 7 |
| 3 | 2 | 2 | 2 | 12 |
| **Total** | **25** | **54** | **51** | **51** | **147** |
| ***102*** *demos in total* |

Error feedback has been built into each of these activities. If a student makes an error, the tool provides an indication of where the error has occurred. Initially there is an audio cue (“booing” noise) to draw students’ attention. This is followed by visual feedback to help students see where they made an error. For example, if a student has to count the number of birds by clicking on them but they did not click on all of the birds, then the error feedback shows them which birds were not clicked on, and hence were not counted. The error feedback is context sensitive, with over 140 different instances where an incorrect answer is supported by distinct informative feedback. A soft-lock feature has also been incorporated into the tool, to help teachers to identify students experiencing difficulties in a particular skill. If a student makes three consecutive errors in a particular activity, he/she will be given a new set. In other words, the student will get a similar problem at the same level without gaining the puzzle piece. If the student then makes three more consecutive errors, he/she will receive a notice that the teacher should be called for help. The student will again get a similar new problem at the same level and so can continue using ORME until the difficulty has been overcome. At the same time, an unobtrusive icon will appear on the student’s screen so that a circulating teacher will be able to immediately become aware of which students are experiencing difficulty and need assistance. In addition, the teacher will be notified by electronic reports as to which students triggered such a soft-lock and during which activity the students were having difficulty.Although ORME is first and foremast a mathematics tool, the practicing and developing these skills was situated within a “world” framework. Inspired by the notion that mathematics is a universal language, each theme is assigned to a continent. For example, the *Number Concept* theme has been associated with the North American continent. Each continent has a host animal that helps guide students. Thus, Chuck the Moose is the host for *North American Friends*/*Number Concept*. Each idea has a particular animal category, such as “birds” for the *Count* idea in *Number Concept*. Each activity has a particular animal assigned to it, which lives in the associated geographical location. This animal is an “animal friend” and the picture of that animal friend is used for the puzzles that students are asked to complete. Once a student completes an activity, the animal friend in the picture is added to the student’s collection of animal friend pictures. When students are on the home page of the tool, they have the option to see their own collection by clicking on the “My Friends” page icon. The “My Friends” page displays pictures representing each animal friend that they have gained so far and when students click on a particular picture, a trading card of that friend is displayed. The trading card contains an image of the animal and a short description concerning the animal and its habitat. If students complete the activity a second time, they unlock a second trading card with a different image of the same animal friend. There are currently 58 images of animal friends for the four themes in ORME with many more images downloaded and saved for subsequent version of ORME. This concept of “animal friends” also provides a fun and engaging environment for grade one students.In addition to the above, there are two offline themes represented on the map to help incorporate kinaesthetic experiences in student understanding of mathematics: *Number Line* and *Mathematical Language*. From the student’s perspective, they are given a sneak peak of which animal friend is associated with each activity by being shown an incomplete puzzle. They are guided to ask their teacher how to gain this friend. For each offline activity lesson plans have been developed for teachers to use in their classrooms.Throughout all phases of this project, members of the educational community have provided regular input through meetings of the project team, workshops and classroom visits. During the initial conception phase, two classrooms were visited and students were provided with paper-based versions of activities. This experience aided us in constructing the eventual form of the online activities and also provided insight and feedback from teachers. Once a stable version of the *Count* and *Compare* ideas in *Number Concept* was constructed two classrooms were visited for usability testing, one French and one English classroom. These sessions led to a number of revisions to the student environment in online activities, but student engagement with the tool was extremely encouraging. Please refer to Appendix A for the notes on the usability testing (suggested revisions based on our observations). Appendix B provides a summary of the teacher focus group that was conducted following the usability testing. We also held a focus group session with our pilot teachers, which provided us with additional information concerning how the tool was being used in the classroom and teachers perception of students’ reactions to ORME. Appendix C provides a summary of this focus group session. Again, feedback from both teachers and students was very positive.The Student module may be accessed from: <http://grover.concordia.ca/elm-pilot/>. There are two student accounts that have been setup. Their login information is as follows:Username: eleve1 Username: eleve2Password: 123 Password: 123The account ‘eleve1’ has no content. This is what students will see when they first access ORME. The account ‘eleve2’ has made some progress through the activities. They have gained animal friends for the activities they completed. This account contains situations where the student is in the process of completing an idea with no difficulty, the student had difficulty but was able to move forward, the student is currently soft-locked and requires the teachers help, and the student successfully completed all activities in one idea and now has access to any activity related to that idea (if they want more practice).**B. Teacher Module**The Teacher module is similar in design to the student module but with additional features. Notably, there are no software restrictions in a teacher account, there is a teacher management section and a built in link to a teacher resources page.A student account contains a few software restrictions. Students have to go through the activities sequentially. For example, if they are in the *Number Concept* theme, in the *Add* idea, they have to first complete activity 1 before moving on to activity 2. They have to complete activity 2 before moving on to activity 3, and so on. Teachers do not have this restriction as they can access any activity at any time. They also have access to all of the animal friends. In each classroom the teacher faces students with a variety of background knowledge, abilities and learning styles. Grade one students generally are eager to learn, and have not had time to develop mathematics anxiety. In an effort to provide an environment that perpetuates these positive attitudes, and also accommodates the differences amongst students, ORME includes several features to support differentiation. A few have been mentioned in the previous section, notably the just-in-time help, the error feedback and the soft-lock feature. There are additional differentiation features in the teacher module.The Teacher module has a *Teacher Management* feature, which provides opportunities for differentiation and reviewing students’ progress in ORME. Using this feature the teacher can adjust the number of repetitions for each activity. To do this, the teacher creates a new plan and adjusts the number of puzzle pieces (repetitions) in any given activity. They can also assign an additional ‘redo’ (repeat of the puzzle) for any activity. Teachers are able to assign a single student or groups of students to such a plan. Plans can allow for students to progress through an activity more rapidly or where needed, require additional practice in an activity. For example, if a teacher sees that one (or more) of her students are struggling, she can assign extra practice. if she fears that too many puzzle pieces might discourage students, she can lower the number of puzzle pieces, but force students to do it twice. This means that students will effectively have to do the activity more times before moving on to the next activity, but will experience success more rapidly by virtue of gaining an animal friend sooner, and then a second time.The *Teacher Management* feature also informs teachers about their students’ progress using ORME. They receive notifications when a student has been soft-locked. This notification indicates where the student had trouble as well as the date when the soft-lock occurred. This feature ensures that the teacher is informed of all students experiencing difficulty. When the student is soft-locked, ORME suggests that they ask their teacher for help but the student may not do so. On the students’ screen, there is a small soft-lock icon on the bottom left. A circulating teacher can look for this icon and help any struggling students. Unfortunately, the demands of a classroom might interfere with a teacher’s ability to get to all students that require his or her attention. The notification feature thus allows teachers to determine if there are students struggling that they were unaware of. They can also view a report to obtain an overview of the progress of their class. This report provides information about how many puzzle pieces each student completed whether the student eventually completed a particular activity, if the student had trouble at some point in the activity and whether the student is currently stuck (soft-locked). If a student has been assigned a plan, the report reflects the setting of that plan. We have also created a “job aid” to help teachers understand how to use the Teacher Management features. The teacher module also contains a link to a *Teacher Resources Page*. It can be found here: <http://grover.concordia.ca/resources/elm/teacher/fr/>. This is a webpage that provides a collection of multi-media resources specifically intended to support teachers in their use of ORME. It contains additional information about the tool, and compiles the lesson plans, video demos, job aids, additional classroom resources and recommended external resources and online math games.The lesson plans provided come in a short or long format and were created for each activity in ORME in both languages, resulting in a total of 100 lesson plans. The short format is a condensed version of the longer lesson plan. These lesson plans consist of an overview and description of each activity, the principal learning goals, a list of prerequisite knowledge and skills, resources that will be needed for the proposed lesson plan (included as appendices), a warm-up activity for the students, a description of the main activity (either the online activity or a physical offline activity), a list of potential difficulties students may have with the new concept, suggestions for related activities in other school subjects, and suggestions for leading a consolidating “wrap-up” discussion with the students. The long versions of the lesson plans also suggest additional activities that teachers can offer to students who have completed the activity rapidly. These additional activities use simple resources (often supplied as appendix files) that will challenge these students and help maintain their interest and focus. This is another example of how ORME provides differentiation. The lesson plans can be accessed at this link: <http://grover.concordia.ca/resources/elm/lesson_plans/orme_elm_teacher_resources/orme.html>.Please see Appendix D for a sample lesson plan of an online activity, and Appendix E for a sample lesson plan of an offline activity.The Teacher Module may be accessed from: <http://grover.concordia.ca/elm-pilot/>. The login information is as follows:Username: enseignantPassword: 123Using this account, one is able to access the student activities, all of the animal friends, the *Teacher Resources* page, and the *Teacher Management* feature. There are two students linked to this teacher account. A plan was created and assigned to the second student. In the *Teacher Management* feature, you can see the notification of where they had difficulty and view a report for an overview of their progress.**C. Parent Module**The Parent Module can be accessed from: <http://grover.concordia.ca/resources/elm/parent/fr/index.php>. It is intended to help parents support their children in the home environment as they develop numeracy skills. The content we developed provides parents with an overview of numeracy and why it is important, an explanation of ORME and how the software helps develop numeracy skills, and advice on how to support their children’s budding numeracy skills outside of school.The site outlines the overall objectives of each theme and refers to the online ‘host’ animal in the software. For the online themes (*Number Concept* and *Additive Triads)* we provide detailed descriptions for parents about the activities their children are engaging in (in both French and English). These are simplified versions of what we provide teachers in the lesson plans.We also provide additional links to other early numeracy resources.**Professional Development and Implementation** Three full-day training workshops were delivered to twenty teachers from the partner school boards. These training sessions built upon each other, harnessing the experience and expertise of teachers to explain the pedagogical approach and gain support for the implementation of ORME in Quebec classrooms. **Workshop 1 (October 3, 2014):** The first bilingual workshop was attended (some remotely) by six Grade 1 teachers and three pedagogical consultants from the following four school boards: Commission scolaire Pointe-de-l’ile, Commission scolaire des Affluents, Commission scolaire de la Beauce Etchemin and Commission scolaire English Montreal. This workshop included the following: An overview of the principles and evidence that were used to guide the design of the software, time for teachers to explore the software themselves, explanation of the pedagogical principles underlying the design of ORME, and demonstration of the activities. The teacher resources were also introduced, such as the detailed lesson plans available for each of the activities. Finally, arrangements were made for support of the use of the software in the classrooms.**Workshop 2 (November 14, 2014):** The second workshop was purposefully scheduled almost six weeks after the initial meeting. The original six teachers and two new teachers from CSBE attend and an opportunity was provided for them to share their experiences to date, and swap tips and ideas regarding the implementation of ORME in different contexts. Different ways in which ORME lesson plans were being adapted and integrated into the classroom experiences were also discussed. The Teacher Manage features were presented, which enabled teachers to easily see how they could easily provide differentiated plans for different students depending on varying abilities in their classrooms. Presenting this at this time – after several weeks of use in the classroom – enabled the teachers to (a) be familiar with the software enough so that the features were not abstract and made sense to them, and (b) have concrete data about their students’ performances in order to inform their organization of students into newly made differentiated plans. French and English focus groups were conducted with the participating teachers concerning additional teacher resources required, perceived attitudes and ease of use of the software by students, and possible overlapping with reflective practice to be reinforced with use of ePEARL. **Workshop 3 (January 8, 2015):** Twelve teachers attended this workshop. Five were the original cohort, and seven were new colleagues. The first session explained how ORME tied in to the QEP, and provided novice teachers with some hands-on exploration guided by the experienced teachers. Novice and experienced teachers were then split up. An introduction to the software and its pedagogical underpinnings, as well as the provided lesson plans, were presented to novice teachers, while the experienced teachers were introduced to *Theme 2 (Additive Triads), Theme 3 (Number Line)* and *Theme 4 (Mathematical Language)* activities and lesson plans. The following session introduced the novice teachers to the Teacher Manage section with the help of the experienced teachers. Support for technical issues, like logging in and managing student accounts, was also provided. The afternoon session capitalized on the experience of our original cohort of teachers who volunteered to share their experiences and lessons in a variety of topics, with the novice teachers. Simultaneous discussions were conducted about teaching one specific activity, using ORME as a whole-class activity vs. in a centre, making use of differentiated instruction using the software, and adapting the lesson plans to the classroom reality. The final session of the day touched on the expansion of the Teacher Resources page and the new Parent module, as well as a review of what needed to be done to get started using ORME in the classroom, for the benefit of novice teachers.Relevant printouts and job aids were created and distributed to all the participants at each of the workshops in the language of their choice:* Agendas,
* “Instructions for Getting Started with ELM”, (Appendix F)
* “ELM Cheat Sheet”, (Appendix G)
* “Instructions for Managing Classrooms”, (Appendix H)
* “Job Aid for Changing Student Settings in ELM”, (Appendix I)
* “ELM Cracker Barrel Recording Sheet”, (Appendix J)
* “Workshop Evaluation” (Appendix K)

**Research****Research Summary**A field test of ORME was conducted in the fall of 2014 involving 12 teachers and 234 grade-one students. Six experimental teachers taught their students (N=114) with the aid of ORME, while six control teachers relied on their usual approach in teaching their students (N=120). Classroom observations and ORME trace data indicate that the implementation of ORME varied among the experimental classes including classroom technology configuration, time of student exposure to ORME, and the amount of teacher control over ORME activities. After a 6- or 7-week intervention, where an average student used ORME for less than 30 minutes per week, the data (mathematics achievement and emotions about mathematics) favoured students in the ORME group. Specifically ORME students demonstrated higher gains than their control peers in mathematical skills including adding, subtracting, pattern recognition, etc. as measured by the customised CAT-4 math sub-test, a standardized test of mathematical ability. In addition, experimental students reported less boredom and anxiety in learning mathematics than students in control classes. This field study opens the door to further research of ORME effectiveness, wherein study design, instrumentation, and many aspects of ORME implementation should be refined to ensure conclusive findings. **Method****Study Design***:* In the fall of year three, a full field test of ORME software and pedagogical materials was performed to complete the evaluation stage of the ADDIE model. Five schools, located in urban and suburban areas, from three Anglophone and Francophone school boards (EMSB, CSPI and CSA) in Quebec, participated in this evaluation. In order to capture the changes in student mathematics achievement and attitudes towards mathematics, we designed this field test as a small-scale quasi-experimental two-group post-test study. Twelve teachers and their students from 6 experimental and 6 control classrooms were involved. The control teachers and their classrooms were selected to match as closely as possible the experimental teachers and their classrooms. All teachers followed provincial curriculum requirements for the development of Mathematics and were at liberty to decide on the method of classroom instruction as well as instructional tools. The six experimental teachers taught with the aid of ORME, while their control counterparts relied on their usual teaching approach. We collected student data in December of 2014 after ORME had been implemented in experimental classes for six or seven weeks. In addition, in order to learn about the use of the software by teachers and students, we observed Mathematics instruction in each experimental and control class twice and used trace data (collected automatically by the system). Informed consent was obtained from teachers and students’ parents following Canada’s Tri-Council Policy on the ethical treatment of research participants. **Sample:** Of the 234 students who participated in the field test, 120 were control (did not use ORME) and 114 were experimental (used ORME) students. The initial reduction in the sample size occurred after parents of 27 students did not give us their permission to use their children’s data. Further, nine grade-two students from one split class were excluded, leaving for analysis data collected from grade-one students only. Between 12 and 20 students had not completed one of the tests, further lessening the size of the sample whose data on mathematics achievement (N= 186, Nexp =99, Nc = 87) and attitudes towards mathematics (N=178, Nexp =95, Nc=83) were available for the analyses.I**ntervention***:* During the study, the 6 experimental teachers received two one-day long bilingual ORME training workshops in October and November. The research team also prepared and provided bilingual teaching materials including lesson plans for teaching different mathematics concepts and operations with ORME. The decision to use these materials was left to the teachers’ discretion. ORME also offered embedded multimedia scaffolding and support for teachers and students. The purpose of these workshops was two-fold: to help teachers build capacity in using ORME for mathematics instruction as well as to provide a space for discussion and sharing. To maximize access to the technology, laptops were loaned to the experimental classrooms in order to have a ratio of at least one laptop per six students. Oftentimes teachers chose to add to the existing classroom centers by arranging the laptops as an ORME centre. Rotation between stations enabled students to use ORME individually. Technologies used for mathematics teaching varied among the experimental classrooms. Some arranged for access to a stationary computer lab to be used on a weekly basis; others enjoyed a mobile lab. If available, teachers also used interactive electronic boards to demo ORME activities to their students or to complete activities with the entire class. **Instrumentation**: Students’ skills in mathematics were assessed using a customized version of the 4th edition of the *Canadian Achievement Test*, CAT-4, Mathematics subscale (Canadian Testing Centre, 2010, http://www.canadiantestcentre.com/CAT4/CAT4-Home.php), a standardized achievement measure developed in the Canadian context. Twenty-one multiple choice items from CAT-4 levels 10 and 11 were selected into the compilation based on their relevance to the concepts and operations addressed by ORME including counting, adding, subtracting, pattern recognition. An abridged version of *Academic Emotions Questionnaire – Elementary School*, AEQ, (Lichtenfeld, Pekrun, Stupinsky, Reiss & Murayama, 2012, http://dx.doi.org/[10.1016/j.lindif.2011.04.009](http://dx.doi.org/10.1016/j.lindif.2011.04.009%22%20%5Ct%20%22doilink)) of 20 items was used to measure students’ emotions about mathematics in class and at home. These tapped on the three commonly experienced in school context emotional states of mathematics enjoyment, anxiety and boredom. In order to fit the context of French and French immersion, both instruments were home translated into French. *Mathematics Instruction Observation form* (Lysenko, Rosenfield, Dedic & Searle, 2014, Appendix L) was used to collect and report observations performed twice in each of the 12 control and experimental classrooms. The form focused on the following aspects: classroom physical context, classroom management, affects of technology, structure of mathematics instructional activities, students’ motivation, engagement and enthusiasm, and ORME implementation. Besides the form also offered a scale of overall quality of teaching and student engagement. The observation schedule included two visits to each classroom: the first wave completed in the beginning of October and the second one in the middle of November. Control and experimental classes from the same school were observed on the same day in sequence by a trained observer with mathematics teaching experience. *ORME trace data* were also retrieved monthly. Learning Toolkit generated statistics of the time students spent in ORME that allowed us to follow the dynamics of use over the two months and to estimate the amount of student exposure to ORME.**Conclusions and Recommendations**The outcomes of this short-duration field test suggest that in the hands of teachers, ORME, an evidence-based tool, shows significant promise in increasing student mathematics abilities and decreasing mathematics anxiety and boredom. A few important considerations need to be addressed so that the findings of the full-fledged study of ORME effects are conclusive:1. Study design: To allow for examining the impact of ORME instruction on student achievement and mathematics-related emotions, the design of the study (quasi-experiment or experiment/RCT) should also include pre-testing of students.
2. Time of intervention: the implementation of ORME should start closer to the beginning of the school year in sync with the content offered by the curriculum and syllabus.
3. Length of ORME intervention and student exposure to ORME: In accordance with the research findings (*e.g.*, Slavin, 2011), an implementation has to be at least twelve weeks to ensure that any impact is reliably measurable. Our own research (Meyer, Abrami, Wade, & Scherzer’s, 2011) on the use of educational technology with young students suggests that the exposure to ORME should approach 60 minutes per student per week of student direct interaction with the tool.
4. Instrument selection: To ensure the appropriateness of the selected measures, the evidence collected during the testing should be considered. This need pertains to the pertinence of AEQ (both items wording and scale) to the student age group targeted in the study. CAT-4 items level of difficulty should be examined for probable ceiling and floor effects.
5. Development of teacher capacity to integrate ORME in mathematics instruction should focus on the following aspects: ORME’s affordances for math instruction (*e.g.*, differentiation); the fit between Quebec normative documents (QEP and Math Progression of Learning) and use of ORME for mathematics instruction; integration of ORME usage considering classroom constraints (managing centers, student rotation, ORME homework).
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| 1. **Évaluation du projet – Impacts et retombées**

The following section presents the results that were obtained after analyzing the student and classroom data. The CAT-4 and AEQ results make the core of this section whereas the description of the ORME instruction allows for situating these results within the instructional context.**Student Data:** To measure the difference between experimental and control students *the CAT-4* results were analyzed with an independent sample t-test allowing us to compare mean scores from both groups. We calculated composite scores by averaging the sum of the items addressing the same mathematics concept/operation. As a result the following 7 scores were available for the analysis: count and compare; count and subtract; add; subtract; pattern; counter; add and subtract. Table 1 shows the difference between ORME and control groups in CAT-4 mean scores. Table 1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Group | N | Mean | Std. Deviation |
| Count & compare | ORME | 99 | 0.93 | 0.17 |
|  | Control  | 87 | 0.92 | 0.15 |
| Pattern | ORME | 99 | 0.65 | 0.30 |
|  | Control  | 87 | 0.59 | 0.29 |
| Count & subtract | ORME | 99 | 0.68 | 0.25 |
|  | Control  | 87 | 0.64 | 0.27 |
| Add | ORME | 99 | 0.73 | 0.31 |
|  | Control  | 87 | 0.71 | 0.33 |
| Subtract | ORME | 99 | 0.56 | 0.42 |
|  | Control  | 87 | 0.53 | 0.42 |
| Counter | ORME | 99 | 0.75 | 0.44 |
|  | Control  | 87 | 0.72 | 0.45 |
| Add & subtract  | ORME | 99 | 0.64 | 0.48 |
|  | Control  | 87 | 0.28 | 0.45 |
| TOTAL | ORME | 99 | 12.83 | 3.71 |
|  | Control  | 87 | 12.02 | 3.53 |

The means presented in Table 1 indicate that students in ORME classes **consistently outperformed their peers in the control group on all mathematics concepts and operations** measured by the customized version of the standardized test. However the difference between the groups was statistically significant for the complex task of combining addition and subtraction skills (t (184)= 5.24, p< 0.000). This problem read as follows “Lakesha rolled two number cubes. Her cubes add up to 2 less than the total of the two number cubes in the picture. Which number shows the total of Lakesha’s roll?” Interestingly, on this item ORME students’ average score (M=0.64, SD=0.48) is higher than that of an average Canadian grade 1 student tested in spring (M=0.45, SD=0.50) (Technical Manual: CAT-4, http://www.canadiantestcentre.com/pdfs/CAT4TechnicalManual.pdf)To analyze the difference between ORME and control students on AEQ Mathematics scale, three composite scores of enjoyment, anxiety and boredom were formed in accordance with Pekrun et al (1992). Table 2 presents the mean scores of the two groups on the three subscales.Table 2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Group | N | Mean | Std. Deviation |
| Enjoyment | ORME | 95 | 3.73 | 1.27 |
|  | Control  | 83 | 3.79 | 1.13 |
| Boredom | ORME | 95 | 2.30 | 1.32 |
|  | Control  | 83 | 2.46 | 1.27 |
| Anxiety | ORME | 95 | 2.04 | 1.16 |
|  | Control  | 83 | 2.12 | 1.09 |

As table 2 shows, on average when reporting about their emotions towards their mathematics-related learning experiences grade one students in both groups manifest more enjoyment (“a lot”) than anxiety and boredom (“a little”). It is noticeable that ORME students reported less boredom and anxiety than their control peers, although no statistical significance was found between ORME and control students’ self-reports.**Mathematics Instruction***:* In total 24 observations were taken in six experimental and six control classes where each class was observed twice over the two months (October and November). On average in both groups the “quality of teaching and student engagement” ratings measured on a five-point scale are around 4 (Mexp= 4.08; Mc=4.04) implying the following scenario: “Most students are attending to the given task. There is minimal or no off task behaviour. The teacher is able to guide students through activities effectively.” It is important to note that the range of ratings in the experimental group varies from 2 to 5 whereas in the control group it ranges from 3 to 5. The lowest score of 2 was given in one case to a student teacher who taught in one of the experimental classes and means “Students occasionally attend to the given task. There is occasional disruption and movement not related to the activity. Occasionally, when the students are off task the teacher is able to refocus the group with some effort.” With this case removed, the average score of “quality of teaching and student engagement” in the experimental group changes from 3.83 in October to 4.7 in November whereas in the control group the score shifts from 3.75 to 4.33. Observation reports show that the control teachers in their instruction relied on technology in some form: almost all used smartboards and some educational mathematics software (for instance, Fish Game [www.toytheatre.com/fishing.php](http://www.toytheatre.com/fishing.php)). Table 3 presents the mean scores based on the ratings on a few quantitative questions pertaining to mathematics instruction provided in the observation reports of the experimental and control classes. The ratings granted to ORME teachers’ pedagogical actions were higher than those given to control teachers on all items except reinforcing mathematics concepts and skills and encouraging student dialogue and discussion. Table 3

|  |  |  |
| --- | --- | --- |
|  | Control teachers (N=6) | ORME teachers (N=5\*) |
| Teacher used mathematical language when giving instruction | 3.92 | 4.00 |
| Teacher provided clear directions | 3.75 | 4.50 |
| Teacher circulated and provided feedback | 4.25 | 4.50 |
| Teacher reinforced Mathematics concepts and skills | 4.25 | 4.00 |
| Teacher allowed the students who mastered the basics taking more challenging tasks | 2.08 | 3.20 |
| Teacher took initiative to check on student understanding during instructional time | 4.08 | 4.40 |
| Teacher took initiative to check on progress during work time | 4.08 | 4.40 |
| Teacher encouraged student dialogue and discussion during activities | 3.25 | 3.15 |

\* scores for a teacher-student removedAlthough it is not evident if higher rated instruction in experimental classes could be linked to the use of ORME, it is important to summarize the features of *ORME instruction*. This included students’ exposure to ORME either in their ordinary classrooms where available computers (including CSLP laptops) were organized in ORME centers around which students rotated or in the school computer labs. Trace data reports retrieved monthly showed that on average an ORME student interacted directly with the tool from 21 to 32 minutes per week. Observation reports in their turn suggest that for a student the optimal focused time spent on ORME software runs from 20-30 minutes per lesson. Students can be most successful on ORME software when before use the teacher explains and demonstrates an ORME activity and also models how to use the ORME help. In addition, ORME instruction seems to be more effective in a computer lab. On the one hand, there is an optimal computer-student ratio (one to one). On the other hand, teachers manage homogeneous all-class task more effectively, whereas managing students working in different centres within a classroom appears to be more challenging and requires additional skills from the teachers. One of the observers wrote: “Teachers attempting to establish part of the class on computers and part with another activity very often had difficulty providing sufficient support simultaneously to both groups.” It is important to note that observation reports indicate that teachers were split in their preference for a providing “flexible” or “controlled” instruction implying that some allowed students to progress with the activities at whatever rate students preferred, whereas other teachers had students perform the activity that teachers had chosen the day before doing any other activity. This did not seem to have any effect on students’ engagement or their ability to navigate the activities, though it did mean that some students would repeat earlier activities instead of moving on to the more difficult ones.Observation reports indicate that student response to ORME was very positive. The majority of students indicated that they found the activities enjoyable and either easy or just challenging enough. Any issues that arose were around technological difficulties with the beta version, and as expected, when students were able to help each other, those having trouble with the instructions were able to succeed.  |
| **5. Plan de diffusion** |
| Over the course of the project, the project team had ongoing and regular written and face-to-face communication with the consultants from the Educational Services departments in our partner school boards (Commission scolaire Pointe-de-l’ile, Commission scolaire des Affluents, Commission scolaire de la Beauce Etchemin and Commission scolaire English Montreal), LEARN and CTREQ to solicit their active involvement in the planning and design of the software. In addition, the school boards were asked to seek participants in the piloting and evaluation of the software. In some cases, online or face-to-face presentations were given to school administrators, math consultants and teachers to increase awareness and interest in the project. Such dissemination activities were met with enthusiasim and eagerness to participate given the critical need for a techology-based mathematical resource such as ORME. In addition to the above, the following two presentations were conducted :Savard, A., Dedic, H., Rosenfield, S., & Naffi, N. (2013, September). *Developing number sense with a digital tool*. Symposium at the Advancing Learning in Differentiation and Inclusion (ALDI) Symposium, Dorval, QC.Savard, A., Dedic, H., Rosenfield, **S**., Idan, E, & Head, J. (2014, November). *Developing number sense with a digital tool*. Workshop conducted at the annual QPAT convention, Montreal, QC.The team will continue to work actively with our partners (especially LEARN and CTREQ) and expand our reach to Canadian school boards through the design of a promotional video and website (both presently in development) and through future conference presentations and publications. Strong interest has already been voiced from the international community, especially from our Kenyan partners (Aga Khan Academies) in their desire to use ORME.**6. Conclusion** The ORME project team is exceptionally pleased with what has been accomplished with the funding from MDEIE. We are especially encouraged by the positive reaction to the tool from the educational community (from both teachers and students alike) and by the promising research results that were obtained from using ORME.The team was thrilled to learn of the awarding of the following additional funding for ORME :Abrami, P. C., Dedic, H., Rosenfield, S., Savard, A., & Wade, A. (2014-2017). *Emerging literacy in mathematics* (Operating: $300,000). Max Bell Foundation. This three-year grant from the MaxBell Foundation will enable further development of ORME and a full-scale study on its effectiveness in developing young students’ excitement and proficiency in mathematics.**Acknowledgements** The generous funding provided by MDEIE has been acknowledged on the following web pages: <http://grover.concordia.ca/resources/elm/teacher/fr/funders.php> and http://grover.concordia.ca/resources/elm/parent/fr/funders.php |
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