RIGOROUS ONLINE COURSES:

Ontario Reach Ahead

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This white paper by Crowdmark:

- identifies the problem obstructing massive online courses from achieving their potential;
- advances the solution through a new online collaborative grading platform;
- describes an online course scenario including rigorous assessment with an effective business model;
- outlines how governments can boost student achievement while saving millions of dollars.

The scenario described here is just one of many ways that online collaborative grading can improve the global education system.

Summary:

Benefits to the Province of Ontario

Reach Ahead opportunities in Ontario public secondary schools have many benefits. Students who earn a university credit during high school are *more likely to finish university*, and *can complete their degree sooner, reducing the demand on the higher education system and reducing student indebtedness*. However, only 35% of Ontario secondary schools offer Reach Ahead opportunities, denying students in the other 65% of schools the benefits of earning university credit. This violates the Province's Equity and Inclusive Education Strategy. In this white paper, Crowdmark presents an online course scenario with rigorous assessment that enables the Ministry of Education to provide Reach Ahead opportunities to *all* secondary schools in Ontario.

Only 35% of Ontario secondary schools offer Reach Ahead opportunities. In this white paper, Crowdmark presents an online course scenario with rigorous assessment that enables the Ministry of Education to provide Reach Ahead opportunities to all secondary schools in Ontario.

We use as an example a first-year calculus class. Crowdmark will work with an Ontario university and secondary school stakeholders to create a rich online calculus course that covers the material from both the Ontario Grade 12 MCV4U Calculus expectations and a first-year university calculus course. The course will be broadcast to every Ontario secondary school twice a week, while on the remaining three days, teachers in the participating secondary schools work with their students on homework and provide additional academic support. Students are assessed using exams distributed electronically to each school, printed and written locally, then uploaded to Crowdmark for anonymization, randomization, and distribution to the participating teachers, who grade the papers online using Crowdmark, in half the usual time. At the end of the year, the top students (based on their assessments) are invited to apply for university credit at a significantly reduced fee. The university has access to the students' portfolios stored in Crowdmark and is able to rapidly determine eligibility for university credit.

Crowdmark has developed a web-based platform to support the rigorous assessment of students required for the success of this scenario. It contains these essential elements:

- *Distribution Infrastructure:* systems to distribute exams to and collect exams from the participating secondary schools;
- *Team Dashboard:* tools for assembling and managing the marking by teachers from the participating secondary schools;
- *Crowdmarking Workflow:* a streamlined web process for marking teams to collaboratively evaluate student work;
- *Data Archive:* an organized repository for storing student work and the associated assessments of that work.

This is just one example of online collaborative grading. Once its value has been demonstrated, online Reach Ahead opportunities could be developed and made available in the sciences and many other academic disciplines, allowing Ontario secondary school students to enter university with up to a full year of validated university credit, and graduate with a four-year degree in three years. This scenario illustrates how the Government of Ontario can boost student achievement while reducing time to degree and saving the Province millions of dollars.

Summary:
Benefits to the University

Reach Ahead opportunities in Ontario public secondary schools have many benefits to students. Students who earn a university credit during high school have expectations and study habits that are more aligned with university requirements. They are more likely to finish university and can complete their degree sooner, reducing the demand on the higher education system and reducing student indebtedness. In this white paper, we demonstrate that Reach Ahead opportunities *provide significant benefits to the university* as well.

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Crowdmark presents a scenario with an effective business model that *creates a new revenue stream* for universities, and has the potential to *reduce the time to degree*. Imagine a Reach Ahead opportunity offered to all secondary schools in Ontario: for example, a first-year calculus class. Crowdmark will work with university and secondary school stakeholders to create a rich online calculus course that covers the material from both the Ontario Grade 12 MCV4U Calculus expectations as well as a first-year university calculus course. The course will be broadcast to Ontario secondary schools twice a week, while on the remaining three days, teachers work with students in class on homework and offer additional academic support. Students are assessed using exams that meet university standards for achievement. The exams are distributed electronically to each school, printed and written locally, then uploaded to Crowdmark for anonymization, randomization, and distribution to participating teachers, who grade the papers online. At the end of the year, the top students (based on their assessments) will be invited to apply for university credit, for a fee. The university will have access to an archived collection of student work to use as the basis for awarding credit.

Crowdmark has developed a web-based platform to support the efficient, rigorous assessment of secondary school students required for the success of this scenario. It is comprised of these essential elements:

- *Distribution Infrastructure:* systems to distribute exams to and collect exams from the participating secondary schools;
- *Team Dashboard:* tools for assembling and managing the teams of both teachers from the participating secondary schools for marking exams, and university assessors for adjudicating credit awards;
- *Crowdmarking Workflow:* a streamlined web process for marking teams to collaboratively evaluate student work;
- *Data Archive:* an organized repository for storing student work and the associated assessments of that work.

This is just one example of the deployment of online collaborative grading. Once feasibility has been demonstrated, Reach Ahead opportunities could be made available in the sciences and many other academic disciplines, providing a significant revenue stream to the university.

The Instructional Communications Mismatch Problem

The emergence of massive online course platforms has expanded the ability of educators to broadcast rich multimedia instruction to huge classes of students all over the world. Participants in these courses demonstrate their learning by answering multiple choice questions inside videos, filling in web forms, and participating in giant online forums with other students.

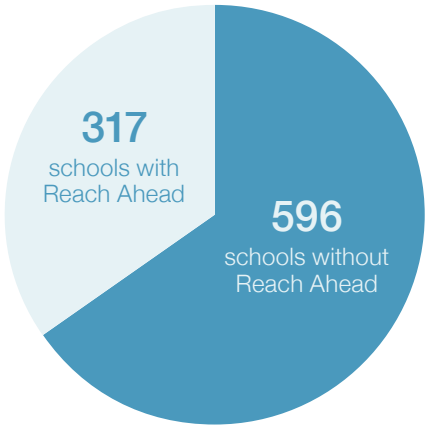
Compared to what happens in a small seminar, students in current massive online courses do not receive rich human responses to their work. The feedback channel from student to instructor has much lower bandwidth than the broadcast channel from instructor to student. The communications mismatch problem in massive online courses obstructs the rigorous certification of learning achievement and accounts for the failure of MOOC business efforts to date.

Collaborative online grading, 'crowdmarking', amplifies human capacity to respond to and evaluate student work to arbitrary scale. Crowdmark solves the instructional bandwidth mismatch problem.

Scenario:
Ontario Reach Ahead

The Province of Ontario has 913 public secondary schools. By offering International Baccalaureate and Advanced Placement programs, 317 of these schools offer a Reach Ahead opportunity allowing grade 12 students to earn first-year university credits through studies at their high school. Students at the remaining 596 schools are disadvantaged and don't have Reach Ahead opportunities. This situation is unfair and violates Ontario's Equity and Inclusive Education Strategy.

Reach Ahead Opportunities in Ontario Secondary Schools



Students at 596 schools are disadvantaged and don't have Reach Ahead opportunities.

The inequity grows more significant when you consider that students who earn a university credit during high school are more likely to finish university. This result has been established through research and makes logical sense: students who perform university-level work while in high school have their expectations and study habits aligned with university before they arrive there. In Ontario, the situation was exacerbated by the elimination of Grade 13 Ontario Academic Credit which produced a gap between the K-12 and postsecondary curricula that continues to widen.

Ontario's investment in higher education is more likely to achieve desired outcomes with an expansion of opportunities for students to earn university credits while in high school.

Proposal:
A Calculus Course to 1,000 Classrooms

We propose a deployment of an online calculus course that equalizes the Reach Ahead opportunity across the entire Province of Ontario.

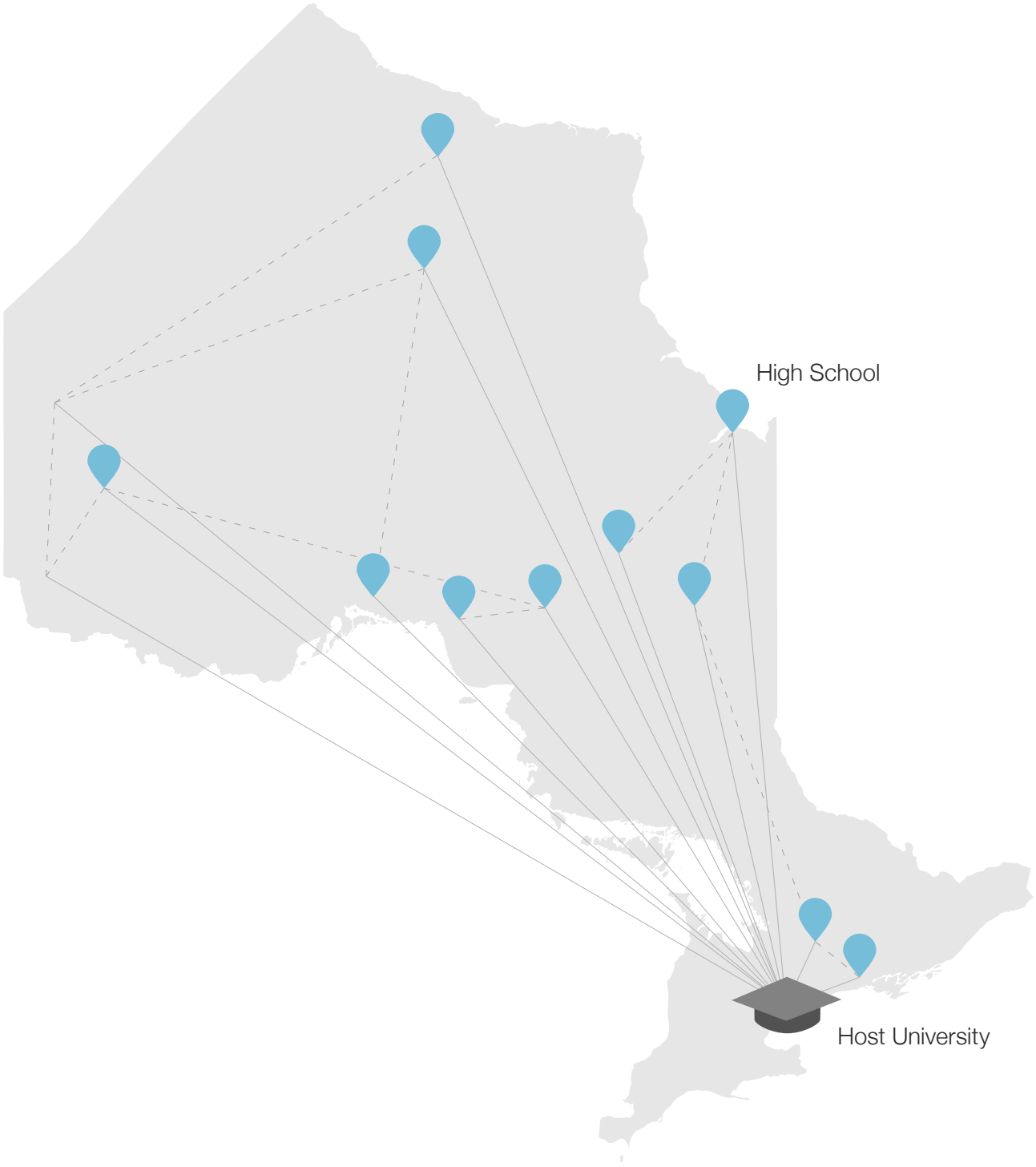
For simplicity, let's assume that:

- Ontario has exactly 1,000 public secondary schools (instead of 931);
- Each public secondary school has a multifunction printer/scanner and basic internet connectivity;
- Each public secondary school has exactly one grade 12 calculus class;
- Each grade 12 calculus class is taught by exactly one teacher;
- Each grade 12 calculus class has exactly 25 students;
- Each class writes two midterms and one final exam per semester;
- Each exam is 10 pages long so each student produces 60 pages of exam work.

Through partnership with an Ontario school board (for example, the Toronto District School Board) or an Ontario independent school (for example, the University of Toronto Schools) and an Ontario university (for example, the University of Toronto), we build a team-taught online course and broadcast rich multimedia calculus instruction from the university into 1,000 Ontario classrooms using the web. The course content, enriched with videos, simulations and synchronous quizzes and differentiated instruction, can be designed to cover the Ontario Grade 12 MCV4U Calculus expectations as well as a first-year university course like MAT135 at UofT. The course is streamed live on Tuesdays and Thursdays. On Mondays, Wednesdays and Fridays, the 1,000 teachers flip the classroom, supplementing the course material with group problem solving sessions and individualized instruction.

Proposal: A Calculus Course to 1,000 Classrooms

Exchange Between Ontario High Schools and the Host University



Archived Rigorous Assessment of 25,000 Students

A rigorous first-year university calculus course will often have two midterm exams and a final exam per semester. These exams include questions asking students to express their ideas through writing and calculation. Each of these exams is about 10 pages long, so throughout the academic year each student creates approximately 60 exam pages to be assessed.

The evaluation of responses from students requires work by skilled graders. When graders give formative feedback to students, the midterm exams create opportunities for students to solidify their learning. The pioneering research by Black and William and a stream of subsequent studies have shown that formative assessment vastly improves learning outcomes.

By taking advantage of cut and paste, embedding links pointing to learning resources on the web, and allowing for the expression of elegant mathematics in comments, the collaborative online grading platform empowers teams of markers to give rich formative feedback to students.

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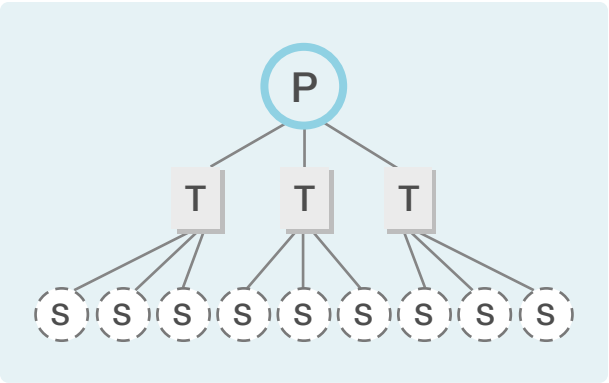
It is a daunting task to imagine reading, evaluating, scoring and annotating 1,500,000 exam pages (60 pages × 25,000 students). This is the equivalent of a row of banker's boxes as long as a football field with each box containing 5,000 pages. But we can accomplish this task by leveraging the team of 1,000 remote teachers involved using online collaborative grading.

Assessment Distribution Infrastructure

Using Crowdmark, we can run and evaluate an exam in the reach ahead calculus class. With LaTeX, Microsoft Word, Adobe Creative Suite or whatever tools they wish to use, the lead instructors in the course oversee the creation of a PDF file containing the exam questions and spaces for the answers. Using the Crowdmark distribution system, 25 copies of this blank ten-page exam can be sent electronically in the form of a 250 page PDF file to each of the 1,000 teachers. Each page distributed this way by Crowdmark has a uniquely addressable graphical code. The teachers print and staple the exams into booklets locally at their school. The exams are then written by students and collected by the teachers. Staff at the schools (or with help from outsource partners) scan the 250 pages into digital images using the school's photocopier/scanner. On standard photocopiers, a scan job of 250 pages will take approximately 20 minutes. The digital images from each school are uploaded into Crowdmark and routed into a database for marking using the graphical codes appearing on each page.

Rigorous Online Course Assessment Distribution



P — University professor sends digital assignments to high schools

T — High school teachers print assignments and distribute papers to students

S — Students complete assignments and hand them in to teachers

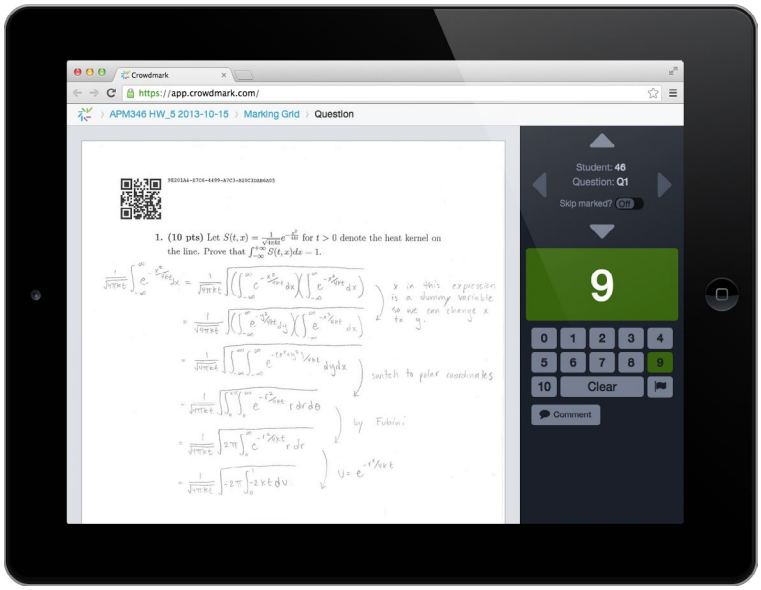
T — High school teachers scan and upload assignments to Crowdmark.

Crowdmarking

Each of the 1,000 teachers are invited to collaboratively grade the exam. This task is organized using the team management dashboard. Each teacher grades the same number of exams as s/he has students, so there is no increase in workload. But instead of marking the exams written by their own students, teachers grade a random sample of exams from across Ontario. Compared to the traditional red-pen-on-paper method, the crowdmarking workflow is streamlined. In experiments to date, Crowdmark has cut grading time by 50% or more. Graders can "write" on the student exam images using a mouse or stylus. Graders can leave rich formative assessment feedback comments with web links and mathematical expressions parsed by TeX and Mathjax.

After the grading of the exam is finished, the lead instructors electronically return the scanned images with the associated scores, comments and annotations to each student. Data for their own students is also made available to individual teachers.

This streamlined process allows the team to review score disputes. Communications channels between students, teachers, and parents (if appropriate) promote information exchanges anchored on the assessment and build new opportunities for learning and engagement.



Archived Portfolio

The exam images and associated feedback from the marking team are stored in the cloud. The formative assessment from all previous exams remain instantly accessible to students as they study. The teachers have access to each student's portfolio of work. The feedback given by the marking teams is visible to the central instructional team. By using the communications channels and referencing the portfolio of student work and assessment, exchanges among the central instructional team and among the 1,000 remote teachers can improve the quality of instruction and promote better Grade 12 to university curriculum alignment.

Using the communications channels and referencing the portfolio of student work and assessment ... can improve the quality of instruction and promote better Grade 12 to university curriculum alignment.

The portfolio belonging to each student includes scanned images of every page of their work in the course and the scores, comments, and annotations given by graders on each page. This record enables the university to make a detailed, evidence-based evaluation of student performance as part of the process for deciding whether to issue credit. The university could choose to hide the scores of 1,000 teachers and carry out a complete internal evaluation of the student's work. At the other extreme, the university could choose to completely trust the evaluation skills of the 1,000 teachers. By building systems to evaluate and train crowdmarkers, Crowdmark empowers the university to tailor their review of the student portfolio producing more rigorous decisions about issuing credit. The portfolio of student work also contributes to a more equitable, evidence-based decision process for determining whether credit can be transfered to another university.

Business Model for Reach Ahead Courses

As a point of reference, and based on FFTE and Ontario Basic Income Units, traditional year-long credits at the University of Toronto cost about $2,800. We describe a business model in which Grade 12 students in the massive online Reach Ahead calculus course earn credits for $100, a massive decrease of 96.5% of the traditional cost. Students who perform well, for example in the top 20% of the class, as measured by their scores on the exams are given the option to submit the portfolio of their work to the university for consideration for credit. The cost to make the request is $100 and the $100 is kept by the university if it determines that a credit should be issued. If the credit is not issued, the $100 payment can be returned to the student. If the top-performing 20% of the class exercises this option, the university receives $100 from 5,000 students, generating revenue of $500,000 from one calculus course.

Students earn credits for $100, a massive decrease of 96.5% of the traditional cost.

We can estimate the costs of running the course (see the following page). Note that the salary of the 1,000 teachers, the salary of the central instructional team, the past investment in hardware and software infrastructure, the past investment in physical infrastructure like buildings and classrooms are leveraged in this scenario and do not represent new costs. The main adjustment is to change from an essentially isolated set of 1,000 high school classrooms generally following a curriculum defined by the Province to a new collaborative workflow of 1,000 classrooms working together in partnership with a university and the Province.

Cost Estimates

- The online course content needs to be designed and prepared.
- Each student writes 6 exams per year, producing 60 pages of work to be evaluated.
- 25,000 students × 60 pages = 1,500,000 total pages
- Those pages need to be printed and scanned (we have a quantified solution).
- The pages written by students in the top 20% need subsequent review by university staff.

Quantifications

1. Course preparation cost: $100,000 (one-time-only)*
2. Paper cost: $12,900†
   - A case of paper containing 10 reams has 5,000 pages.
   - Each box cost $43 at Office depot. 300 boxes are required.
3. Paper printing cost: 1,500,000 × $0.03 = $45,000†
4. Outsource scanning: 1,500,000 × $0.08 = $120,000†
5. Crowdmark costs: $5/student × 25,000 students = $125,000
6. Review of Top 20%: 5,000 × 60 = 300,000 pages = $80,000‡
   - Experiments at UofT indicate crowdmarkers can review calculus exam pages at 150 pages per person-hour.
   - 300,000 pages reviewed at 150 pages per hour will take 2,000 hours.
   - UofT graduate student TAs cost $40/hour.

Total Cost, Year 1 (Estimate): $482,900 (Subsequent years will cost significantly less.)

* Represents the one time only costs of producing an online course including video production and technical support. After the content assets are produced, later versions of the course will be less expensive to produce.

† Can potentially be viewed as part of the normal workflow of the 1,000 schools and therefore may not be actual costs.

‡ Estimated under the assumption that every page written by students in the top 20% receives a detailed review by UofT graduate student teaching assistants. This level of review may not be necessary and will become unnecessary as the training and evaluation systems of the crowdmarkers develop in sophistication.

Cascading Benefits

The rigorous online course strategy outlined above is not restricted to mathematics courses. The same approach—leveraging online collaborative grading to scale rigorous assessment—can be used in other subjects. Imagine if this strategy were successfully implemented across all major disciplines. We can envision a future in which a majority of persevering first-year students arrive at university with a year of coursework already completed. This shortens the time to degree and opens up capacity in the higher education system.

Universities can begin to devote more of their limited resources toward advanced courses and research efforts. The portfolio of student work and all the associated feedback from markers allows entities like ONCAT and ECTS to facilitate credit transfer decision-making based on more thorough evidence of student achievement.

We can envision a future in which a majority of persevering first-year students arrive at university with a year of coursework already completed.

Conclusion

We have demonstrated that Ontario can cost-effectively provide reach ahead credits to students Province-wide. The risk is minimal, as the approach leverages existing investments in educational infrastructure and uses a proven method for scaling the assessment of student learning. It provides the opportunity for Ontario to improve student achievement and student success across our entire educational system.

About Crowdmark

Crowdmark is an education technology company based in Toronto. Crowdmark's ultra-scalable assessment platform and badged labor market enables evaluating and certifying learning on a massive scale. The global education explosion lacks scalable methods to certify achievement. Evaluating student work currently involves paging through piles of paper or using ineffective multiple-choice exams. Crowdmark streamlines document assessment and makes it easy for instructors to rapidly mark the work of their own students, or to assemble and manage teams of qualified graders for large classes with hundreds or thousands of students.

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