CSAP/PREC

COLLEGE STUDENT ACHIEVEMENT PROJECT

Developing Mathematics Assessment, Learning Outcomes and Curriculum for the Ontario College System: Final Report of a Feasibility Study

For the

Ontario Ministry of Education

and the

Ontario Ministry of Training, Colleges and Universities

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&

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Preface

The College Student Achievement Project (CSAP) team was requested by the Ministry of Training, Colleges and Universities (MTCU) to conduct a feasibility study into the development of a common assessment, common learning outcomes and common curricula for first semester college mathematics, of which this document is the final report.

The authors would like to acknowledge the contributions of all 24 colleges at each stage of this study and, in particular, of the Coordinating Committee of Vice-Presidents Academic (CCVPA) and its special subcommittee set up to guide the development of this report. As part of its work, the CSAP team distributed a discussion paper and invited comments from both college and school communities and we would thank every contributor to that process. Many of the comments received have been reproduced in this report. We would also single out Chris Blackwood of Mohawk College whose support throughout the study and detailed comments on the first draft of this report have made significant contributions to our work.

Finally, the authors wish to acknowledge the constant support and advice of their colleagues at Seneca College, especially Laurel Schollen (Associate Vice-President, Academic Excellence and CSAP Project Director) and Pina Marinelli-Henriques (CSAP Project Manager).

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Chapter 1: Background and Methodology

This study, while a part of the College Student Achievement Project (CSAP) which began in fall 2012, has its origins in the College Mathematics Project (CMP) which operated for six years from 2006 to 2012. The vision of the CMP was improvement in the college mathematics achievement of first-year students and, to this end, the CMP annually analysed the achievement of each first-semester cohort of students who took a college mathematics course and related this both to demographic factors and to the students' secondary school mathematics backgrounds. The CMP research model of deliberative inquiry also involved deliberations at local, regional and provincial levels through presentations at forums that brought college educators together with secondary school educators. The focus of these forums was always the search for new and better ways of increasing student success at college, particularly in mathematics. The results of this research and the subsequent forums are outlined in a series of CMP reports developed annually[1].

One of the features of the CMP was the understanding that student success at college was a responsibility shared among several partners, including the students themselves, the colleges, the elementary and secondary schools, and the government, among others. From its inception, the CMP was devoted (in the words of Jennifer Lewington, a writer on Canadian education) to "the politics of solutions" not "the politics of blame[2]." In this spirit, every CMP final report contained recommendations addressed both to the college community (including college faculty, administrators and the Ministry of Training, Colleges and Universities) and the school community (including teachers, administrators and the Ministry of Education).

The final report of the CMP 2011 included an extended chapter devoted to the qualitative analysis of the place and type of mathematics in college programs, the topics covered in a representative selection of first semester college mathematics courses, and a mapping of these topics back to the Ontario mathematics curriculum of grades 1-12[3]. Two types of mathematics course were analysed:

- Preparatory (remedial) mathematics courses and foundational mathematics courses (those found in the first semester of pre-business and pre-technology programs);
- Diploma-level mathematics courses, specifically representative 1st semester business mathematics courses or 1st semester technology mathematics courses.

[1] Reports of the College Mathematics Project for the past three years (for students entering college in Fall 2008, Fall 2009 and Fall 2010) are available on the CMP web site: http://collegemathproject.senecac.on.ca.
[2] Lewington, J. and Orpwood, G. *Overdue Assignment: Educating Canadians for Tomorrow's World* (Toronto: Wiley, 1993).
[3] Graham Orpwood, et al. *College Mathematics Project 2011: Final Report* (Toronto: Seneca College of Applied Arts & Technology, 2012), pp. 31-56.

The results of these analyses suggested that there was a relatively high degree of commonality across the college system in the foundational mathematics courses in pre-business programs, and also in pre-technology programs, a fairly high degree of commonality in diploma-level business mathematics courses, and a somewhat lesser degree of commonality in diploma-level technology mathematics courses[4].

Following the publication of this report, discussions began between the Ministry of Education, the Ministry of Training, Colleges and Universities (MTCU) and the Seneca College-based CMP research team concerning the future scope of CMP. In these discussions, MTCU officials made it clear that they saw an opportunity from this research for the colleges to work more closely together in the interests of student success and retention. Specifically, they proposed that the mandate of a new project (CSAP) be expanded to include three elements in addition to the normal research and deliberation on student achievement:

- Development of a common mathematics assessment for post-admission students;
- Development of common learning outcomes for initial mathematics courses; and
- Development of common curricula for initial mathematics courses.

As this was new to the college system and to the CMP/CSAP research team, the first phase of work in this expanded mandate needed to be a feasibility study, which would determine for each of these three elements, both the technical feasibility – can it be done? – and the political feasibility – do the colleges agree that it should be done? This report is the conclusion of this feasibility study.

Methodology

Of the three components of the feasibility study, one – the common assessment system – was the least well defined at the outset. It was known that some but not all colleges already used post-admission mathematics assessments and that a number of different assessment tests were in use across the province[5]. This information needed to be updated and assessed to determine the potential of building on what one or more colleges were already doing. In addition, the CSAP team wanted to integrate into the project the latest ideas about assessment from the international research literature. Accordingly, the following plan was undertaken:

[4] It should be noted that diploma-level mathematics courses were not selected for analysis from the full range of technology programs (i.e. from all Technology sub-clusters). We consider it likely that, had the full range of diploma-level Technology mathematics courses been analysed, the degree of commonality would be even less than that reported.

[5] A survey was conducted in 2008 for the (then) Heads of Mathematics - now the Ontario Colleges Mathematics Council (OCMC).

1. An email survey of all 24 colleges to determine which were using some form of post-admission mathematics assessment;
2. A teleconference with the relevant personnel at each college currently using a post-admission mathematics assessment to determine the instruments used, the purposes served by the assessment, their satisfaction with the assessment tool currently used, and their thoughts about developing a system-wide common assessment;
3. Preparation of a discussion paper to include the results of the teleconference surveys, a discussion of some of the principles that should underpin a common assessment system, and proposals for a specific model for a common assessment;
4. Following public distribution of the discussion paper, a survey of comments from colleges, from provincial college organisations, and from individuals at both colleges and schools;
5. Based on the feedback received, consideration of appropriate next steps.

In the case of the other two elements of the feasibility study – common learning outcomes and common curriculum – the methodology was, in one sense, more straightforward, in that the discussion paper (step 3 above) could contain the proposals with the feedback surveyed (step 4), and next steps considered (step 5) in the same way as with the assessment. However, while these elements were undoubtedly more clearly understood, establishing a province-wide consensus in relation to them might well prove more complex or controversial.

Throughout the process, members of the CSAP team have met with provincial groups of college officials, to explain the options and listen to comments on the proposals in the Discussion Paper. Specifically the following groups[6] were consulted during the year:

- Coordinating Committee of Vice-Presidents, Academic (CCVPA)
    - Heads of Business (HOB)
    - Heads of Interdisciplinary Studies (HOIS)
        - Ontario College Mathematics Council (OCMC)
    - Heads of Health Sciences (HOHS)
        - Provincial Pre-Health Coordinators
    - Heads of Technology (HOT)
- Committee of Registrars, Admissions & Liaison Officers (CRALO)
- Ontario College Mathematics Association (OCMA)

This report is being reviewed by an ad hoc committee of the CCVPA prior to its being sent to all colleges for final approval before it is submitted to the MTCU.

[6] The groups are shown here hierarchically deliberately to show their reporting relationships.

Discussion paper & survey of responses

The discussion paper, *Assessing Mathematics Skills for College: A Way Forward,* was published in February, 2013 and is available on the CSAP web site[7]. While it is not reproduced in full here, chapters 2, 3 and 4 of this report include a summary of the main points of each section of the paper. The paper concludes with questions for consideration by readers and a link to an on-line survey instrument, which was the required means for responding to the paper. Respondents were required to identify themselves and to state if they were responding on behalf of a college, a provincial organisation or on their own behalf. To date, we have received responses from 22 colleges, 3 provincial college organisations and a number of individuals from both college and secondary school sectors.

Each of the survey questions consists of a statement along with a four-point set of response options: strongly agree; agree; disagree; strongly disagree. This is followed by an open section for comments, so respondents may add whatever feedback they wish. The CSAP team therefore has a full database both of formal agreement or disagreement responses and of open-ended comments.

Outline of this report

This report follows the elements of the feasibility study mandate. Chapter 2 outlines the principles of assessment set out in the discussion paper together with the main features of the proposed assessment model. This is followed by a detailed analysis of the feedback received from colleges and others. Note that, in this and subsequent chapters, the quantitative analysis of agree-disagree responses from official representatives of colleges is first displayed graphically[8]. In each case, this is followed by a table showing the responses from three provincial organisations of college representatives which responded to the survey (Heads of Business, Heads of Technology and the Ontario College Mathematics Council). Finally, selected comments from all groups are set out.

Chapter 3 focuses on the learning outcomes and curriculum in foundational mathematics courses, with a particular focus on pre-business and pre-technology programs. Chapter 4 covers the same topics for diploma-level mathematics, with a particular focus on Business and Technology programs. In both of these chapters, the responses and comments from colleges, organisations and individuals are summarised.

Chapter 5 brings the report to a conclusion by outlining the next steps proposed in the three areas of the feasibility study mandate: assessment, learning outcomes and curriculum.

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[7] Graham Orpwood & Emily Brown. *Assessing Mathematics Skills for College: A Way Forward* (Toronto: Seneca College of Applied Arts & Technology, 2013). Links to both the paper and the survey are on the CSAP web site: http://csap.senecacollege.ca/en/index.php.

[8] Agreement or disagreement responses from other groups are not displayed graphically as we cannot assume that they are representative of each group. Their comments however are included.

Chapter 2: Mathematics Assessment of Incoming Students

As noted earlier, our preliminary research had revealed that 14 of the 24 colleges already conducted some form of post-admission mathematics assessment of students in some or all program areas where mathematics was a significant subject in the curriculum. The subsequent teleconferences with those fourteen colleges revealed only a moderate level of satisfaction with existing instruments and assessment practices and a general openness to developing a province-wide assessment test[9].

Principles of assessment

With this background, the CSAP team proposed a set of four principles to underpin any future development of a system-wide approach to assessment of incoming college students. These principles, which are explained more fully in the Discussion Paper, are as follows.

1. *The primary purpose of the assessment should be to support students' learning.*

Before embarking on a system-wide approach to assessing college students' mathematics skills, there needs to be a consensus on its basic purpose. On this, both the international research literature and Ontario policy has evolved significantly in recent years and is now clearly in favour of a student-centred system where "assessment for learning" takes precedence over "assessment for administrative purposes". The Discussion Paper cited five features of assessment for learning:

- The active involvement of students in their own learning;
- The provision of effective feedback to students;
- Adjusting teaching to take into account the results of the assessment;
- The need for students to be able to assess themselves;
- Recognition of the profound influence that assessment has on the motivation and self-esteem of students, both of which are crucial influences on learning[10].

Placing a focus on students' learning need not diminish an assessment's direct value to colleges. As the paper argued, a good mathematics skills assessment can assist colleges in placing students into appropriate courses in their first semester, it can enable institutions to use the results as baseline data for program or course evaluation, and it can enable the early identification of students likely to require additional support in college. It can also provide the basis for facilitating a constructive conversation with the elementary and

[9] More details of the results of this preliminary research and the teleconferences are set out in the Discussion Paper (see note 7).
[10] Adapted from: Stobart, G. (2008). *Testing times: The uses and abuses of assessment*. London: Routledge.

secondary school community about colleges' expectations of students in relation to mathematics knowledge and skills.

2. *The focus of the assessment should be on high levels of competence on basic numeracy skills.*

It is clear from the review of existing practice that any system-wide mathematics assessment should not be equivalent to an evaluation of students' grade 12 achievement. Not only are the tests in current use assessments of more generic mathematics skills, analyses conducted as part of the CMP 2011 research program showed that the preparatory mathematics courses offered at most colleges are focused more on basic numeracy skills than on topics taught in grades 11 and 12 mathematics courses[11]. In both pre-technology and pre-business mathematics, the list is headed by order of operations, fractions, decimals, percentages, ratio and proportion, and basic algebra. These are considered to be the basic mathematics competencies required for successful participation in college diploma programs.[12]

While the mathematical knowledge and skills to be assessed are of a fundamental nature, the competency required of students should be high. A 50% pass mark in calculations involving percentages or fractions, for example, is insufficient for students entering a college program that prepares them for employment in technology, business or health care.

3. *The assessment should be developed and operated according to high standards of quality.*

Over the past several years, standards for the development and use of assessment tests have been developed both in Canada and internationally.[13] These standards should guide the development of a college mathematics assessment. Selected aspects of these are as follows:

- Assessment must be seen not as a (test) document alone, but as a complete process that includes the conduct of the assessment and the uses made of the results.
- Assessments should be aligned with expectations for student learning and instructional opportunities and provide for feedback to students as an essential design element.

[11] See note 3.

[12] While a basic list applies to business and technology programs, some additional skills are required for technology programs.

[13] For example: *Principles for fair student assessment practices for education in Canada* (1993) (Edmonton: Joint Advisory Committee, Faculty of Education, University of Alberta); Joint Committee on Standards for Educational Evaluation (JCSEE). *Classroom assessment standards* (5th draft) (2013). In publication.

- Assessments should respect students' cultural and linguistic diversity and be free of bias.

4. *The assessment should be as cost-effective as possible*

While the assessment system needs to be of high quality, its costs – whether to the students, the colleges, or the system as a whole – need to be taken into account and the assessment system needs to be as efficient as possible. Developing the system involves much more than the development of the tests themselves and as the project proceeds many practical factors will need to be taken into account. Some of these are addressed in the final chapter of this report.

Responses to the principles

The focus of the first part of the survey is on the guiding principles behind a province-wide common mathematics assessment for the colleges, broken down into four specific principles. Figure 1 shows a strong level of support for a province-wide common mathematics assessment based on the four guiding principles:

- The purpose of the assessment is to support students' learning;
- The focus of the assessment should be on high levels of competence on basic numeracy skills;
- The assessment should be developed and operated according to high standards of quality;
- The assessment should be as cost effective as possible.

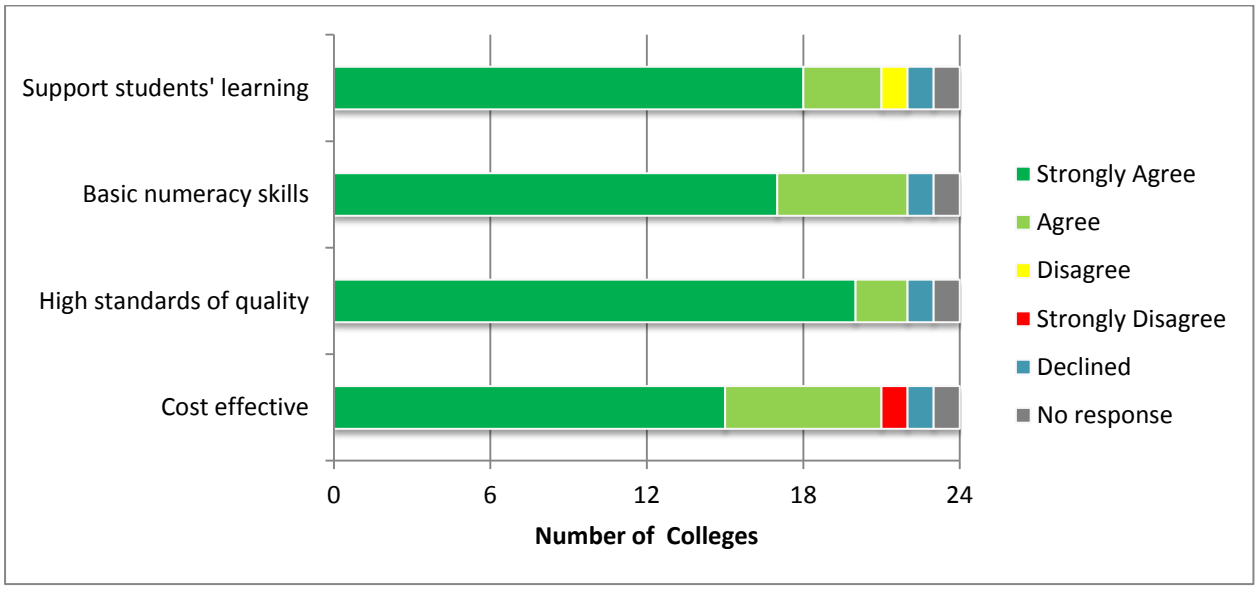

Figure 1: Colleges' responses to proposed principles for mathematics assessment

Table 1.
Provincial organisations' responses to proposed principles for mathematics assessment

	Heads of Business	Heads of Technology	Ontario College Mathematics Council
Assessment to support student learning	Strongly Agree	Strongly Agree	Strongly Agree
Assessment focus on basic numeracy skills	Strongly Agree	Strongly Agree	Strongly Agree
Assessment of high standards of quality	Strongly Agree	Strongly Agree	Strongly Agree
Assessment as cost effective as possible	Agree	Strongly Agree	Strongly Agree

While the figure above charts the results of the survey responses from official college representatives and provincial organisations, the comments listed below are drawn from all survey contributors which include those from the school boards, and college faculty and administrators who indicated that they were self-reporting to the survey. Readers should note, throughout this report, that we have selected comments to reflect the diversity of opinions expressed in the survey, and not as a reflection of our own views.

Supporting students' learning

Supporting students' learning was found to be of utmost importance to most respondents. The ability to be placed in suitable courses or programs, to identify areas of concern for remediation or areas of strength, and the timely administration of the assessment so a student could be better prepared before arriving at the college campus are described as ways that the common assessment could support students' learning.

- Assessing students alone is of little help to them unless there is some follow-up remediation or action taken to support their numeracy development. Information could be fed back to schools as well. Assessing FOR learning!!!
  -Numeracy coordinator, school board

- Another benefit would be to have this assessment done at the secondary level so the student can see if he/she is ready for post-secondary well before they have applied to a certificate/diploma program. So I really like your informal mode of use for the assessment in which the learner can take it while still in school.
  -College faculty

- We want to support student learning and success. An assessment tool that identifies areas for improvement and/or high levels of competence necessarily achieves that objective. Students are more likely to succeed when supported (e.g. placement in courses matched to their abilities; additional homework or remedial tools) according to their need.
  -College representative

- This philosophy of assessment has become embedded in K-8 education and it is becoming more firmly established in 9-12 education. Using assessment for learning helps to focus resources and supports for student learning which, in turn, allows for greater student success. It is a logical extension that colleges should adopt a similar approach to assessment.
  -School board superintendent

- The idea that students could access an "informal" test, obtain feedback on their weaknesses and be directed to resources to address those weaknesses prior to (or at the time of) applying to college is important and we are particularly supportive of the proposed model. The student could use this window of opportunity to self-remediate prior to writing a formal skills assessment.
  -College representative

- It is also felt that it will allow for the better utilization of resources.
  -College administrator

- Any math assessment, whether common to the college system or not, should not be a barrier for admission to college programs. It must instead be a method for students to self-evaluate their mathematic fundamentals, self-identify where mathematical weaknesses exist, and determine if further training is necessary for their success at college. It must not be viewed as an "Exit Exam" from secondary school mathematics if we are to work cooperatively with the elementary and secondary school system to improve the delivery of mathematics across the province.
  -Heads of Technology

Assessing basic numeracy skills

Many reported a concern with a lack of basic numeracy skills and foundational mathematics understanding of incoming students. While there was some concern over the definition of basic numeracy skill, it was agreed that students must come with the mathematics skills and knowledge to succeed in their chosen programs and that college instructors were not able to review those fundamental concepts as part of their college mathematics courses.

- I have found that in the last 5 years the learner's understanding of very BASIC numeracy skills has decreased immensely. I believe with a stronger foundation of these skills learners can be more successful.
  -College faculty

- I am very concerned with the lack of skills our students are coming to us with. Basic and complex numeracy (as well as literacy) skills are critical and oftentimes lacking.
  -*College administrator*

- Numeracy skills are very important to enable efficiency and accuracy during math tasks within the program, and within the workplace. But other skills are also important. i.e. a person without a high degree of competence with numeracy skills may still possess the critical thinking skills to apply what they have learned and/or problem solve through a task, using a calculator or other tool to aid them (including others working with them who have these skills). Whereas a person with a high level of numeracy competence without the critical thinking skills is less useful in a problem-solving situation or in the workplace.
  -*Math consultant, school board*

- The strong mastery of fundamental mathematics skills provided the foundation needed for success. At college we can teach them the more specific mathematical skills required by the industry (e.g. trigonometry for surveying, physics for structural design, calculus applications for fluid hydraulics) but we simply cannot afford the time and effort required to teach fundamental concepts such as order of operations, fractions, basic geometry and mensuration, basic algebra). Those are skills that they must bring with them, with a certain level of confidence and understanding, for the college system to do its job.
  -*Heads of Technology*

- It depends on what you mean by "basic numeracy". I would agree that number sense and operation sense *(not just computation)* should be pivotal, along with measurement, data management and some geometry and spatial sense. As for computation, the focus should be on mental skills and estimating, as well as other methods, reflecting their priority in the real world. The high school math curriculum is NOT basic numeracy. Internationally, the threshold for numeracy (according to IALSS) is approximately where the grade 8 curriculum in Ontario ends.
  -*Numeracy instructional coordinator, school board*

Maintaining high standards of quality in assessment

There was consensus that any common mathematics assessment must be of high quality to be of value to the college system and to students; a test which is reliable, trustworthy, modifiable and able to be validated.

- Agree wholeheartedly with the concept of a "High Quality Assessment" as described in the Discussion Paper.

-College administrator

- If there is to be an assessment it must be one of quality and validity. I would encourage CSAP to consult with the Education Quality and Accountability Office (EQAO) regarding their experiences in drafting quality tests related to curriculum expectations. If the test is going to focus on basic numeracy, the Grade 9 mathematics tests that have been created by EQAO would serve as a foundation and model for development of tests for the colleges.
  -Superintendent, school board

- Any testing has to be reliable or the results will never be considered trustworthy. This point is key to both faculty and students believing in the process. Ideally, the test should reflect (or be modifiable) to the Canadian post-secondary environment.
  -College representative

- As presented in the discussion paper, a high quality assessment test must be reliable and valid. There needs to be a means of ensuring quality in both the short and long term. Financial support must be provided and maintained if this assessment test is to have longevity and purpose. If possible, the test should include questions that demonstrate the applicability/transferability of basic numeracy skills in different contexts.
  -Ontario College Mathematics Council

Ensuring cost-effectiveness in assessment

While the cost of developing, maintaining and administering a common mathematics assessment is of some concern to colleges as a potential added expense to the college or the student, the effectiveness of the tool to support students' learning is stated as more important than cost. Adding to its benefits, it is suggested that the assessment may increase student retention and allow for a better use of resources.

- Not only does the process have to be cost-effective, but easy to integrate and manage. Additionally, the testing has to be time-effective as well. Everyone involved with the post-admission testing process has to have the results almost in real-time and therefore the assessment has to be computer based.
  -College representative

- The value of retention far outweighs any minor losses in the assessment process.
  -College faculty

- There might be additional costs associated with student support after assessment.

-College representative

- Cost is an important consideration in the production and use of the tool. However I believe that cost should be a less important consideration in the construction of the tool - better to create a strong tool than to save money
  -College representative

- It needs to be as cost effective but not "as possible". If we do that, we have a multiple choice test that can be marked by a computer...i.e. did they get the computation correct? The cheapest assessment does not measure mathematical thinking
  -Supervisory officer, school board

Summary

Overall, both from the formal (agree-disagree) responses and also from the comments, there is a strong consensus among the colleges about these principles. This consensus is most strongly expressed in relation to the purpose of assessment, which lies at the foundation of the proposed assessment model (described below). In relation to numeracy skills, the last comment reminds us that numeracy skills are a necessary *but not sufficient* basis for success at college. The second comment on the quality of the assessment also reminds us that any planned project should draw on the available assessment expertise and the comments on cost effectiveness encourage maintaining an appropriate balance between costs and the needs of students and the college system. Armed with these principles, we now turn to the model for a mathematics assessment system proposed in the discussion paper.

A proposed assessment model

In our survey of present practices across the Ontario college system, we learned about many aspects of assessment and the model proposed in the Discussion Paper drew on these experiences. In what follows, we reproduce the main features of the model.

Modular design for diagnostic purposes

In order to maximise the assessment system's benefits for student learning, a modular design that enables diagnosis and feedback leading to remediation is desirable. We envision a system made up of a basic set of numeracy modules (each focused on one topic, such as fractions, decimals, percentages etc.) together with possible supplementary sets focused on technology-specific, health care-specific or business-specific topics. Students could choose

to take the basic set and (optionally) one of the other sets, depending on the program areas they were interested in pursuing at college. Each module would be made up of a number of pre-tested items sufficient to establish a reliable topic score, from which to infer whether or not a student had demonstrated competence on that topic.

Computer-based assessment

In order to provide multiple consistent and reliable assessments, the test system would be computer-based. Each individual test would be constructed from a pool of items whose psychometric characteristics have been established. In addition, each test module would be linked to a remedial self-instructional unit so that students failing any given topic could immediately seek support.

Internet platform for universal access

In order to provide students with access to the assessment system throughout the province, we expect that both the assessment and instructional systems would be mounted on a web-based technology platform accessible from anywhere in Ontario. It should also be possible for the remedial instructional modules to be similarly accessible so that students could use them at school or at home as well as at college (see the next section for alternative modes of use).

Informal and formal modes of use

In order to maximise the value of this assessment system, we propose two modes for its use, formal and informal. The formal use of the assessment would be under the supervision of a college and be accessible to students who had received an offer of a place in (any) college program. The overall pool of items would be divided into two equivalent groups, with those for use in the formal mode of the assessment being maintained securely. A given student's results could be recorded on a student's profile (possibly in cooperation with the Ontario College Application Service (OCAS)) where it could be accessed by any college to which the student had made an application. Students would be invited to take the assessment as soon as they received an offer of admission with the results being recorded on the student's file. At the discretion of a college, as is the case at present, all or some students entering business or technology programs could be required to take the assessment.

By contrast, the informal use of the assessment would be widely accessible to students who might be still at secondary school or in academic upgrading and who are thinking about applying to college. It would use the non-secure part of the same item pool as the formal test, with feedback being provided to users (only) along with access to the remedial units. No permanent record would be kept of students' achievement for this mode of use. The advantage to students of taking the assessment would be to build self-confidence in their

readiness for a college program and/or to alert them of areas in need of further preparatory work prior to enrolling at college. The intended advantage to the colleges would be a reduction in the numbers of students requiring remediation or in danger of being 'at risk.'

Test development

To develop and field test a sufficiently large number of items for such a modular assessment to function in both informal and formal modes requires the cooperation of the entire college system and the mathematics teaching community in particular. We anticipate that test items and instructional modules will be sought from all colleges, edited into a standard format and field tested. In addition, the CSAP in cooperation with OCMC would set up a special committee to review the items being developed, approve their final selection following field testing, and assist in the development of self-study units. Input from the mathematics teaching community at the K-12 level and from EQAO will also be important to ensure the overall quality and appropriateness of the test items. In addition, specialist psychometric support will be required to establish item characteristics and design the modular test system.

Summary

Figure 2 is a graphic representation of the two modes of the proposed assessment model. Anchoring the overall model are the learning outcomes, which are common to both formal and informal modes of the assessment. These learning outcomes correspond to those of the foundational or preparatory mathematics courses (discussed in chapter 3 of this report) and the test items comprising the overall item pool are linked to these. The improvement (or remedial) modules (in the informal mode) and the foundational mathematics curriculum (in the formal mode) are also based on the same learning outcomes.

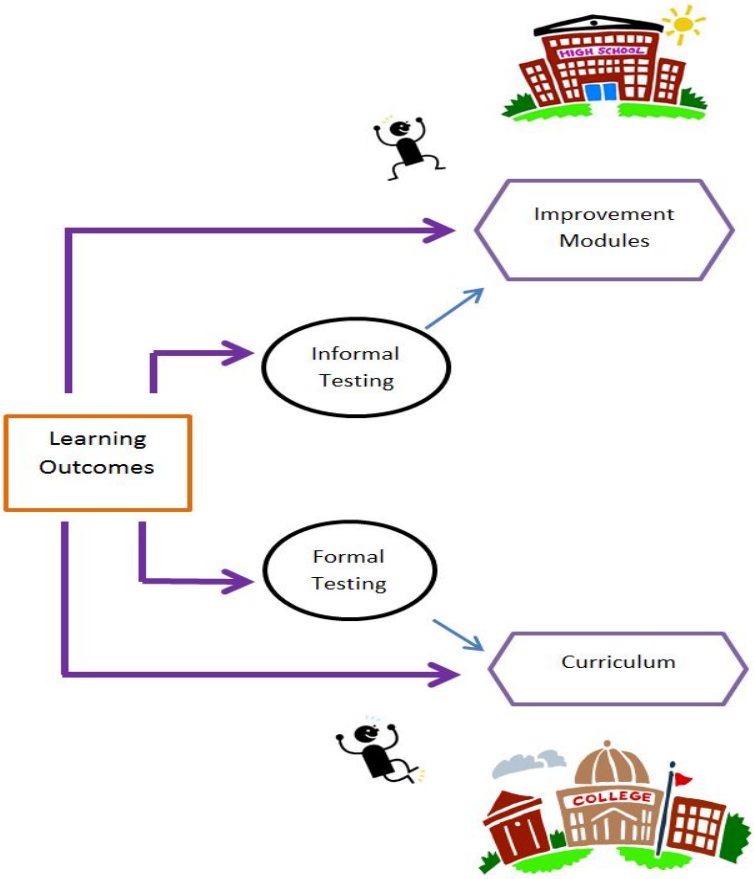

Figure 2: Formal and informal modes of assessment

Responses to the model

The survey asked respondents to consider whether the assessment model as outlined above would be a suitable one for colleges to adopt. Since the components of the model are all inter-dependent, only one response to the appropriateness of the model was requested. It was hoped that respondents would consider the model's strengths and weaknesses in developing an overall sense of its appropriateness and use that overall judgement to respond.

There was a generally positive response to the assessment model as proposed by official college representatives, as indicated by Figure 3 and Table 2. The comments below, taken from responses from official college representatives, those self-reporting from the colleges and from the school boards, offer further support for the assessment model. There were a particularly large number of very thoughtful feedback comments with regards to the model.

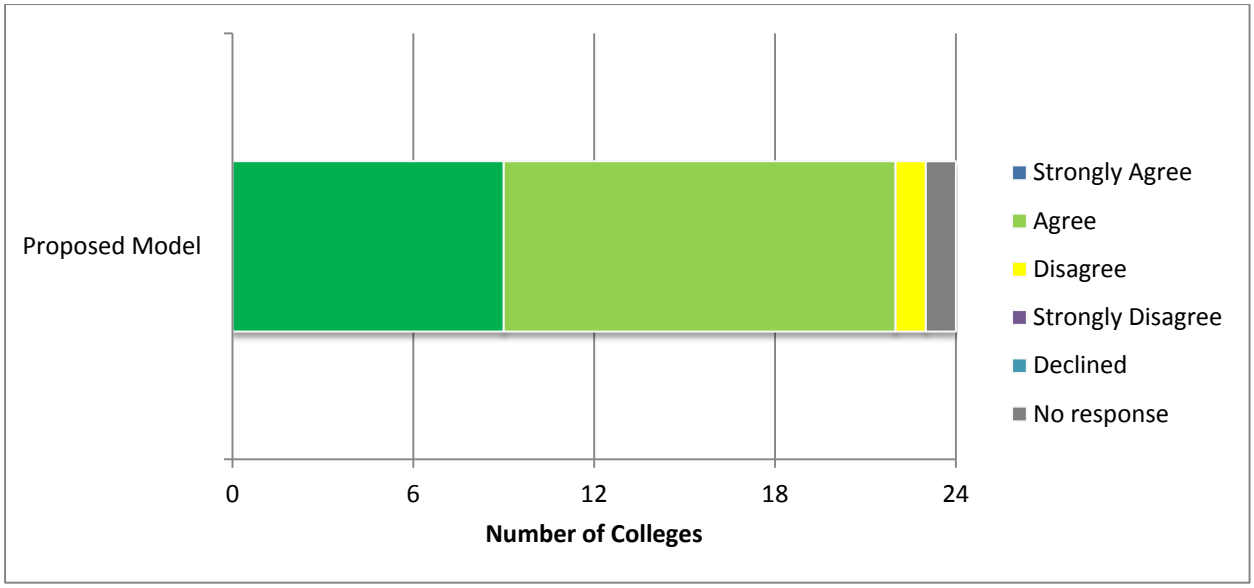

Figure 3: Colleges' responses to the proposed assessment model

Table 2:
Provincial organisations' responses to the proposed assessment model

	Heads of Business	Heads of Technology	Ontario College Mathematics Council
Proposed Model of Assessment	Strongly Agree	Agree	Agree

Comments on the proposed assessment model

- If all the colleges adopt a similar platform, then testing results are easily compared regardless of where the testing took place. Any assessment tool can be considered a first step to developing common learning outcomes and curricula for a first semester math course.
  -College representative

- We agree with the proposal, but we do think it should be designed so students can do the assessment without the aid of calculators and other assistive devices.
  -College representative

- Agree with the elements of the model and consider each appropriate.
  -College representative

- Recommend that testing be done online. The informal testing process is strongly supported.
  -College representative

- The only part I somewhat disagree with is giving the student "options" on the assessment. I believe today's learner will in most cases choose not to do anything that is deemed optional. If we require, or think it is in the best interest of the learner, to do all or part of a section then they should not have the option to select how much they are doing. I like how it will be computer based. Results are calculated much faster and learners feel more comfortable using a computer than having paper and pencil. The only issue I have from a math background is learners showing work. In some instances a learner could have the process of the question correct but make a small error and in conclusion select a wrong answer. How would this be taken into consideration with the assessment model?
  -College faculty

- We somehow need to ensure that the 'Informal mode' doesn't turn into an opportunity for High School Teachers to "Teach to the Test". The spirit of the Assessment model as a learning process needs to be enforced at this level.
  -College representative

- Love the modularity (adaptive?) nature of the assessment. Very important as students are at vastly different points along a continuum of numeracy throughout grades 7-12 and graduates are no different.
  - Numeracy instructional coordinator, school board

- The "informal" aspect of the model is of tremendous value to students and will also provide secondary school teachers and parents with important information on the skills that are critical for success in college mathematics. That said, the integrity (and therefore separation) of the formal assessment must be a priority. We need to work with or include the school boards and secondary schools as we undertake this work. The framework of the common assessment tool which is catered to technology or business would in turn provide some context for high school teachers and courses. Perhaps gently stream students in high school based on interest (technology, business, and humanities) rather than according to their perceived ability.
  -College representative

- Very flexible approach. Each module needs a successful outcome to ensure mastery of the content
  -College administrator

- The proposed model for an assessment test seems in fact to be much more than an assessment test. The access to the Informal Mode and the directed remediation are wonderful features. However, it almost seems to constitute more of a learning

system than a test for the purpose of placing a student in an appropriate course. In fact, we believe the most valid result for a student writing the initial assessment test is obtained when they do not do extensive preparation or review for the test. We want a snap-shot of a student's numeracy level, as opposed to a peak performance achieved after study and remediation.
-College faculty

- A flexible, modular tool sounds ideal. It would allow each college to customize the assessment tool to the needs of their programs and departments.
-College representative

- I agree that the assessment test be modular. I agree to the computer-based delivery of the test, but it must be administered in an invigilated scenario. We do not want students to have assistance from tutors, parents or others while taking the assessment. I agree to the internet platform if the assessment test is to be administered across the province. This must however be done in a cost-effective manner, and would be under the College's control and not OCAS or the provincial MTCU control. I agree to the informal and formal use of the assessment test as proposed in the discussion paper. One concern is that the assessment would deter students from actually applying to college if they were to take the test prior to the application deadline. This may chase students away from considering college, to not apply to certain technology and health programs, once they see the level of mathematics that is required. There should be a limit as to the number of times that a student can take the test. I would suggest only twice; the first time to gain an understanding of the nature of the test and questions; the second to have some time to review math concepts that may have been learned but not practiced sufficiently to stay in long-term memory.
-College administrator

- We like the idea of a common assessment to work with because that would mean more resources/money to draw from. However, on balance, we are opposed to a common assessment because, what if we want to change something in the assessment WE give and the potential for problems with multiple computer servers with computer delivered assessments.
-College faculty

Summary

There is strong support for the proposed model as indicated by the agree/disagree responses and in the feedback comments. The flexible modularity of the assessment is seen as a strong feature. Having the assessment completed online is seen as positive for the

student and would allow for access to the results by any college or program that the student has applied to, with the potential for the results to be available very quickly. The informal/formal options are strongly supported as a way for students to take the informal test in order to be better prepared and more confident for the formal test, and to seek remediation sooner if indicated by the informal test. While one respondent suggested that the informal test might deter students from applying to college programs with a strong mathematics component, others viewed it as a great resource for students, parents and secondary schools to better understand the mathematics knowledge that is necessary to be successful in college. Concerns were raised over the possibility of 'teaching to the test' at the secondary level, and of students taking the informal test too frequently. This is something that will need to be addressed.

Chapter 3: Learning Outcomes and Curriculum – Mathematics for Foundation Programs

Background

The mandate of CSAP also includes the consideration of the feasibility of developing common learning outcomes for various types of first semester mathematics courses and of developing common curricula for these courses. The feasibility of developing common learning outcomes and/or common curricula in mathematics depends on two separate factors: the degree of system-wide diversity that currently exists; and, where there is significant diversity, whether that is simply an artefact of the separate curriculum development across the college system over many years or, on the other hand, if it reflects important and principled differences in the needs of students or programs.

Throughout the history of the college system, each college has developed its own academic policies and programs with little expectation that these should be coordinated with those of the other colleges. Indeed, their mandates called for them to respond to the needs of each of their unique communities. Thus, for example, we discovered at the start of the CMP research program, each college developed its own system of grading for student achievement and there has been little occasion – until the CMP began its research – for these 24 grading systems to be brought into alignment. To this point, however, the benefits of such a reform have not been so evident as to outweigh the upheaval at colleges having to change their current system.

Diversity of practice in mathematics curriculum can be just a natural outcome of the historic autonomy of the colleges. It can also be the result of principled decisions about the mathematics skill requirements of different types of program. The systematic differences between mathematics courses for business programs and mathematics courses for technology programs represent an obvious instance of this type of diversity. In the case of system-wide diversity, we have also been reminded that the differences among the communities served by colleges can also be the basis for differences in the provision of mathematics courses. For example, some colleges are able to require that incoming technology students have taken MCT4C as part of their secondary school program for direct admission to diploma-level technology programs. Others – particularly those serving the northern parts of the province, where few students have had the opportunity to take the MCT4C course at secondary school – find that several preparatory mathematics courses may be needed to enable students to reach the same diploma-level graduation standard.

First semester college mathematics courses are of two main types. The first are the standalone mathematics courses in regular diploma-level vocational programs. The second type are *either* mathematics courses contained in one-year foundation programs (such as

pre-business, pre-health, and pre-technology) *or* preparatory mathematics courses that are not part of any program but which students may take if they do not appear ready to take a regular first-semester diploma-level mathematics course. Enrolment and student achievement in each of these types of courses have been outlined in the annual reports of the CMP and will be reported by the CSAP later this year. The present chapter examines the feasibility of developing common learning outcomes and common curricula for this second type of mathematics course. Chapter 4 considers diploma-level courses.

CMP research on foundational mathematics courses

Part of the research program conducted by the College Mathematics Project (CMP) in 2011 was a topical analysis of first-semester college mathematics courses[14]. This analysis built on work begun a year earlier when a pilot study had been carried out. From the pilot study, a framework of numeracy skills was established which was used in 2011 for the more systematic analyses. In the case of foundational mathematics courses, colleges were asked to submit course outlines for first-semester mathematics courses in pre-business and pre-technology programs and 11 pre-business mathematics course outlines and 18 pre-technology mathematics course outlines were received and analysed.

Tables 3 and 4 (overleaf) show the seven most commonly encountered numeracy topics in pre-business mathematics and pre-technology mathematics, respectively.

Table 3.
Numeracy topics in foundational mathematics courses: Pre-business

College	Order of Operations	Fractions	Decimals	Percentages	Ratio & Proportion	Algebra	Exponents
A	Y	Y			Y	Y	Y
B	Y	Y	Y	Y		Y	
C	Y	Y	Y	Y	Y	Y	
D	Y	Y	Y	Y	Y	Y	Y
E	Y	Y	Y	Y	Y	Y	Y
F	Y	Y	Y	Y	Y	Y	
G	Y	Y	Y	Y	Y		
H	Y	Y	Y	Y	Y	Y	Y
I	Y	Y	Y	Y	Y	Y	Y
J	Y	Y	Y				Y
K	Y	Y	Y	Y	Y		
Total	11	11	10	9	9	8	6
Percent	**100%**	**100%**	**90.9%**	**81.8%**	**81.8%**	**72.7%**	**54.5%**

The tables show, firstly, the high degree of similarity between foundational mathematics courses from different colleges. Order of operations, fractions, decimals, percentages, and

[14] This is reported in G. Orpwood et al. *op.cit*. pp 45-50.

ratio & proportion appear in over 80% of the pre-business mathematics courses analysed and order of operations, fractions, decimals, ratio & proportion, basic algebra and exponents in over three-quarters of pre-technology mathematics courses. There are some topics that appear more in pre-business mathematics that are less common in pre-technology mathematics and vice-versa but in general, this research shows that a high degree of similarity already exists. It should be noted that the analysis was focused on topics covered in the courses only. More detailed analysis of learning outcomes and curricula was not carried out. However, the research suggests that a reasonable basis exists for considering the development of a set of common learning outcomes and common curricula for pre-business mathematics and for pre-technology mathematics. This was, in fact, the proposal expressed in the discussion paper for consideration by the colleges, whose feedback is outlined below.

Table 4.
Numeracy topics in foundational mathematics courses: Pre-technology

College	Order of Operations	Fractions	Decimals	Percentages	Ratio & Proportion	Algebra	Exponents
A	Y	Y			Y	Y	Y
B	Y	Y	Y		Y	Y	Y
C	Y	Y	Y		Y	Y	
D	Y	Y	Y	Y	Y	Y	Y
E	Y	Y	Y	Y	Y	Y	Y
F	Y	Y			Y	Y	Y
G	Y	Y	Y	Y	Y	Y	
H	Y	Y	Y		Y	Y	
I	Y	Y	Y	Y		Y	Y
J	Y	Y	Y	Y	Y	Y	Y
K	Y	Y	Y	Y	Y	Y	Y
L	Y					Y	Y
M	Y	Y	Y	Y		Y	Y
N	Y	Y				Y	Y
O	Y	Y	Y	Y	Y	Y	Y
P	Y	Y	Y	Y	Y	Y	Y
Q	Y	Y	Y	Y	Y	Y	Y
R	Y				Y	Y	Y
Total	18	16	14	10	14	18	15
Percent	**100%**	**88.9%**	**77.8%**	**71.4%**	**77.8%**	**100%**	**83.3%**

At the time of this research, foundational mathematics courses from pre-business and pre-technology only were considered and the discussion paper makes reference to these two program areas. Since then, however, preliminary research for the CSAP has shown that three-quarters of all students taking foundational mathematics courses are enrolled in pre-

health programs[15]. We have therefore consulted with the pre-health working group of the Heads of Health Sciences about the potential of incorporating mathematics for pre-health into any future development and this suggestion has been welcomed. The work of the pre-health group towards developing a common program is more advanced than is the case with the other foundation areas. They note that "the biggest issue for us is that we are ahead of your study: Pre-health outcomes for the first semester numeracy course are set and we have come to preliminary agreement on curriculum across the province.[16]" Despite this, they have expressed the desire to see any further work on common approaches to foundational mathematics to include the pre-health area. We address this further in chapter 5 of this report when we look forward to the next phase of this project.

Responses to proposals concerning common learning outcomes and common curricula for mathematics in foundation programs

Foundational mathematics courses from pre-business and pre-technology were considered with respect to developing and adopting common learning outcomes and common curricula. Figure 4 and Table 5 (below) and Figure 5 and Table 6 (on page 29) show the degree of support from colleges while the comments are taken from all contributors to the survey.

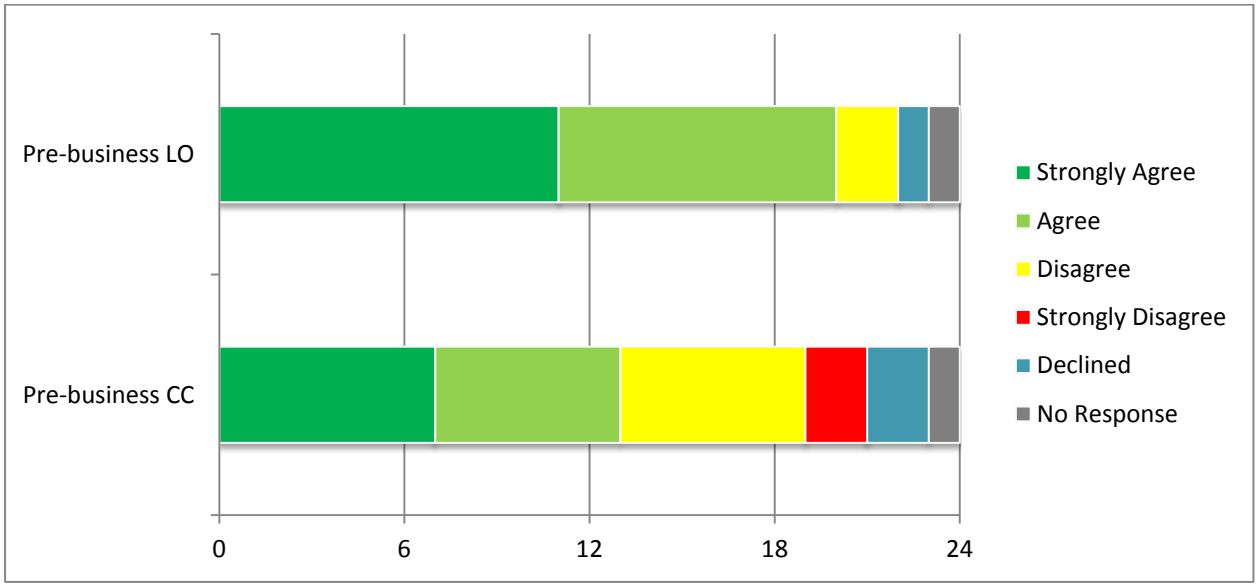

Figure 4: Colleges' responses to the proposed development of common learning outcomes (LO) and common curricula (CC) for mathematics in pre-business programs

[15] Of the 4,539 students enrolled in foundation program mathematics in Fall 2011, 427 were in pre-business, 537 in pre-technology, and 3,479 in pre-health programs.
[16] Private communication.

Table 5.
Provincial organisations' responses to the proposed development of common learning outcomes and common curricula for mathematics in pre-business programs

Mathematics for Pre-Business	Heads of Business	Heads of Technology	Ontario College Mathematics Council
Common Learning Outcomes	Strongly Agree	No response[17]	Agree
Common Curricula	Agree	No response	Agree

Common learning outcomes and common curricula for mathematics in pre-business programs

There is support amongst most colleges for developing common learning outcomes and a common curriculum for foundational mathematics courses in the pre-business programs. A high level of consensus arising from the comments indicates that common learning outcomes for foundational pre-business courses offer benefits to the student, the colleges and the school system. It is noted that if programs have been developed to comply with provincial learning outcomes, then the expectation is that common learning outcomes could be easily developed. Concerns raised about the adoption of a common curriculum centred around the desire for a local focus for the courses based on community or business sector needs, on college autonomy or individuality. The use of common texts /learning resources and assessments as well as expected delivery method of courses would need to be considered. Comments from college representatives, other college members and school boards elaborate on these responses.

Comments on proposed development of common learning outcomes for pre-business mathematics

- This will also support my work as a high school math teacher, since I can say 'you will be using this idea in this program'. Currently there are too many possible applications of an idea; but none specific.
  -Teacher, school board

- I believe this will raise the standards with all Ontario college programs.
  -Math consultant, school board

[17] Heads of Technology intentionally did not respond to this as it was outside their jurisdiction, not because they were indifferent.

- Ensure that all stakeholders are considered and links between the panels are considered.
  -Instructional leader, school board
- We are surprised the ministry has not insisted on this before!
  -College faculty

- We strongly agree but currently do not offer a pre-business program
  -College administrator

- I think this is especially important so that we have a common platform across all colleges. This becomes especially important with the College Transfer Projects that are being implemented.
  -College administrator

- I know that all high schools, have common learning outcomes and curricula but each college is unique and for this reason, I am not sure that a common curricula and learning outcomes will be achievable. There will be overlap between colleges but 100% compliance is unlikely.
  -Teacher, school board

- Colleges should have the autonomy to opt in or out based on local conditions.
  -College representative

- I don't have a strong background in business math but from what I understand it doesn't change depending on what city you go to school in, and with that I think it should be standardized. This way someone who applies for a position in a different city would have all the same curriculum as someone who is from that city.
  -College faculty

- The development of common curricula and learning outcomes for college mathematics programs will support efforts by secondary schools in preparing students for success in college level mathematics. In effect, a K-College continuum of knowledge and skills related to mathematics could then be designed and implemented.
  -Superintendent, school board

- The acquisition of basic numeracy skills is essential to the success of students in business programs - ensuring that students enter diploma-level programs with a minimum level of competency should be a goal of this process.
  -College representative

- Strongly agree. If the focus is on developing high level competencies in math fundamentals, then common Learning Outcomes are feasible.
  -College representative

Comments on proposed development of common curricula for pre-business mathematics

- We do not believe that individual colleges should have to have that level of detail - they should not have to use the same text book - same schedule and evaluation and assessment.
  -College representative

- There are plenty of ways to teach math and it is not necessary to have common curriculum to meet common learning outcomes. This is something that has been worked on for the last 8 months with the Provincial pre-Health Standardization Project. This group has agreed on common learning outcomes for health-related math courses, but each college will develop its own curriculum to meet those outcomes. At the same time, it is important that the preparatory math courses meet local needs; that is, the needs of the programs we feed into at our "home" college. Flexibility is required; a one-size fits all model is not feasible.
  -College representative

- We were not sure what would be included in a common curricula-does this mean prescribed topics, set assessment tools, prescribed textbooks/learning materials etc.. We would need more information before we could make informed decisions. We are supportive of developing common learning outcomes but are less supportive of common curricula.
  -College representative

- I really believe that all programs should have common curricula because going to school in Ontario the learner has been receiving (or should be) a standardized curricula all along. If the program is the same, the curricula should be the same regardless of what college it is.
  -College faculty

- The development of common curricula would support transferability between colleges in line with MTCU policy however the development of common curricula must be done in such a way that some college individuality is still maintained.
  -College representative

- This level of mathematics is so fundamental that there should be few issues with this goal. There may be some issues that arise out of the use of different textbooks; use of technology in delivery; online versus blended versus in-class delivery.
  -College administrator

- Depends on how curriculum is defined. If there is some flexibility for faculty and institutions to meet local demands then that is strongly supported.
  -Heads of Business

Common learning outcomes and common curricula for mathematics in pre-technology programs

Support for common learning outcomes in the foundational pre-technology courses was given by the majority of the colleges, with fewer supporting a common curriculum, as shown in Figure 5.

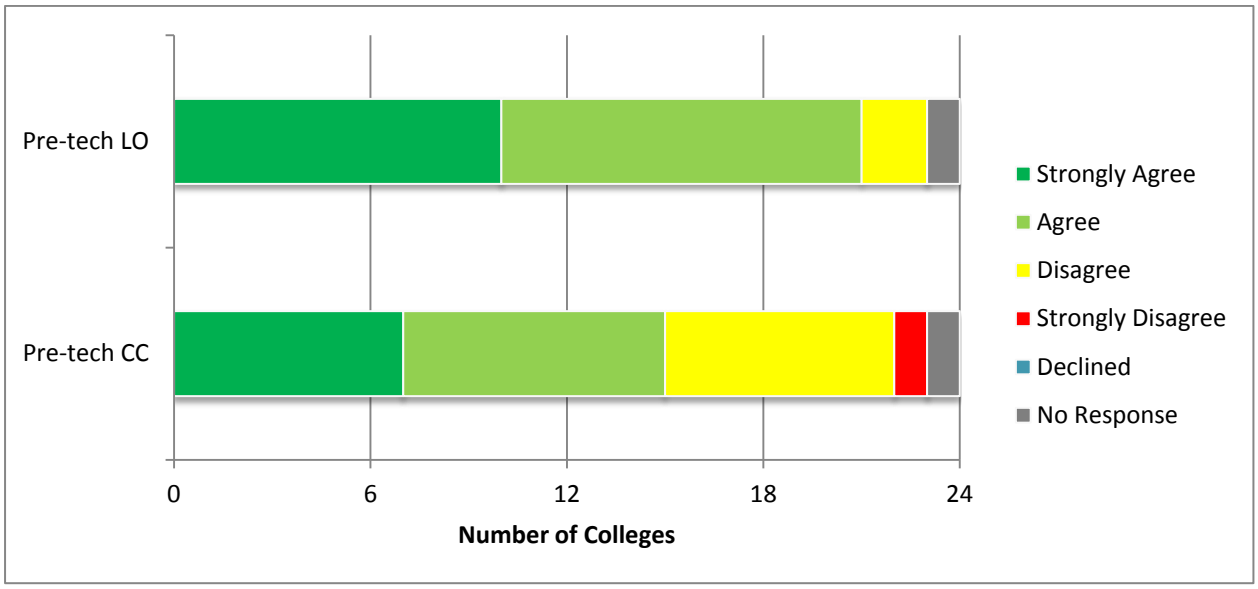

Figure 5: Colleges' responses to the proposed development of common learning outcomes (LO) and common curricula (CC) for mathematics in pre-technology programs

Table 6.
Provincial organisations' responses to the proposed development of common learning outcomes and common curricula for mathematics in pre-technology programs

Mathematics for Pre-Technology	Heads of Business	Heads of Technology	Ontario College Mathematics Council
Common Learning Outcomes	No response	Agree	Agree
Common Curricula	No response	Agree	Agree

One benefit of common learning outcomes is the transferability at the end of the one year program without impinging on the academic freedom of the institution or the teacher. The curricula for the pre-technology courses are considered to be so fundamental that a common curriculum would be feasible. There may be issues that arise with respect to the use of different textbooks; use of technology in delivery; online versus blended versus in-class delivery and the fact that many pre-technology courses have been developed in order to feed directly into particular specialist programs, such as those focused on chemistry, mechanics, electricity or the building sciences. Comments from all survey respondents provide further insight. It should be noted that many of the comments about the pre-business courses were echoed for the pre-technology courses.

Comments on proposed development of common learning outcomes for pre-technology mathematics

- The CMP findings indicated a high degree of commonality in topics and emphasis, though not as high as for pre-business mathematics as some colleges teach accuracy and precision, scientific notation and roots and radical while most do not. This would pose some challenge, however we are supportive of having common learning outcomes developed.
  -College representative

- There will need to be a differentiation between techniques, technician and technology programs during the planning process. Colleges should have the autonomy to opt in or out based on local conditions.
  -College representative

- If these programs have been developed to comply with provincial learning outcomes there shouldn't be any doubt that common learning outcomes couldn't be developed for pre-technology mathematics. [Our college] uses the same prep math courses for both GAS and its series of Pre-Technology programs.
  -College administrator

- With flexibility to recognize in house uniqueness.
  -College faculty

- Strongly agree. If the focus is on developing high level competencies in math fundamentals, then common Learning Outcomes are feasible.
  -College representative

Comments on proposed development of common curricula for pre-technology mathematics

- A common curriculum would be more challenging to develop since colleges have unique programming requirements, but the technology field is supported by the same foundational math blocks so it should be able to be developed to support the variety of destination technology programs.
  -College representative

- Dependent on the College's needs, mode of delivery and PAC influence to support community specific/industry needs.
  -College representative

- The development of common curricula would support transferability between colleges in line with MTCU policy however the development of common curricula must be done in such a way that some college individuality is still maintained.
  -College representative

- This should be aimed at bringing students up to the MCT4C standard.
  -College faculty

- One college cannot (should not) focus on all areas of technology (or business). Having a deep focus on some areas leads to 'specialty' areas, which I believe is good and serves communities/workforce better.
  -Math consultant, school board

Summary

While colleges are strongly in favour of developing a common mathematics assessment system for post-admission students, there is much greater diversity of opinion with respect to common learning outcomes and common curricula. In the case of foundational mathematics, nearly 90% of responding colleges agreed with the proposals to develop common learning outcomes – in both pre-business and pre-technology programs – but only about two-thirds agree with the proposal to develop common curricula in both program areas.

Reasons for supporting common learning outcomes include:

- That it could raise standards
- That it could facilitate student transfer
- That it could facilitate better preparation of students at secondary schools

- That it could promote better dialogue between schools and colleges

Concerns expressed were as follows:

- The need to differentiate between technician and technology programs
- The need for colleges to see the proposed learning outcomes before committing themselves to their implementation
- The possible implications for existing transfer agreements (with college or university degree programs)
- The possible implications for existing accreditations
- The need to maintain unique features and individuality of college programs

Reasons in favour of common mathematics curricula in both pre-business and pre-technology were as follows:

- Ease of transferability between colleges
- No reason for differences

Concerns in relation to common mathematics curricula include:

- Standardisation at this level is not needed for common learning outcomes to be achieved
- A ‘one size fits all’ approach is not needed
- Colleges need to respond to local conditions with different curricula
- Development would be difficult because of the diversity of programs (in technology)
- Uncertainty about what a common curriculum would look like

In summary, we conclude that a strong majority of colleges are in favour of developing common learning outcomes for pre-business and pre-technology mathematics but that this agreement does not extend to the development of common mathematics curricula for these programs.

Chapter 4: Learning Outcomes and Curriculum – Mathematics for Diploma Programs

In chapter 3, we reviewed proposals based (in part) on research conducted as part of the College Mathematics Project (CMP) on first semester mathematics courses in pre-business and pre-technology *foundation* programs. The same research program also analysed course outlines of first-semester mathematics courses in *diploma-level* programs in business and technology. The results of these analyses are shown in Tables 7 and 8.

Table 7.
Numeracy topics in diploma-Level mathematics courses: Business

College	Order of Operations	Fractions	Decimals	Percentages	Ratio & Proportion	Algebra	Exponents
A	Y	Y	Y		Y	Y	
B	Y	Y	Y	Y	Y	Y	
C	Y		Y	Y		Y	
D	Y	Y	Y	Y	Y	Y	Y
E	Y	Y		Y	Y	Y	
F	Y	Y	Y	Y	Y	Y	Y
G						Y	
H	Y	Y	Y	Y	Y	Y	
I	Y	Y	Y	Y	Y	Y	Y
J						Y	
K	Y		Y	Y		Y	
L							
M				Y		Y	
N	Y	Y	Y	Y	Y	Y	
O	Y			Y	Y	Y	
P						Y	
Q	Y	Y	Y	Y	Y	Y	
R	Y		Y	Y	Y	Y	
S	Y	Y	Y	Y	Y	Y	Y
Total	15	10	12	14	12	18	4
Percent	**78.9%**	**52.6%**	**63.1%**	**73.7%**	**63.1%**	**94.7%**	**21.1%**

The percentages at the bottom of the columns in each table represent the proportion of colleges whose mathematics course included any given topic. Averaging these percentages gives an average topic frequency and an indication of the inter-college similarity of each type of mathematics course. Table 9 shows that the similarity for diploma-level mathematics courses was less than was the case with foundational mathematics courses. There was little difference (in the degree of inter-college similarity) between business mathematics and technology mathematics, at either foundational or diploma-level.

However, it should be noted that a maximum of one mathematics course from all technology programs and one mathematics course from all business programs were collected from each college for this analysis. We have only limited measures of the variability of mathematics courses among different programs in business or technology. However, the fact[18] that many colleges have only one first semester business mathematics course but several technology mathematics courses suggests that there is substantial variability among technology mathematics courses and much less in the case of business.

Table 8.
Numeracy topics in diploma-level mathematics courses: Technology

College	Order of Operations	Fractions	Decimals	Percentages	Ratio & Proportion	Algebra	Exponents
A		Y				Y	Y
B	Y	Y	Y			Y	Y
C	Y	Y	Y	Y	Y	Y	Y
D	Y	Y			Y	Y	Y
E							
F		Y				Y	Y
G	Y	Y	Y	Y	Y	Y	
H	Y		Y		Y	Y	Y
I	Y	Y	Y	Y	Y	Y	Y
J	Y	Y	Y	Y	Y	Y	Y
K						Y	Y
L	y	y	Y	Y	Y	Y	Y
M	Y	Y			Y	Y	Y
N	Y	Y	Y	Y	Y	Y	Y
O	Y					Y	Y
P						Y	
Q						Y	
R					Y	Y	Y
S	Y	Y				Y	Y
T		Y	Y	Y	Y	Y	Y
U	Y	Y	Y	Y	Y	Y	Y
V						Y	Y
W	Y	Y		Y		Y	Y
Total	14	15	10	9	12	22	19
Percent	**60.9%**	**65.2%**	**43.5%**	**39.1%**	**52.2%**	**95.7%**	**82.6%**

[18] As shown by the CMP master program list (http://collegemathproject.senecac.on.ca).

Table 9.
Degree of similarity of first-semester mathematics courses across colleges

	Number of colleges	*Average topic frequency*
Pre-business mathematics	11	83.1%
Pre-technology mathematics	18	83.3%
Business mathematics	19	63.9%
Technology mathematics	23	62.7%

Based on this evidence, the CSAP Discussion paper proposed that common learning outcomes should be developed for diploma-level business mathematics but *not yet* for diploma-level technology mathematics (as a whole). Unfortunately this one negative proposal, following a series of positive ones, resulted in a certain degree of confusion in the subsequent survey but we have found that in most cases, respondents' written comments have made their views clear even if they were confused over the "agree/disagree" response. In other cases, the CSAP research team has contacted individual colleges to clarify their intended response.

Common learning outcomes and common curricula in business diploma-level mathematics

Most colleges supported the development of common learning outcomes for first year courses at the Business Diploma-level, as indicated by Figure 6 and Table 10. However, a much smaller majority supported the development of a common curriculum at this level.

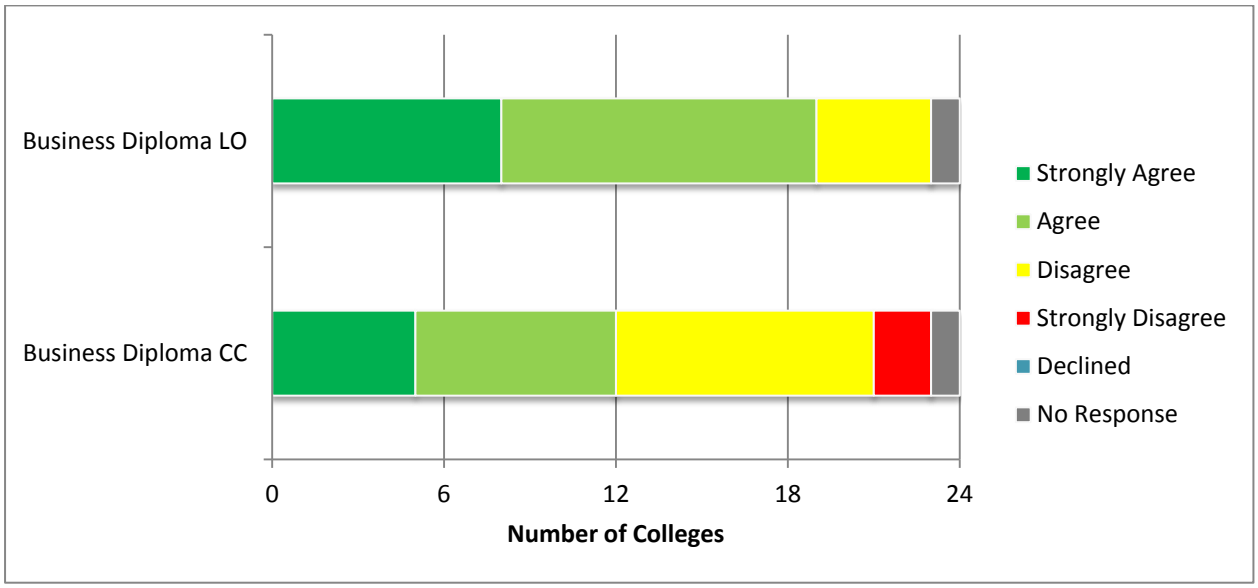

Figure 6: Colleges' responses to the development of common learning outcomes (LO) and common curricula (CC) for mathematics in business diploma-level courses

There are concerns about the variety of textbooks used for different Business Diploma-level courses and how common learning outcomes could be successfully accommodated. Colleges which cluster programs together such as accounting, marketing and business would require the option to select learning outcomes based on the specific needs of each program from a larger pool of learning outcomes. Some college curricula are in place due to the advice from program advisory committees to reflect the needs of local businesses and industry. Finally, there are significant concerns about the implications for transfer agreements (to college and university degree programs) and for accreditation agreements. One college expressed such concern over this that it could not support any development of common learning outcomes and curricula in mathematics.

Table 10
Provincial organisations' responses to the development of common learning outcomes and common curricula for mathematics in business diploma-level courses

Mathematics for Business	Heads of Business	Heads of Technology	Ontario College Mathematics Council
Common Learning Outcomes	Agree	No response[19]	Agree
Common Curricula	Agree	No response	Agree

Comments on proposed development of common learning outcomes for business diploma-level mathematics

- At [our college] there are several mathematics courses which vary across different types of business programs. We support common learning outcomes for a first semester course.
  -College representative

- This would help to support greater transferability between programs. The CMP study indicates the majority of diploma level business math teach the following topics/skills: order of operations, fractions, decimals, percentages, ratio and proportion and algebra. We are generally supportive of common learning outcomes for college level first year business math courses.
  -College representative

- In the interest of transferability, common learning outcomes should be developed for diploma level business programs. In similar projects across different college departments across the province, it has been possible to develop common learning outcomes in which students from different colleges reach common points at the end of each academic year.

[19] See footnote 17.

-College representative

- Will help with transferability.
  -College administrator

- Colleges should have the autonomy to opt in or out based on local conditions.
  -College representative

- Unless the programs differ in some way from college to college then the outcomes should remain the same.
  -College faculty

- One roadblock to this would be the use of varied textbook publishers. This may offer some challenges to developing common learning outcomes. There may also be some colleges that cluster business/marketing/accounting programs together, that require some variations in learning outcomes from one college program to another. Perhaps learning outcomes, encompassing all these areas normally associated with business can be developed with the program areas then allowed to pick and choose the appropriate outcomes required for specific programs.
  --College administrator

Comments on proposed development of curricula for business diploma-level mathematics

- We do not believe that individual colleges should have to have that level of detail - they should not have to use the same text book - same schedule and evaluation and assessment.
  - College representative

- We should avoid standardized curriculum tests across the province. While a standardized 'Assessment' test is great, standardized tests throughout the 'curricula' impinges on Academic Freedom.
  - College representative

- We strongly suggest that this be staged such that common LO and common curriculum in pre-business math be assessed by the colleges before proceeding with additional work at the diploma level. We were not sure what would be included in a common curricula-does this mean prescribed topics, set assessment tools, prescribed textbooks/learning materials etc.. We would need more information before we could make informed decisions.
  - College representative

- We are hesitant to endorse this because of potential local issues, like many students flunking the "first" course so we need an extra course in the program. Or the program has too many math courses, so the content needs to get squished into one less math course in the program. However we do agree with common learning outcomes for a business diploma.
  -College faculty

- I believe there should be foundational common curricula, but beyond that colleges should choose (decide among each other?) what areas of the curriculum they wish to put a stronger emphasis. (based on needs in their community, professors/teachers in their college, partnerships they have developed, themes/vision of the college, etc.)
  -Math consultant, school board

Common learning outcomes and common curricula in technology diploma-level mathematics

The question of common learning outcomes and common curricula in technology diploma-level courses was posed differently, asking whether there was agreement that common learning outcomes and a common curriculum *not* be developed. Figure 7 and Table 11 show that, among the college representatives and provincial organisations, there was a general agreement that common learning outcomes and common curricula for technology diploma-level mathematics should *not* be developed at this time.

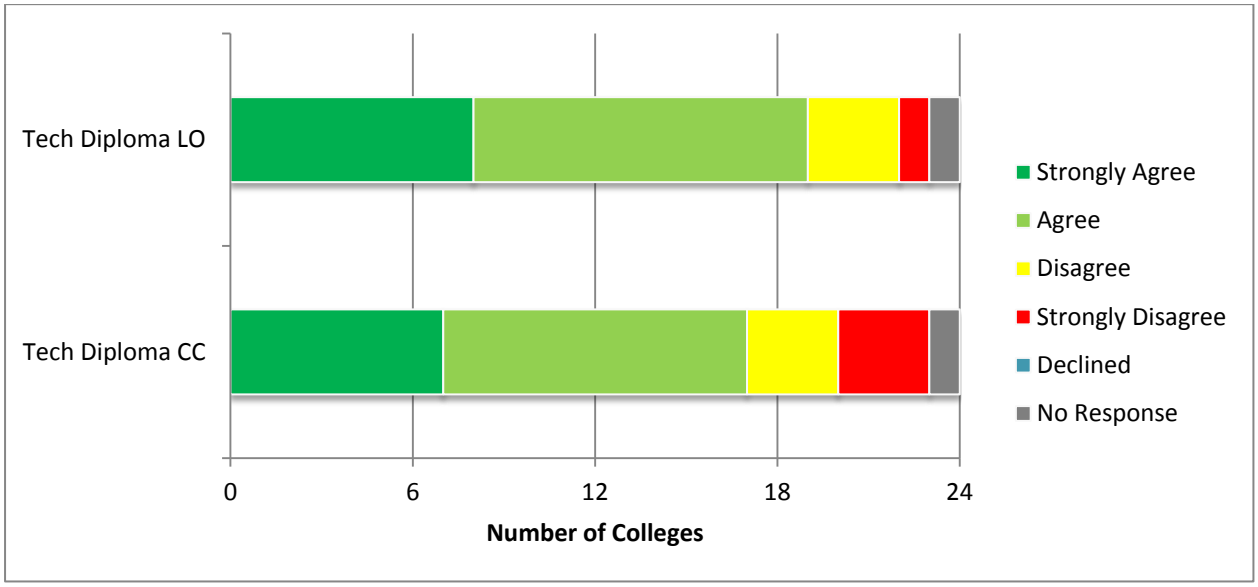

Figure 7: Colleges' responses to the development of common learning outcomes (LO) and common curricula (CC) for mathematics in technology diploma-level courses

Technology diploma-level mathematics courses are often program specific and many believe that developing common learning outcomes and a common curriculum might be more challenging. There is too wide a variation in learning outcomes for technology programs. It may however be possible to develop common learning outcomes on a program-by-program basis to facilitate credit transfer between colleges.

Table 11
Provincial organisations' responses to the development of common learning outcomes and common curricula for mathematics in technology diploma-level courses

Mathematics for Technology	Heads of Business	Heads of Technology	Ontario College Mathematics Council
Common Learning Outcomes	No response	Agree*	Agree*
Common Curricula	No response	Agree*	Agree*

* Agree that common learning outcomes and common curricula should **NOT** be developed at this time.

While some colleges did support a common curriculum for Technology Diploma-level mathematics, several colleges expressed concerns based on the many challenges that developing common curricula would present. These challenges centre on local variation which includes industry needs, secondary school student intake population, and local pressures resulting from staffing, scheduling, and levels of funding. Many of the comments concerning common learning outcomes overlapped with comments concerning common curricula. Once again, concerns over the implications for transfer agreements and program accreditation were raised.

Comments on proposals in relation to common learning outcomes for technology diploma-level mathematics

- Greater regional areas of specialization could lead to different requirements for technology curricula-technology math is less generic than business math.
  -College representative

- We do believe however that there could be common courses developed among similar programs - say civil, electrical etc. Along with the potential for grouping of similar 1st year math in similar programs - control, energy systems etc.
  -College representative

- We think they should be there eventually, but proceeding cautiously is appropriate and warranted.
  -College representative

- Common learning outcomes would be advantageous. Although the outcomes are embedded in courses and may vary dependent on the program, a common understanding of what we are trying to achieve would be valuable.
  -College representative

- Some technology programs have different topics that should and should not be covered. If the pre-tech math is sufficient, students should have no trouble with differences in math curricula.
  -College representative

- I think it's time that this gets done province wide.
  -College faculty

- The CMP report presents results for technology diploma math based on a sample of one course per institution so before proceeding with this we would need to perform an analysis of all of the technology math courses to determine the commonality of topics. The results in the CMP report indicate this is worth doing and we are in agreement that common learning outcomes for Technology Diploma level math should be developed.
  -College representative

- Some core outcomes should be the same. But because tech programs can be very different and the math we teach is slanted to their content, the learning outcomes at the diploma level should not be the same.
  -College faculty

- Currently there is considerable variation in the curriculum of first semester technology courses so common learning outcomes would mean that students may have to take "extra" topics. The concern is that the students may not see the relevance of why they are studying certain topics except that it may help with transferring to another program. However, common learning outcomes can be developed.
  -College administrator

- There is a wide variation in learning outcomes for Health and Technology programs. What may be possible is to develop common learning outcomes on a program-by-program basis to facilitate credit transfer between colleges.
  -Heads of Technology

- I believe this could be done within programs addressing the same technology sector.
  -Math consultant, school board

- Learning outcomes of a specific math course are incorporated in the mapping for a specific engineering program and therefore are not the same even within the same college. They heavily depend on the program area demands. That's why we have a variety of different math courses and that's why it is not feasible approach
  -College faculty

Comments on proposals in relation to common curricula for technology diploma-level mathematics

- We should first pilot the common curriculum with the foundations courses. Then a second step would be to develop the common learning outcomes. Before embarking on the time-intensive process of developing curriculum we would need input from various stakeholders on the common learning outcomes to see if it makes sense to go further.
  -College administrator

- It is not the time for common curricula however we do support common outcomes. There are different admission requirements and some technology programs integrate the math into courses rather than a stand along math course. We require this flexibility dependent on the program.
  -College representative

- There should be some ability to draft common curricula for each of the technology sub-sets which would be unique to the needs of those sub-sets.
  -Superintendent, school board

- This is dependent on the college's needs, mode of delivery and Program Advisory Committees' influence to support community specific/industry needs.
  -College representative

- We believe that common curriculum should be developed, however there is a greater diversity in the number of mathematics courses in technology and the focus of these courses. As such this presents a greater challenge.
  -College representative

Summary

The responses to the proposals for developing common learning outcomes and common curricula for diploma-level mathematics were clearly more diverse and a clear consensus is not as clear as it is in the case of foundational mathematics. Nonetheless, it is our judgment

that sufficient agreement exists for the development of common learning outcomes for diploma-level business mathematics and that discussions should continue about the possibility of developing common learning outcomes in diploma-level mathematics for selected technology areas. If we used the five CMP/CSAP technology sub-clusters as a starting point, it might be possible to develop common learning outcomes in mathematics for each of those. We do not believe that the survey shows sufficient support for common curricula in either business or technology diploma-level mathematics, however. Table 12 summarizes the conclusions of chapters 3 and 4 of this report.

Table 12
Feasibility study conclusions regarding common learning outcomes to common curricula

	Common Learning Outcomes	Common Curricula
Pre-business mathematics	Proceed with development	Not at this time
Pre-technology mathematics	Proceed with development	Not at this time
Business mathematics	Proceed with development	Not at this time
Technology mathematics	Not at this time	Not at this time

Chapter 5 of this report further develops these recommendations with suggestions for next steps.

Chapter 5: Next Steps

The College Student Achievement Project (CSAP) is mandated not only to conduct this feasibility study but also, subject to its outcome, to continue with two further projects, to begin on September 1, 2013 and to be completed by December 31, 2014.

- Common Mathematics Assessment Development
- Common Mathematics Learning Outcomes & Curriculum Development

These will be referred to here as the "Assessment Development Project" and the "Learning Outcomes Development Project." In this final chapter, we extend the conclusions of the feasibility study towards outlines of work-plans for these two projects.

While each project is distinct, they are also related, since the learning outcomes for the foundational mathematics courses will also be the learning outcomes on which the assessment will be based.

Assessment development project

Since the overall time line of 16 months from initiation to completion is relatively short, many aspects of this project will need to be developed simultaneously. These include the following (in no particular order of priority).

- Development of assessment content framework: the modules (and learning outcomes) required for use for all programs + those required exclusively for pre-technology, pre-business and pre-health programs;
- Collection from existing sources, further development, field testing and evaluation of assessment items;
- Collection from existing sources, further development, field testing and evaluation of (remedial) instructional materials;
- Provision of all materials in both English and French;
- Selection and further development of a web-based technology platform for delivery of assessment, remedial instruction, scoring, feedback, etc. in both formal and informal modes of operation;
- Development of ownership, governance, management and administrative protocols;
- Beta-testing of assessment and instructional system.

These activities will be carried out by CSAP team members under the general supervision of the CSAP Steering Committee and with the specific advice of an advisory committee made up of representatives of the colleges with specific experience in this area.

Learning outcomes development project

The discussion paper and survey responses have begun a conversation among the colleges about common learning outcomes and common curricula that we regard as being far from finished. The results of this feasibility study should not therefore be taken as final in any long term sense. The CSAP team considers that it has received a clear mandate to begin work with the colleges to develop common learning outcomes (LOs) in mathematics for foundational business and technology programs and in business diploma-level mathematics.

With regard to common curricula, the conversation will continue, likely beyond the current timeframe of CSAP. As the results of the feasibility study have shown, the college system does not at present have a consensus regarding the development and implementation of common mathematics curricula. Nevertheless, learning outcomes are a fundamental component of any curriculum and if common LOs exist for each type of mathematics course, then many of the goals of having common curricula, such as facilitating student transfer, will already have been achieved. It can be noted, in passing, that at the K-12 level, while schools share common overall and specific learning "expectations" (as set out by the Ministry of Education), the detailed courses of study used to reach those expectations can and does vary from school to school and classroom to classroom. Colleges and college faculty value their professional autonomy in determining the most appropriate ways in which to assist their students reach the learning outcomes, as do teachers and schools at the elementary and secondary levels. Thus, to a great extent, the establishment of common LOs will have achieved the intent of common curricula without encroaching on the autonomy of colleges and college faculty.

The development of common LOs will not be without its challenges, however. Issues of concern raised by some respondents – such as the implications for existing program accreditations and degree transfer agreements – are not trivial ones and must be faced carefully and sensitively. By their very nature the common LOs developed by the colleges and the CSAP will represent *minimum* common standards for first semester mathematics courses, and colleges could add to them to meet their particular needs, though that might have implications for the transferability of credits. These and other issues will be aspects of the ongoing conversation that CSAP will coordinate during the next phase of activity.

As was the case with the proposed Assessment Project (above), the CSAP will work with the colleges to set up an advisory committee to support the development work over the coming months.