

Rapid Synthesis

Fostering K-12 Students' Global Competencies

1 April 2018



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**Rapid Synthesis:
Fostering K-12 Students' Global Competencies
30-day response**

1 April 2018

Forum+

The goal of Forum+ is to generate action on the pressing social-system issues of our time, based on the best available research evidence and systematically elicited citizen values and stakeholder insights. We aim to strengthen social systems – locally, nationally and internationally – and get the right programs, services and products to the people who need them. By social systems we mean the following government sectors and program areas: citizenship, children and youth services, community and social services, consumer protection, culture and gender, economic development and growth, education, employment, financial protection, food safety and security, government services, housing, infrastructure, public safety and justice, recreation, and transportation. With Forum+, we are building on McMaster’s expertise in advancing human and societal health and well-being.

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Timeline

Rapid syntheses can be requested in a three-, 10- or 30-business-day timeframe. This synthesis was prepared over a 30-business-day timeframe. An overview of what can be provided and what cannot be provided in each of the different timelines is provided on the Forum’s Rapid Response program webpage (www.mcmasterforum.org/find-evidence/rapid-response).

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Conflict of interest

The authors declare that they have no professional or commercial interests relevant to the rapid synthesis. The funder played no role in the identification, selection, assessment, synthesis or presentation of the research evidence profiled in the rapid synthesis.

Merit review

The rapid synthesis was reviewed by a small number of policymakers, stakeholders and researchers in order to ensure its scientific rigour and system relevance.

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KEY MESSAGES

Questions

- How are students' global competencies fostered, assessed, evaluated and reported on? Are there any commonly travelled paths/progressions that students take in their long-term development of global competencies?
 - How can the development of these competencies be fostered (i.e., what pedagogical approaches are used; how does fostering of competencies consider cultural relevance, well-being and equity)?
 - How can the development of these competencies be assessed (e.g., what criteria, methods and tools can be used; how assessment considers cultural relevance, well-being and equity)?
 - How can the development of these competencies be evaluated (e.g., what criteria, methods and tools can be used; how does evaluation consider cultural relevance, well-being and equity)?
 - How can the development of these competencies be reported (e.g., at what level and how should the indicators be reported; how does reporting consider cultural relevance, well-being and equity)?

Why the issue is important

- Globalization has brought forward tremendous innovation in how society operates, whether this is in the workplace or in the community, and as a result has changed how workplaces function and the skills needed for individuals to succeed.
- To enable this, there has been a global movement to identify and conceptualize the set of skills and competencies required for students to succeed as active and engaged citizens in the 21st century.
- In Canada, these have been conceptualized as a set of six global competencies, including: critical thinking and problem solving; innovation, creativity and entrepreneurship; learning-to-learn/self-awareness and self-direction; collaboration; communication; and global citizenship and sustainability.
- The Government of Ontario is planning a significant multi-year curriculum change with a focus on fostering students' global competencies. It is therefore timely to take stock of the empirical research evidence on how students' global competencies are fostered, assessed, evaluated and reported.

What we found

- From our searches of empirical literature, we identified a total of 32 relevant documents, including eight systematic reviews, 21 primary studies, and three organizational reports.
- The literature revealed a general lack of agreement about what constitutes "global competencies", with a variety of frameworks having been proposed and other jurisdictions commonly using "21st-century skills" or "deeper learning" to conceptualize similar competencies.
- In terms of fostering global competencies, we found the following:
 - the most frequent strategies used to foster the six competencies of deeper learning (e.g., mastery of core academic content; critical thinking and complex problem solving; effective communication skills; collaboration skills; an understanding of how to learn; and an academic mindset) were project-based learning, internship opportunities, and collaborative group work;
 - there was a focus on strategies using real-life examples, various forms of technology (e.g., robots and robotic construction kits; computer-based simulations; computer games; and web-based curriculums), and providing students of all ages with the opportunity to learn in different environments and contexts to support their development of global competencies.
- In terms of assessing global competencies, we found:
 - the use of technology and problem simulations is a key tool to assess how students were progressing in their development of certain competencies, including using online games and collaborative learning opportunities through which to observe students' actions;
 - consistent methods of assessment or self-assessment were only reported for meta-cognition (or learning-to-learn), otherwise reported assessments appeared to have developed one-off projects or assignments;
 - most of the literature assessed students' abilities for critical-thinking and problem-solving competencies through the use of dynamic and collaborative problem-solving tasks and computer games; and
 - one organizational report suggested the use of long-term assignments such as portfolios or exhibitions where students must present and defend their work to assess collaboration and communication competencies.
- We found relatively little literature on the formal evaluation of global competencies, however, we found three studies which reported using the following tests to evaluate students' development of competencies or educational trajectories: International Baccalaureate English language arts test; Advance Placement English language arts test; Human Behaviour Rating Scale and the Brief Human Behaviour Rating Scale; and the Community Index of Child Development.
- We were unable to identify any empirical research evidence about reporting on students' global competencies.

QUESTIONS

How are students' global competencies fostered, assessed, evaluated and reported on? Are there commonly travelled paths/progressions that students take in their long-term development of global competencies?

- How can the development of these competencies be fostered (i.e., what pedagogical approaches are used; how does fostering of competencies consider cultural relevance, well-being and equity)?
- How can the development of these competencies be assessed (e.g., what criteria, methods and tools can be used; how assessment considers cultural relevance, well-being and equity)?
- How can the development of these competencies be evaluated (e.g., what criteria, methods and tools can be used; how does evaluation consider cultural relevance, well-being and equity)?
- How can the development of these competencies be reported (e.g., at what level and how should the indicators be reported; how does reporting consider cultural relevance, well-being and equity)?

WHY THE ISSUE IS IMPORTANT

The environment in which children are growing up today is very different than that of previous generations. There has been tremendous innovation in how society operates, with the rapid expansion of technology, globalization of businesses, new careers and opportunities, and increasingly diverse communities. Students graduating from high school have tremendous opportunities to be personally successful, economically productive, and actively engaged. To capitalize on these opportunities however, it is critical that our education systems support students in acquiring the right competencies to navigate increasingly complex societies.

For some time, there have been discussions about how to best equip the next generation of students by reforming K-12 curriculum. In 2009, the Organisation for Economic Cooperation and Development (OECD) called on governments internationally to “make an effort to identify and conceptualise the set of skills and competencies required so as to incorporate them into educational standards that every student should be able to reach by the end of compulsory schools.”(1) As a response, there has been a global movement to position 21st-century readiness and global competencies at the centre of K-12 education.

This movement has been taken up in the province of Ontario through the 2014 Achieving Excellence policy document, which commits to defining and measuring 21st-century competencies.(2) Since then, a discussion document and a Framework of Global Competencies have been developed which push forward this commitment. The ministry is now embarking on a multi-year initiative to modernize the curriculum with a focus on global competencies.(3) The following rapid synthesis has been commissioned by the Ministry of

Box 1: Background to the rapid synthesis

This rapid synthesis mobilizes both global and local research evidence about a question submitted to the Forum's Rapid Response program. Whenever possible, the rapid synthesis summarizes research evidence drawn from systematic reviews of the research literature and occasionally from single research studies. A systematic review is a summary of studies addressing a clearly formulated question that uses systematic and explicit methods to identify, select and appraise research studies, and to synthesize data from the included studies. The rapid synthesis does not contain recommendations, which would have required the authors to make judgments based on their personal values and preferences.

Rapid syntheses can be requested in a three-, 10- or 30-business-day timeframe. An overview of what can be provided and what cannot be provided in each of these timelines is provided on the McMaster Health Forum's Rapid Response program webpage (www.mcmasterforum.org/find-evidence/rapid-response).

This rapid synthesis was prepared over a 30-business-day timeframe and involved four steps:

- 1) submission of a question from a policymaker or stakeholder (in this case, the Ontario Ministry of Education);
- 2) identifying, selecting, appraising and synthesizing relevant research evidence about the question;
- 3) drafting the rapid synthesis in such a way as to present concisely and in accessible language the research evidence; and
- 4) finalizing the rapid synthesis based on the input of at least two merit reviewers.

Education of Ontario to support this work and examine empirical research evidence about how students' global competencies are fostered, assessed, evaluated and reported.

There are various conceptual and theoretical understandings of global competencies. The ministry uses the term competencies to refer to the knowledge, skills and attitudes students need to reach their full potential and to face complex challenges now and in the future, while the term global refers to the learner as a whole. For the purpose of this rapid synthesis however, we use the global competencies described by the Council of Ministers of Education (CMEC) in their Pan-Canadian Global Competencies document. The CMEC defined global competencies generally as “sets of overarching attitudes, skills, and knowledge that can be interdependent, interdisciplinary and leveraged in a variety of situations both locally and globally.” Table 1 below details these competencies and provides the definition given by the CMEC.(4)

Table 1. CMEC Pan-Canadian Global Competencies

Global competency	Definition and description
Critical thinking and problem solving	“Address complex issues and problems by acquiring, processing, analyzing and interpreting information to make informed judgments and decisions. The capacity to engage in cognitive processes to understand and resolve problems includes the willingness to achieve one’s potential as a constructive and reflective citizen. Learning is deepened when situated in meaningful, real-world, authentic experiences.”(4)
Innovation, creativity and entrepreneurship	“Innovation, creativity, and entrepreneurship involve the ability to turn ideas into action to meet the needs of a community. The capacity to enhance concepts, ideas or products to contribute new-to-the-world solutions to complex economic, social and environmental problems involves leadership, taking risks, independent/unconventional thinking and experimenting with new strategies, techniques or perspectives, through inquiry research. Entrepreneurial mindsets and skills involve a focus on building and scaling an idea sustainably.”(4)
Learning to learn/self-awareness and self-direction	“Learning to learn and to be self-directed and self-aware, means: becoming aware and demonstrating agency in one’s process of learning, including the development of dispositions that support motivation, perseverance, resilience, and self-regulation. Belief in one’s ability to learn (growth mindset), combined with strategies for planning, monitoring and reflecting on one’s past, present and future goals, potential actions and strategies, and results. Self-reflection and thinking about thinking (meta-cognition) promote lifelong learning, adaptive capacity, well-being and transfer of learning in an ever-changing world.”(4)
Collaboration	“Collaboration involves the interplay of the cognitive (including thinking and reasoning), interpersonal, and intrapersonal competencies necessary to participate effectively and ethically in teams. Ever-increasing versatility and depth of skill are applied across diverse situations, roles, groups, and perspectives in order to co-construct knowledge, meaning and content, and learn from, and with, others in physical and virtual environments.”(4)
Communication	“Communication involves receiving and expressing meaning in different contexts and with different audiences and purposes. Effective communication increasingly involves understanding both local and global perspectives, societal and cultural contexts, and adapting and changing using a variety of media appropriately, responsibly, safely, and with regards to one’s digital footprint.”(4)
Global citizenship and sustainability	“Global citizenship and sustainability involves reflecting on diverse worldviews and perspectives and understanding and addressing ecological social and economic issues that are crucial to living in a contemporary, connected, interdependent, and sustainable world. It also includes the acquisition of knowledge, motivation, dispositions, and skills required for an ethos of engaged citizenship, with an appreciation for the diversity of people, perspectives, and the ability to envision and work toward a better and more sustainable future for all.”(4)

Given the push to integrate these skills into the curriculum of K-12 students, it is critical to take stock of the existing empirical research evidence on how students' global competencies are fostered, assessed, evaluated and reported on, as well as to determine whether there are any commonly travelled paths or learning progressions to support the long-term development of these competencies.

For the purpose of this rapid synthesis, a few additional concepts should be defined at the outset. The term 'assessment' refers to the use of projects, assignments and tests by students and teachers to improve learning through feedback on learning goals as well as the active participation of students in monitoring their progress. The term 'evaluation' refers to the process of judging student learning based on established performance standards.⁽⁵⁾ Finally, the term reporting refers to the use of report cards (Elementary Progress Report Cards for Grades 1 to 6, Elementary Provincial Report Cards for Grades 7 and 8, and Provincial Report Cards for Grades 9 to 12) to show a student's achievement at specific points in the school year, as well as the development of learning skills and work habits.

WHAT WE FOUND

We identified a total of 38 relevant documents, including eight systematic reviews,⁽⁶⁻¹³⁾ 21 primary studies,⁽¹⁴⁻³⁴⁾ six non-systematic reviews⁽³⁵⁻⁴⁰⁾ and three organizational reports.⁽⁴¹⁻⁴³⁾

In general, we found relatively little empirical evidence on how to foster, assess, evaluate and report on global competencies. While we found a number of systematic reviews and primary studies on strategies to foster individual competencies, only one systematic review described how students were acquiring global competencies (e.g., through a learning progression or other mechanism). In addition, we found relatively little empirical evidence on the cultural relevance, well-being or equity, however two studies focused specifically on strategies to foster global competencies for low-income students.

Findings from identified systematic reviews on global competencies generally focused on three of the competencies: critical thinking and problem solving; communication; and global citizenship and sustainability. Further, two limitations were noted with respect to the broad applicability of the research evidence found. First, despite our best efforts to prioritize Canadian literature,

Box 2: Identification, selection and synthesis of research evidence

To answer the questions posed in the rapid synthesis, we identified systematic reviews and primary studies on global competencies, 21st century skills and deeper learning. We conducted searches in October 2017 in Social Systems Evidence (www.socialsystemsevidence.org), ERIC, EPPI, Campbell Collaboration, and PsychInfo. In Social Systems Evidence, ERIC and PsychInfo, we initially ran a broad search for empirical evidence on global competencies generally, with the following search strategy: "global competencies" OR "21st-century skills" OR "deeper learning." To ensure we also captured literature on the individual competencies, we ran six additional searches using the following search strategies: 1) (critical thinking OR problem solving) AND (skills OR competenc*); 2) (innovation OR creativity OR entrepreneurship) AND (skills OR competenc*); 3) (learning*to*learn OR self*awareness OR self*direction) AND (skills OR competenc*); 4) (collaboration) AND (skills OR competenc*); 6) (communication) AND (skills OR competenc*); 7) (global citizenship OR sustainability) AND (skills OR competenc*). We combined these search strategies with filters for language (English and French), recency (2006 – present), education level (K-12), and for peer-reviewed and scholarly journals. We also hand searched systematic reviews from EPPI and Campbell Collaboration.

In addition, we undertook a purposeful sampling of grey literature from relevant organizations including the Organisation for Economic Cooperation and Development, Partnership for 21st Century Skills, and National Centre for Research on Evaluation, Standards, and Student Testing (CREST).

The results from the searches were assessed by one reviewer for inclusion. A document was included if it fit within the scope of the questions posed for the rapid synthesis.

For each systematic review included in this rapid synthesis, we documented the focus of the review, key findings, last year the literature was searched (as an indicator of how recently it was conducted), methodological quality using the AMSTAR quality appraisal tool (see the Appendix for more detail), and the proportion of the included studies conducted in Canada. For primary studies, we documented the focus of the study, methods, key features of the intervention, and key findings. Note that the methodological quality of primary studies was not appraised due to the shortened timeframe required to conduct a rapid synthesis.

it should be noted that a large portion of primary studies have been conducted in the United States where the education contexts may not be directly comparable. Second, many of the primary studies report on specific instructional programs or approaches, and have relatively small sample sizes, often relying on findings from a single school or class.

Taxonomies and frameworks used in the empirical literature

The empirical literature revealed a general lack of agreement about what individual competencies make up the set of global competencies that should be taught to students, with a variety of frameworks being proposed. Global competencies and the language used to describe them appears to differ significantly between jurisdictions, with the United States and select education-oriented organizations (e.g., Asia Society, Big Picture Learning, International Network for Public Schools) increasingly using the term “21st-century skills” or “deeper learning” to describe similar sets of skills. Despite the differences in taxonomies, empirical evidence on both 21st-century skills and deeper learning has been included where relevant.

In addition to the variety of taxonomies used, one key question that was brought up in the literature is how information communication technologies (ICT) and digital skills (or digital literacy) fit into the framework. While it is suggested in some taxonomies that competencies in communication imply an understanding and development of ICT skills, this is less explicit in other taxonomies, and begs the question whether they should be conceptualized as part of a competency, a separate competency or whether it is a transversal competency (i.e., intersects across all the competencies). One recent medium-quality review developed a framework that conceptualizes the integration of global competencies and digital skills.⁽⁷⁾ The framework re-imagines these competencies as:

- technical skills (e.g., understand the characteristics of devices and applications; operate basic applications; avoid losing orientation when navigating online);
- information management (e.g., use ICT to formulate research statements; use ICT to find and retrieve information from a variety of sources; judge the usefulness of information; organize information to find it later);
- communication (e.g., communicate information and ideas to multiple audiences using media and online formats);
- collaboration (e.g., interactive communication using a range of contemporary tools; use ICT to share ideas);
- creativity (e.g., generate ideas or new ways of doing things using ICT);
- critical thinking (e.g., use ICT to ask questions; use ICT to judge the suitability of a source for a given problem; link facts, ideas and notions; use ICT to suggest new ideas for discussion); and
- problem solving (e.g., acquire implicit or explicit knowledge about a problem from ICT; apply this knowledge to find a solution).⁽⁷⁾

The review emphasizes the need for more research on how this revised model should be incorporated to best benefit students.⁽⁷⁾

Fostering the development of global competencies

We found nine systematic reviews, 15 primary studies, and three organizational reports that directly addressed how to foster the development of global competencies in K-12 students. Generally, we found little empirical evidence examining whether global competencies were developed through learning progressions, and relatively little evidence on the long-term effects of strategies to foster these skills. We did identify one study examining the implementation of deeper learning strategies across network schools (i.e., those focused on fostering deeper learning competencies in line with the William and Flora Hewlett Foundation and used specifically to describe 13 high schools in New York and California attached to the study).⁽⁴³⁾ This study noted that the most frequent strategies used to foster the six competencies of deeper learning (e.g., development of core academic content; critical thinking and complex problem solving; effective

communication skills; collaboration skills; an understanding of how to learn; and an academic mindset) were project-based learning, internship opportunities, and collaborative group work (i.e., collaborative work that requires learners to share, construct and build upon the knowledge and information that other group members contribute).(43) The study also noted that to implement these strategies, structural and cultural changes had to be made to accommodate deeper learning strategies, including advisory classes, alternative scheduling and personalized learning environments.(43) Advisory classes are implemented by schools to strengthen relationships between adults and students, and generally include regular meetings between an advisor and a student or a group of students providing academic and social support.(43) Alternative or flexible scheduling allows for more concentrated periods of studying that are essential for deeper learning.(43) Finally, personalized learning environments can facilitate deeper learning through the creation of a supportive and engaging environment (43) that allows for personalized learning to occur. This environment was established through smaller class sizes and through student-teacher teams.(43) A follow-up study, with data collected two, three and four academic terms following high-school graduation, examined whether students who attended network schools had higher educational achievements and found that, as compared to non-network high-school students, network students:

- achieved higher scores on the OECD PISA-Based Test;
- had positive interpersonal and intrapersonal outcomes;
- reported higher levels of collaboration skills, academic engagement, motivation to learn, and self-efficacy;
- were more likely to graduate from high school; and
- had similar rates of enrolment in post-secondary institutions.(43)

There was a focus in the empirical literature on technology-enhanced strategies to support the development of global competencies. However, the literature revealed equity considerations with regards to technology-enhanced strategies, since these technologies may not be equally available across communities. For example, a survey of Ontario public schools found that the adoption of mobile and computer technologies has been instrumental in promoting class motivation, sustaining conversations and supporting seamless learning experiences. However, low-income students were found to be more likely to lack access to such technologies.(23)

With respect to specific competencies, systematic reviews and primary studies found the following strategies were supportive of the development of critical thinking and problem solving:

- using of real-life problems combined with depictions or descriptions (also referred to as authentic learning) (e.g., incorporating students' historical, natural and cultural environment);
- employing robots and robotic construction kits;
- employing computer-based simulations to work through dynamic problems;
- designing computer games;
- open discussions of scientific questions; and
- introducing problem-based learning.(9; 12; 14; 20; 27; 34; 41; 42)

We found one recent medium-quality review that discussed the process by which students acquire the global competency of problem solving.(12) The review describes that the learning progression begins with sequencing, before progressing to causal inferences, conditional reasoning and finally ending with the adoption of systems thinking.(12)

Strategies to foster innovation, creativity and entrepreneurship include:

- providing resources and materials that can take on different shapes (e.g., modelling foam or clay for younger students, and media and technologies for older students);
- allowing students the opportunity to direct their own activities;
- using game-based learning;
- being flexible with time;
- participating in extra-curricular activities; and

- learning in alternative environments such as in museums and galleries.(10; 19; 25)

In addition, one primary study examined the use of a 10-unit web-based curriculum on entrepreneurship and found it improved students' acquisition of 21st-century skills, knowledge of how to set and achieve goals, and how to look for employment.(25)

No empirical literature was found on strategies to foster learning-to-learn/self-awareness and self-direction or whether the competency is developed through a learning progression or other means.

One report summarizing policy approaches on supportive learning environments across OECD jurisdictions found that student-driven inquiry and design-based approaches, such as hypothesis generation, scientific inquiry and literary analysis, improved communication and collaboration. The report suggests that these strategies can be augmented by using technology such as digital cameras and video recording which can collect real-time data, laptops that offer online searches, or through game-based learning or online simulations.(1; 41) Similarly, one medium-quality review found that the use of cloud computing (e.g., online exchange, online document editing, and concept map tools like Google Collaboration Platform) and its potential for real-time feedback and interaction improved student-teacher rapport and student-student rapport.(8)

One primary study examining an after-school program that taught communication and collaboration skills for socio-economically deprived populations found that communication was critical in the development of other 21st-century competencies. Other systematic reviews and primary studies identified the following strategies that fostered communication:

- participation in decision-making at school;
- use of online communication tools; and
- training in analyzing and evaluating media sources.(9; 26; 30)

A common finding across strategies aimed at improving global citizenship and sustainability is the importance of providing students of all ages with different experiences and learning environments that they can reflect on. For example, one primary study found that experiential learning (e.g., learning through reflections on participation in activities or on being immersed in new environments) was perceived as being practical and memorable because it was associated with a particular experience.(6; 8; 11; 16; 21; 22; 24; 28) Further, the study found that students used the experience to make informed behaviour changes in their own lives. One study provided lower socio-economic groups with an opportunity to develop global citizenship skills within their own communities by interacting with individuals from different ethnocultural and socio-economic groups.(22) The study found that these approaches were highly valued by students and teachers in developing global competencies, and helped students to acquire critical evaluative skills, and learn about and become empathetic of other students' cultural and social backgrounds.(22)

Finally, we only found one recent medium-quality review that discussed the process by which students acquire the global competency of problem solving.(12) The review describes that the learning progression begins with sequencing, before progressing to causal inferences, conditional reasoning and finally ending with the adoption of systems thinking.(12)

A summary of the key findings from the empirical research evidence identified in this rapid synthesis is provided in Table 2. For those who want to know more about the systematic reviews and primary studies contained in the table (or obtain citations for the reviews), a fuller description of the synthesized evidence is provided in Appendix 1 and 2.

Table 2. Summary of key findings from systematic reviews and primary studies relevant to fostering the development of global competencies

Global competency	Key findings
Critical thinking and problem solving	<ul style="list-style-type: none"> • Benefits <ul style="list-style-type: none"> ○ One report on supportive learning environments for global competencies suggested authentic learning opportunities using real-life problems to better engage students. This includes offering hands-on experiences and incorporating students' historical, natural and cultural environment into learning activities.(41) ○ The use of robotic construction kits among K-12 students was found in one recent medium-quality systematic review to elicit a learning progression which began with sequencing (i.e., ability to arrange items in a specific order), before progressing to causal inferences conditional reasoning and finally, to systems thinking.(12) <ul style="list-style-type: none"> ▪ Based on this progression, the same review found that evidence to support the use of robotic construction kits among some middle-school aged children can improve systems understanding and problem solving through a trial and error approach.(12) ○ Another recent medium-quality review found that the use of robots in early childhood education encourages the development of problem-solving abilities and collaboration.(13) ○ One recent report on problem solving in OECD countries found that using depictive and descriptive representations improved students' understanding of learning materials and improved problem-solving skills, in particular. This can be accomplished by using computer-based simulations which allow for more dynamic problem solving.(42) <ul style="list-style-type: none"> ▪ The same review found that dynamic problem solving has two main phases in which students must first acquire knowledge of the system (or problem) as a whole and then identify relevant variables before applying this knowledge to manipulate variables and observe their effect.(42) ○ One primary study found that engaging Grade 7 students in designing a computer game has the potential to help students develop a range of skills, including critical thinking, critical reasoning, visual design, problem solving and audience awareness skills (e.g., anticipating the needs/interests of those who will be playing the game).(14) <ul style="list-style-type: none"> ▪ Through observations and student reflections, the study found significant improvements in system analysis and design, decision-making and trouble-shooting compared to a control group, which did not improve any problem-solving skills.(14) ○ Using computer-based assessments, one primary study found a positive correlation between secondary students' willingness to engage in problem solving and their performance on PISA 2012 tasks.(20) <ul style="list-style-type: none"> ▪ The study suggests that performing well in creative problem solving may be linked to increases in students' self-confidence, and may have a positive impact on future problem-solving tasks.(20) ○ One primary study observed how discussing a scientific question can help second and third grade students to build problem-solving competencies. The study found that throughout conversation about the question, students actively evaluated theories and evidence, made connections with past experiences and knowledge, and problem solved.(27) ○ One primary study found that a shift to problem-based learning for science and math curriculums in CEGEP resulted in no difference in levels of preparedness for college, but improved problem-solving skills of individuals in the post-reform cohort.(34)
Innovation, creativity and entrepreneurship	<ul style="list-style-type: none"> • Benefits <ul style="list-style-type: none"> ○ One older medium-quality systematic review focused on enabling creative environments found that these promote academic success, student motivation, creative thinking and emotional and social skills development (studies included in the review differed in the methods and ages of students included).(10) <ul style="list-style-type: none"> ▪ The same review found that these environments can be established by making changes to students' physical environment, pedagogical environment, and by creating partnerships that span beyond the school.(10) ▪ These changes include: providing resources and materials that can take on different shapes (e.g., modelling foam and clay for younger students, as well as media and

	<p>technologies for older students); providing students with the opportunity to direct their own activities within a lesson; using games-based learning; flexibility with time; participation in extra-curricular activities; frequent discussions with teachers; and learning in alternative environments (e.g., museums and galleries).(10)</p> <ul style="list-style-type: none"> ○ Through observations and answers to students' reflection sheets, one primary study comparing students' skills in the development of computer games to those playing the games found that among Grade 7 students, constructing a game is a better way to enhance deeper learning, including creativity and problem solving, than by playing an existing game.(14) ○ One primary study evaluated a 10-unit web-based curriculum on entrepreneurship designed to teach secondary students 21st-century skills including goal setting, knowledge on how to find jobs, and information on colleges.(25) <ul style="list-style-type: none"> ▪ Using a pre- and post-curriculum test, the study found that the 10-unit curriculum improved students' acquisition of 21st-century skills, knowledge of how to set and achieve goals, and how to look for employment. The curriculum was found to disproportionately benefit those with greater reading skills.(25) ○ One primary study examined the use of education-related wikis developed by teachers to create and share information. However, only 1% of wikis examined were found to be collaboratively made for group projects and multimedia presentations, 25% were found to be made individually for student projects, and the remaining were created by educators and focused on teacher-led materials rather than fostering collaboration across students.(19) <ul style="list-style-type: none"> ▪ The study further found that wikis created for students attending high-socio-economic schools created more opportunities for 21st-century skills development than those created in low-socio-economic schools.(19)
Learning to learn/ self-awareness and self-direction	<ul style="list-style-type: none"> ● No empirical evidence was found
Collaboration	<ul style="list-style-type: none"> ● Benefits <ul style="list-style-type: none"> ○ One report on supportive learning environments for global competencies found that inquiry and design-based approaches, such as hypothesis generation, scientific inquiry and literary analysis, may improve communication, collaboration (both socially and cognitively) and creativity, but are often challenging to implement.(44) <ul style="list-style-type: none"> ▪ The same report suggested that these approaches are often augmented using technology such as digital cameras and video recording which can collect real-time data, laptops that offer online searches, or through game-based learning or online simulations.(44) ○ One medium-quality review found that the use of cloud computing (e.g., online exchange, online document editing, and concept map tools like Google Collaboration Platform) in both primary and secondary school has the potential for real-time feedback and interaction, improved student-teacher rapport and student-student rapport, and in some studies was found to lead to administrative efficiencies when implemented across an entire school board.(8)
Communication	<ul style="list-style-type: none"> ● Benefits <ul style="list-style-type: none"> ○ One older medium-quality review found that high school students' (e.g., Grades 9 to 12) participation in decision-making at school, such as through school councils, student councils and class councils, had a positive effect on the development of life skills, teamwork skills, and communication skills. <ul style="list-style-type: none"> ▪ The same review found that participation improved school ethos, specifically by encouraging positive attitudes, greater ownership over the school, and greater student enjoyment.(9) ○ One primary study examined intentionally taught communication and collaboration skills through an after-school program targeted at socio-economically deprived secondary-school students and found them to be critical to the adoption of other 21st-century skills. <ul style="list-style-type: none"> ▪ Students participating in the study reported during interviews that their credibility increased as an outcome of learning effective communication techniques.(26)

	<ul style="list-style-type: none"> ○ Through 10 media-literacy analysis and evaluation classes and 15 media production classes, one primary study observed improvements in Grade 7 students’ ability to access, analyze, evaluate and create media.(30) <ul style="list-style-type: none"> ▪ The study found three key findings that supported the success of this initiative: 1) teachers used a range of media texts to encourage active participation; 2) teachers actively sought to include popular examples in the curriculum in order to capture student interest quickly and effectively; and 3) teachers acted as leaders by holding events and sharing curricula with other teachers to encourage skill development outside of the classroom.(30)
<p>Global citizenship and sustainability</p>	<ul style="list-style-type: none"> ● Benefits <ul style="list-style-type: none"> ○ One older medium-quality review found that citizenship education can enhance student learning and achievement, communication skills, and academic achievement, and can result in changes in operations of movement from concrete literal thinking to abstract thinking.(6) <ul style="list-style-type: none"> ▪ The review emphasized that this can be facilitated through a wider range of learning environments, such as the local community beyond the school, as well as employ active service learning through drama, role-play and games.(6) ▪ The review also found the following learning processes contributed to improving the outcomes of citizen education: engagement (i.e., increased opportunities to participate); promoting discussion (i.e., class discussions and teacher-student dialogues); learner-centred teaching (i.e., teachers’ skills are tailored to the students’ ability level); meaningful curricula (i.e., connecting historical and abstract constructs with real-life experiences of students); and personal development (i.e., assisting students to explore spiritual, moral and cultural aspects).(6) ○ One medium-quality systematic review found that using cloud computing to share resources across educational settings can improve access in both developed and developing nations, and support the opportunity to learn from different cultures.(8) ○ One recent high-quality review examined the use of mindfulness strategies for primary and secondary school students and found strategies improved cognitive and socio-emotional outcomes, but found no positive outcomes on academic or behavioural outcomes.(11) ○ Through student focus groups, one primary- study conducting three case studies across Ontario found that environmental studies programs resulted in Grade 10 and 11 students finding that learning had ‘real-world’ applications, was relevant to their lives and resulted in making changes to their behaviours based on what they had learned.(16) ○ Another primary study used virtual-world development in computer games to teach fourth grade students about sustainability and other science-related subjects. Through surveys following the activity, the study found that the global awareness competency was used by 91% of students. <ul style="list-style-type: none"> ▪ The same study reported observing students using a variety of other global competencies including technology skills, communication, as well as critical thinking/inquiry, collaboration, and problem solving.(21) ○ One primary study built on ‘cosmopolitan theory’, which recognizes that previously isolated groups now live in close proximity to one another to form communities, found that this new reality provides significant opportunity to confront other cultures and backgrounds.(22) <ul style="list-style-type: none"> ▪ The study employed three strategies including: the cultural kitchen – where students are asked to imagine the life of someone just like them living in a different culture; community walls – which consists of an interactive activity where students stay overnight at and present their artwork to travellers at a local hostel; and Dialog – which brought two diverse student groups together into a productive dialogue.(22) ▪ The study found that these approaches were highly valued by secondary school students and teachers in developing global competencies, and helped students to develop critical evaluative skills, and learn about and become empathetic of other students’ cultural and social backgrounds.(22) ○ One primary study observed that the use of interactive, participatory exercises that employed bio-regional content fostered values of sustainability by deepening Grade 10 students’ awareness of the social and cultural landscapes in which they live.(24)

	<ul style="list-style-type: none">• Stakeholders' views and experience<ul style="list-style-type: none">○ One study reported that experiential learning can be used to instil a greater sense of global citizenship and environmental sustainability, however Grade 10 and 11 students reported in focus groups that this was sometimes perceived as 'not real work', and not having the same value as traditional classroom experiences.(16)○ One primary study conducted a survey among K-12 public schools in Alberta and found that relatively few efforts had been implemented to improve the levels of cultural competence among students and teachers.(28)<ul style="list-style-type: none">▪ The study noted that to make improvements schools would need to restructure the professional-preparation program to enhance understandings of cultural diversity, increase parental involvement in informing school activities, and allocate adequate resources to promoting diversity and competence.(28)
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Assessing, evaluating and reporting on the development of global competencies

Adapting the methods and content of what students are learning to better prepare them for current workplace environments also requires the development of innovative assessment methods and tools for students, schools, districts and the education system as a whole. We found relatively less empirical research evidence on each of these three elements, but have summarized key findings from systematic reviews and primary studies in each of the three sections below.

Assessing the development of global competencies

We found one systematic review, five non-systematic reviews, three primary studies, and three organizational reports that directly addressed the assessment of global competencies by teachers or students. Across the literature, a common finding for assessing competencies was the use of technology and problem simulations as being a key method/tool to determine how students were progressing in their development of certain competencies. This included using online games and collaborative tasks through which to observe students' actions. Consistent methods only were discussed for the assessment or self-assessment of meta-cognition (or learning-to-learn), while other methods and tools for assessments appeared to have been developed as one-off projects or assignments.

Four of the non-systematic reviews discussed the assessment of global competencies generally. Three non-systematic reviews found that assessments best positioned to predict their development of global competencies incorporate higher-order thinking and cognitively demanding skills rather than relying on multiple choice or single word answers.(35-37) Specifically, the reviews found that assessments of global competencies should:

- require the transfer of learned skills to new contexts and types of problems;
- require students to perform tasks that resemble those they may be asked to perform in the real world; and
- reflect underlying concepts rather than test-taking skills.

One of these non-systematic reviews describes the process of developing assessments for global competencies and notes that it should begin with a common definition of what terms such as "college and career readiness" mean, and should go on to define measures, in collaboration with educators, that clearly relate back to this definition and any specified outcomes.(36)

Most of the competency-specific literature focused on assessing students' abilities for critical-thinking and problem-solving competencies, which an OECD report notes has been a focus of a number of member countries since problem solving was incorporated in PISA measures in 2003.(42) The OECD report found that training students to monitor and assess their own learning progress may also contribute to the improvement of problem solving.(18; 42) Further, the report notes that dynamic problem-solving tests can be used as the basis for teachers' assessments on how well they prepare their students for life outside of K-12

education. By working through two phases, the knowledge-acquisition phase and the knowledge-application phase, dynamic problem solving allows for teachers to assess students' cognitive skills as students work through the problems in a controlled environment, where results are not masked by existing knowledge.(42)

Three primary studies focused on teachers' assessments of students' critical-thinking and problem-solving competencies.(17; 18; 20) One primary study examining the use of computer games to teach students 21st-century skills administered the PISA problem-solving test before and after the strategy to assess the extent to which students' skills had improved. Another primary study designed an assessment framework for collaborative problem solving which examines the social and cognitive dimensions of collaborative problem solving. For the social dimension the study included the following skills:

- participation in the task;
- perspective taking (e.g., ability to understand the perspective of others); and
- social regulation (e.g., navigation of collaborative spaces through negotiating and resolving differences and taking responsibility for solving problems).

The cognitive dimension included the following skills:

- goal setting;
- connecting information; and
- testing hypotheses.(17)

The study used 'the Olive Oil' task, which pairs two students together and asks them to virtually fill one jar with four litres of olive oil. The two students have different resources and so must work together to determine how they can successfully meet the objective.(17) This framework and task were used to infer individuals' skills from the actions they take in the online assessment.(17) The study notes that the advantage of these types of collaborative problem-solving tasks is that it moves the assessment of these competencies, particularly for the cognitive dimension, away from correct versus incorrect answers, which have been historically used in assessing students.(17) Generally, the study emphasized the importance of being able to deconstruct each of the global competencies into sub-skills for assessment, and noted the potential of using online tasks, where data can easily be tracked and analyzed, to facilitate these assessments.(17)

The third study developed a 29-item test based on 'Around the World in 80 Days' that assessed students' critical thinking abilities according to five key sub-skills: interpretation; analysis; evaluation; inference; and reasoning and explanation.(18) The test was found to be a reliable measure of critical-thinking skills for students in Grades 3 and 4, however, the test found that there were significant differences in the critical thinking skills of students from different socio-economic statuses, with the gap in critical-thinking skills increasing as students progressed through their educational careers.(18)

With respect to collaboration and communication, one organizational report on deeper learning in the United States found that these competencies were assessed through long-term assignments such as portfolios or exhibitions where students must present and defend their work.(43)

Finally, one recent medium-quality review examined methods of assessing meta-cognition or learning-to-learn.(38) The review found that learning-to-learn was most frequently assessed using self-reporting measures such as questionnaires, surveys and tests, while the other less common methods included one-on-one interviews between students and teachers, task-based assignments, or teachers' observations of students.(38)

Evaluating the development of global competencies

As mentioned earlier in the synthesis, we found relatively little empirical evidence on formal evaluations of global competencies. However, we found that two organizations in the United States, the Smart Balanced Assessment Consortium and the Partnership for Assessment of Readiness for College and Careers (PARCC), are developing common standards to evaluate students' deeper learning and engagement with 21st-century skills.(45) The evaluations include both formative and summative evaluations that combine technology-administered assessment with extended performance tasks in both English language arts and mathematics.(45) The intention of these evaluations, once developed, is to document the extent to which students are college ready. The PARCC assessment will also provide teachers and schools with tools that can be used to diagnose learning needs throughout the year.(45)

In addition to this, we found three primary studies that examined methods of formally evaluating global competencies.(31; 32; 46) A recent primary study examined the extent to which six United States and internationally administered tests measure the competencies that make up 'deeper learning' (e.g., development of core academic content; critical-thinking; problem solving; collaboration; communication; and 'learn-how-to-learn').(46) The study found that only two internationally-administered tests, the International Baccalaureate and Advance Placement Tests for English language arts, met the established threshold for cognitive demand to qualify as methods for evaluating students' development of deeper learning skills. The study established this threshold using the Depth-of-Knowledge (which categorizes tasks along a continuum from recall and reproduction to extended thinking according to the complexity of thinking required to complete them) and the PARCC frameworks for English language arts/literacy and mathematics (which outline standard expectations for content knowledge, conceptual understanding and expertise for each of arts, literacy and mathematics, from which to develop benchmarks according to whether or not the standard expectations of each grade are met).(46)

A second primary study sought to develop a brief version of the Human Behaviour Rating Scale (HBRS) to measure 21st-century skills including persistence, curiosity, externalizing and internalizing affect, and cognition. The HBRS-Brief sought to condense the 91-item Likert scale, which has also been used to evaluate students' development of 21st-century skills, to 30 items.(31) The evaluation was completed by teachers five months into the school year and then compared against results from the end of the school year. Based on comparisons against other academic and behavioural indicators (e.g., standardized test results, student absences, and office discipline referrals), this test was found to be a moderate to strong predictor of student academic and behavioural performance.(31) The scale was also found to have high internal consistency and inter-item correlation.(31)

Finally, a third primary study examined the use of the Community Index of Child Development in British Columbia as a method of measuring a child's readiness for school and trajectory throughout their early years of education.(32) The Community Index of Childhood Development examines the overall trajectory of childhood development using two tests, one administered in kindergarten and one in Grade 4. The two tests measure physical (e.g., assess gross and fine motor skills; coordination; energy levels for classroom activities), socio-emotional (e.g., eagerness to try new experiences; knowledge of acceptable behaviour; ability to control one's own behaviour), language/cognitive (e.g., age-appropriate reading and writing; age-appropriate math; board game performance) and communication (e.g., ability to communicate needs and wants; symbolic use of language; storytelling) domains of school readiness.(32) Together results determine the trajectory a given student is on. Students can have a positive trajectory (not found vulnerable on the first test and passed the second); negative trajectory (found vulnerable on the first test and failed the second); negative deflection (not found vulnerable on the test and failed the second); or a positive deflection (found vulnerable on the first test and passed the second).(32) The score is calculated as a ratio of positive-to-negative paths and deflections and are used to measure the trajectories in a given school district.(32) Findings from the application of this to Vancouver show the development of children from high vulnerability jurisdictions (jurisdictions where the majority of students are found to be on a negative trajectory or negative deflection) falls significantly behind

that of children from low vulnerability jurisdictions (jurisdictions where the majority of students are found to be on either a positive trajectory or positive deflection), however later in their academic career some convergence was observed. This type of evaluation could be used to compare school-readiness and trajectories of success in school districts across the province.(32)

Reporting on the development of global competencies

We found no empirical research evidence on reporting on the development of global competencies. This may be a result of schools and education systems still being in the process of experimenting and implementing curriculums and one-off strategies that focus on global competencies, and not yet being at the point of systematically reporting their results.

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APPENDICES

The following tables provide detailed information about the systematic reviews and primary studies identified in the rapid synthesis. The ensuing information was extracted from the following sources:

- systematic reviews - the focus of the review, key findings, last year the literature was searched and the proportion of studies conducted in Canada; and
- primary studies - the focus of the study, methods used, study sample, jurisdiction studied, key features of the intervention and the study findings (based on the outcomes reported in the study).

For the appendix table providing details about the systematic reviews, the fourth column presents a rating of the overall quality of each review. The quality of each review has been assessed using AMSTAR (A MeaSurement Tool to Assess Reviews), which rates overall quality on a scale of 0 to 11, where 11/11 represents a review of the highest quality. It is important to note that the AMSTAR tool was developed to assess reviews focused on clinical strategies, so not all criteria apply to systematic reviews pertaining to delivery, financial or governance arrangements within health systems. Where the denominator is not 11, an aspect of the tool was considered not relevant by the raters. In comparing ratings, it is therefore important to keep both parts of the score (i.e., the numerator and denominator) in mind. For example, a review that scores 8/8 is generally of comparable quality to a review scoring 11/11; both ratings are considered “high scores.” A high score signals that readers of the review can have a high level of confidence in its findings. A low score, on the other hand, does not mean that the review should be discarded, merely that less confidence can be placed in its findings and that the review needs to be examined closely to identify its limitations. (Lewin S, Oxman AD, Lavis JN, Fretheim A. SUPPORT Tools for evidence-informed health Policymaking (STP): 8. Deciding how much confidence to place in a systematic review. *Health Research Policy and Systems* 2009; 7 (Suppl1):S8).

All of the information provided in the appendix tables was taken into account by the authors in describing the findings in the rapid synthesis.

Appendix 1: Summary of findings from systematic reviews about the effects of strategies to support the development of global competencies

Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
Key characteristics of creative learning environments, as well as impact of these environments and role and support of teachers in facilitating creative learning environments (10)	<p>The review included 58 empirical studies examining creative learning environments in education.</p> <p>This review focused largely on the learning environment characteristics that promote creative skills development in children and young people. The majority of the examined literature pertained to this topic, with other studies investigating the impact of creative environments, the role of teachers, and ways in which teachers can be supported. The results of the review indicate that the characteristics that promote creativity in learning environments can be categorized into the physical environment, the pedagogical environment and the role of partnerships beyond the school. It should be noted that the majority of the literature focused on environmental characteristics stemmed from an event or special project, which may not have lasting effects on the creativity of students.</p> <p>The physical environment was found to stimulate creativity by establishing openness and flexibility in the spaces where children play, providing resources and materials, notably those that can take on any shape (e.g., clay, modelling foam for younger students, and for older student media and technologies), as well as encouraging collaboration in unique creative environments, such as the outdoors. Novel and stimulating projects and material were found to contribute to creativity, and giving children a degree of control over their curriculum can further enhance this process. For example, this could include providing children with the opportunity to direct their own activities within a lesson. Also falling under characteristics of the pedagogical environment, the review found that games-based learning, flexibility with time, extra-curricular activities, frequent discussions with teachers and collaborative relationships with student peers, also contribute to creativity among young learners. Lastly, partnerships beyond the classroom can positively contribute to creative development. Engagement with alternative environments such as museums and galleries can promote creative learning.</p> <p>To a lesser extent, the review also investigated other components of the creative learning process, with findings suggesting that creative environments promote academic success, student motivation, creative thinking, and emotional and social-skill development. The specific role of teachers in creativity promotion was examined, with results suggesting that creative teachers foster engagement of students. These teachers should be aware of learner needs, be flexible with lesson plans, and should be aware of the external pressures that can inhibit creative pedagogies – such as curriculum and assessment. Finally, this review examined the ways in which teachers can be supported to develop the skills needed to facilitate creative learning environments. It is necessary that development opportunities be provided to teachers, that their beliefs about teaching be unpacked, and that external partnerships are developed.</p> <p>Overall, this review focused on the key characteristics of creative learning environments which included characteristics of the physical environment, pedagogical environment and the role of external partnerships. To a lesser extent, this review explored the impact of these creative learning environments, the roles that teachers play and how these roles may be supported and developed.</p>	2011	6/9 (AMSTAR rating from McMaster Health Forum)	Not reported in detail
Explore how robotics construction kits function as learning	The review included 21 studies that examined K-12 learning with robotics construction kits (RCKs) in the STEM disciplines (science, technology, engineering and mathematics).	2013	5/9 (AMSTAR rating from	Not reported in detail

Forum+

Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
tools in P-12 STEM education (12)	<p>These included studies were sorted into two categories based on their relevance and approach to the use of computational manipulatives. First-order uses involve direct learning about robotics, and second-order uses involve the use of manipulatives for understanding concepts from a computational perspective.</p> <p>Of the 21 studies include in the current review, 15 reported on RCKs as first-order computational manipulatives, four studies report on RCKs as second-order computational manipulatives, and two studies addressed the function of RCKs as related to both uses.</p> <p>The main purpose of this review was to explore how RCKs function as computational manipulatives, or scaffolds for learning, in K-12 STEM education.</p> <p>The educational outcomes of first-order RCKs use were sorted into three categories: computational thinking, problem solving, and computer programming. First, in terms of computational thinking, the first-order use of RCKs elicited a learning progression in students studying robotics. This progression began with sequencing before progressing to causal inference, conditional reasoning and, finally, systems thinking. Sequencing ability involved the ability to arrange items in a specific order – an ability that has been found to improve significantly among preschool- and kindergarten-aged children engaging with robotics programming activities. This sequencing ability requires reasoning abilities, an ability which is key on the path to greater systems understanding. Complex reasoning abilities are limited in children, as younger children struggle with some forms of causal reasoning and middle-school-aged children demonstrate problems with advanced conditional reasoning. Despite these limitations, there is evidence to support the idea that robotics study can improve systems understanding among some middle-school-aged children. Engaging with robotics encourages this progression of thinking in young learners. Second, the first-order use of robotic devices presents a series of problem-solving challenges. Over the course of time and with more experience, students move from more basic forms of problem solving, such as the trial-and-error approach, to more sophisticated modelling approaches. Third, the learning of computer programming is an important component of robotics study among students. Research demonstrates that learning with robotics significantly contributes to a student’s understanding of programming.</p> <p>The educational outcomes of second-order RCK use, as defined by using robotics analogically to understand a target concept, is less documented in the literature. However, the current review emphasizes the importance of this topic and summarizes the existing findings while encouraging further research. Learning with robotics was categorized into three sections: research on physics, research on biology and research on developing science literacy. Research on the use of robotics in teaching physics has suggested that robotics use can support student learning. Research focusing on the use of robotics to teach biological concepts has suggested that robotics can create a stronger context for discussing theoretical concepts such as evolution, and that creating models of biological processes – such as a Venus flytrap plant catching prey – can lead to enhanced insight into these processes. Research on developing science literacy through the engineering design process indicates that this process challenges the thinking of students. While longer-term experiences are likely needed to develop skills, there are promising albeit limited results for this area of research.</p> <p>All of the research findings in this review are limited by sample size, but the results indicate the potential of robotics for supporting student STEM learning in the K-12 setting.</p>		McMaster Health Forum)	
Analyze the effectiveness of using	The review included 27 studies aiming to evaluate the effectiveness of incorporating robots into early childhood and lower-level education.	2013	4/9 (AMSTAR	Not reported

Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
robots in early childhood education (13)	<p>Specifically, study results elucidated the influence of robots on child behaviour and development, the perception of stakeholders regarding the use of robots in early level education, and the reaction of children to robot design or appearance.</p> <p>The development of problem-solving abilities, team skills, and collaboration skills were found to be some of the main outcomes of robots' influence on child behaviour development, supporting constructivism as a learning method. In order to construct robots, students discuss, solve problems, work with their peers, and combine their knowledge to engineer a solution. Studies further reported an increase in students' achievement scores in science, engineering, and technical knowledge following the introduction of robots at the kindergarten and elementary school level. Robots designed to deliver language lessons found similar benefits in elevating language skills and engagement in students. Finally, the use of robots was shown to improve participation rates among students, through robotics-related endeavours such as workshops, after-school programs, and professional-development programs.</p> <p>Parents, educators, and children generally reported positive perceptions of educational robots. While most parents would consider educational robots as beneficial for their children, one study found that they were less confident when playing and teaching their children using robots. It was also found that children gain a great deal from educational robots and have an increased interest in engineering or science university programs for the future.</p> <p>One study presented anecdotal data on children's reactions to educational robots. It was found that human-like robots are generally received as aggressive and machine-like ones as friendly.</p> <p>Overall, the paper presents educational robots as a positive influence on child behaviour and development, well-perceived by stakeholders, and has resulted in the ascribing of cognitive, behavioural, and affective characteristics to robots upon exposure. Unfortunately, experimental methods are generally lacking in the included studies and quantitative analysis is needed to validate the studies' results.</p>		rating from the McMaster Health Forum)	
Effects of student participation in decision making at school (9)	<p>The review included 32 studies exploring the effects of student participation in decision-making processes at school.</p> <p>The review identified five types of student participation: 1) councils; 2) in temporary school working groups; 3) in class decision-making; 4) in school decision-making; and 5) in multiple types of decision-making environments. The majority of studies focused on students' participation in councils including school councils, student councils and class councils.</p> <p>The main outcomes examined in the review were: personal effects of participation on students, personal effects on teachers, effects on interactions, and effects on school as an organization.</p> <p>It was found that participation has a positive effect on the development of students' life skills, including developing a sense of responsibility, developing or increasing communication skills, developing a sense of agency, gaining organizational skills, learning teamwork, developing decision-making or problem-solving skills, and cultivating an awareness of reality. Other positive personal effects on students included, improved self-esteem, civic knowledge and awareness of democratic processes, improved academic performance and better goal attainment. Mixed effects were found on improvements in health and behaviour with some positive associations in self-rated health, as well as bicycle helmet and car seatbelt use, however,</p>	2009	6/9 (AMSTAR rating from McMaster Health Forum)	1/32

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Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	<p>negative associations with alcohol use, binge drinking, cigarette use, and physical fighting were also found. A few negative effects were reported in some studies including student disillusionment, disappointment and frustration in not having policies and requests granted.</p> <p>Personal effects on teachers included better morale among staff, increased authority, and general learning experiences for staff. One study reported difficulty with being challenged by students as a result of this participation. In addition, improvements were reported in both student-adult relationships as well as in peer relationships among both students and teachers.</p> <p>Finally, improvements in the physical facilities and policies at schools were reported as a result of participation, including improvements to toilets and playground equipment, as well as to school policies, rules and codes of conduct. Further, the majority of studies found that participation improved the school ethos, specifically by encouraging better student attitudes towards the school, greater ownership over the school and greater student enjoyment.</p> <p>The report lists a number of limitations, including the majority of the included literature only covering one type of participation (i.e., participation in councils). Authors also noted the need for more research to separate effects based on age and country to gain conclusive insights.</p> <p>Overall, the review shows that there is moderate evidence for the positive effects of student participation on: personal outcomes for students; personal outcomes for teachers; effect on interactions; and the effects on schools as organizations.</p>			
Evaluating the importance of digital skills in the 21st-century workforce (7)	<p>The review included 75 studies exploring the importance of digital skills in the modern workforce.</p> <p>Specifically, the authors examined the relationship between 21st-century skills and digital skills and provided a framework of 21st-century digital skills aimed at the knowledge worker.</p> <p>Although digital competency was found to be a dominant component of 21st-century skills, the authors identified seven additional skills that are integral for success: creativity, technical-management skills, information-management skills, communication skills, collaboration skills, critical-thinking skills, and problem-solving skills. In addition, it was found that in contrast to digital skills, 21st-century skills are not necessarily underpinned by information and communication technologies. To support the seven core skills, five additional contextual skills were identified: ethical awareness, cultural awareness, flexibility, self-direction, and lifelong learning.</p> <p>As both 21st-century skills and digital skills are seen as crucial, the combination is not sufficiently defined in literature. To address this gap, the authors created a framework listing the skills conceptualizations and operational components of each article included in the study. For each skill, a conceptual definition and its key operational components were identified.</p> <p>Key findings of the study are hindered by its focus on peer-reviewed articles within the past 16 years. As a result, relevant articles published before the year 2000 and relevant books or conference papers may have been excluded.</p>	2016	4/9 (AMSTAR rating from the McMaster Health Forum)	Not reported in detail

Fostering K-12 students' global competencies

Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
Using cloud computers to foster 21st-century skills (8)	<p>The review included 13 studies examining the potential and barriers of cloud-based teaching in schools.</p> <p>Cloud Computing (CC) is the physical structure of a communications network, where data is stored in large data centres and can be accessed anywhere, at any time, and from different devices. It was found that the adoption of CC in schools can be analyzed in five ways: globalization, educational benefits, administrative benefits, barriers, and implementation.</p> <p>In terms of globalization, CC has led to easier access to education in both developed and developing communities. By providing the infrastructure to disseminate resources with little geographical limitation, CC allows for high-quality educational resources to reach the populations that might not have had access to them before. In addition, CC minimizes the need for software updates associated with traditional computer programs, which increases their longevity and ease of use. The inherent affordances of CC that enable a global learning environment can facilitate an educational paradigm shift from teacher-centred to student-centred learning.</p> <p>Educational benefits provided by CC include increased collaboration, efficiency, motivation, data access, and space for data storage. CC's capability of real-time feedback and interaction has also been shown to improve student-teacher and student-student rapport. Additionally, general improvements were found in teacher-parent communication, flexibility, productivity, creativity, self-organized learning, communication, sharing of knowledge, problem solving, and student responsibility.</p> <p>At the individual school, school district, and school system level, CC has been shown to offer administrative benefits by improving the cost-effectiveness of administrative processes, the efficiency of administrative processes, and the streamlining of established school procedures.</p> <p>Cultural incongruities present as the primary barrier to CC, while lack of technical competency was found to be a secondary barrier. Aside from these two barriers, issues surrounding privacy, security, anonymity, monitoring, reliability and responsibility have also been cited in the literature.</p> <p>Finally, in order to properly implement CC into educational curricula, the availability of technical and paradigm support must be considered. As CC is such a drastic shift from traditional educational methods, it is integral that its implementation aligns with the institution's strategies and goals.</p>	2015	4/11 (AMSTAR rating from McMaster Health Forum)	Not reported in detail
Using mindfulness strategies to improve cognition, academic achievement and socio-emotional functioning (11)	<p>The review included 61 studies exploring the current literature on mindfulness-based strategies implemented in primary and secondary schools.</p> <p>The study aimed to elucidate effects on student achievement, behaviour and socio-emotional outcomes to inform education practice and policy. The study revealed mixed results, citing positive effects on cognitive and socio-emotional outcomes but a minimal effect on academic and behavioural outcomes. The authors thus urge policymakers to take caution in their enthusiasm for the widespread adoption of school-based mindfulness strategies for children and youth.</p> <p>The authors acknowledge that the quality of the evidence in the study varied, with some important risks of bias present across a large proportion of studies which threatens their internal validity.</p>	2015	11/11 (AMSTAR rating from McMaster Health Forum)	2/61

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Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
Identify the assessment tools that are being used to measure meta-cognition in school-aged children (4-16 years) (38)	<p>Eighty tools were identified, with 61% of the tools consisting of self-reporting measures like questionnaires, surveys and tests. These tools are relatively easier to administer on large scales. Fourteen per cent of the tools consisted of interviews, 8% of the tools were based on observations, 6% of the tools consisted of teacher ratings, 8% of the tools used task-based methods, and 4% of the tools utilized multiple methods.</p> <p>Younger students tended to be left out of samples, especially with self-reporting tools, which were only used with students 7 and older. Observational tools only utilized think-aloud protocols with students aged 6-15, and not with students under 6. This reflects the ongoing debate regarding the age at which meta-cognition is developed, and becomes observable and recordable.</p> <p>The review identified several limitations. First, the reliability and validity of the tools were not always reported or given accurately. Second, most of the assessments focused on “core” subjects like math, literacy and science. Last, the review focused on instruments that explicitly operationalized meta-cognition, and did not include measures of executive control and function.</p> <p>Overall, the review found that the definition of meta-cognition within a study often related to the tool used and the outcomes found. The review also found that meta-cognition is not consistently defined throughout literature, and was often used interchangeably with other terms like “self-regulation”. The review recommends that future studies employ tools that combine or triangulate several measures to produce more accurate outcomes, and to use tools that elicit declarative knowledge. Studies should also ensure that the tool used is well-aligned to the definition of meta-cognition adopted.</p>	2012	5/9 (AMSTAR rating from McMaster Health Forum)	Not reported in detail
Examine how large-scale performance assessments can be leveraged to achieve 21 st century standards of learning (37)	<p>The nature and format of performance assessments can affect the depth of knowledge and type of skills developed by students. After the federal No Child Left Behind Act was passed in 2001, researchers noted an increase in reliance on multiple-choice testing. This has raised concerns on whether multiple-choice testing promotes readiness in the real world, which rarely features a limited set of structured potential solutions.</p> <p>The paper presents several suggestions for how performance assessments can be improved so that they encourage the development of 21st-century skills (e.g. problem solving, communication, the ability to transfer skills and knowledge across disciplines). Specifically, assessments should incorporate more analytically oriented multiple choice and constructed response items to assess higher order and cognitively demanding skills. Furthermore, different subjects should be assessed in different manners (e.g., scientific inquiry versus writing).</p> <p>In addition, policymakers should provide teachers with clearer signals about the kinds of skills that are valued, and encourage them to reduce multiple choice testing in classroom instruction. The paper also recommends that teachers score performance assessments to strengthen their curriculum and instruction, and support diagnostic teaching practices.</p> <p>The paper acknowledges that adopting more complex assessments can lead to greater costs. However, costs can be significantly reduced to current levels if states join forces, adopt technology wisely, score tasks efficiently, and involve teachers in scoring. Furthermore, the paper notes that performance assessments are much more cost-effective than other instructional interventions, like professional-development programs, in raising student achievement.</p>	n/a	No rating tool available for this type of document	n/a

Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
<p>Examine how systems of assessment and accountability should be designed in order to support continuous improvement across all educational levels (36)</p>	<p>This paper notes that current assessments do not properly measure certain Common Core Standards, especially those involving in-depth inquiry, extended communication, and 21st-century skills (e.g. collaboration, use of technology). The paper recommends a number of improvements for assessment and accountability systems.</p> <p>First, it is essential to develop standard definitions of terms like “college and career readiness.” This includes determining how the concept can be comprehensively measured, and how the accountability systems can be used to help students achieve goals. After establishing such definitions, decision-makers should align policy areas, program requirements, and funding to create a focused strategy that pulls outcomes in a common, desired direction.</p> <p>Second, decision-makers should determine which professional learning, curriculum, and resource supports are needed to enable college and career readiness. These supports may include process measures, comprehensive education standards, frameworks, tools and modules. Decision-makers should be cognizant of potential future developments in technology when selecting which supports to develop and disseminate.</p> <p>Third, decision-makers should establish a clear framework for assessments that is aligned with Common Core Standards and desired college- and career-readiness outcomes. This involves selecting measures that meet information and accountability needs, and triangulating measures so that student and school performance outcomes are comprehensively informed by multiple sources.</p> <p>Fourth, measures should be developed with post-secondary and workforce representatives to encourage acceptance of new systems and determine how information can be best conveyed and used by their targeted audience.</p> <p>Last, decision-makers should establish ways for systems learning to occur at all levels. For instance, educators can be involved in scoring assessments so that they can learn about the desired outcomes. System learning can also be enabled through online platforms and conferences, feedback loops, and collaboration opportunities.</p>	<p>n/a</p>	<p>No rating tool available for this type of document</p>	<p>n/a</p>
<p>Present a set of criteria that can be used to develop student assessments that promote deeper learning of 21st-century skills (35)</p>	<p>The paper presents five criteria that can be used to develop student assessments that promote deeper learning of 21st-century skills.</p> <p>First, tests should assess higher-order cognitive skills that involve transferring learning to new situations and problems. To accomplish this, tests should include questions that assess the critical skills and abilities outlined in the Common Core State Standards, rather than solely measuring the basic skills that are easiest to assess.</p> <p>Second, assessments of critical abilities should highly correlate to situations in the real world, rather than artificial proxies. Evaluation methods should be as direct as possible. For instance, multiple choice questions can help determine whether a student is able to identify grammatical errors, but does not assess whether the student can independently write or revise a text. More complex tools should be developed to evaluate deeper-level skills.</p> <p>Third, developed assessments should be similar to those used in countries with the best educational outcomes, in terms of the kinds of tasks employed, and the level of performance expected. For example, many other countries have more extended response-structured questions, rather than multiple-choice questions.</p>	<p>n/a</p>	<p>No rating tool available for this type of document</p>	<p>n/a</p>

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Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
	<p>Fourth, items of an assessment should be instructionally sensitive and educationally valuable. Questions should reflect underlying concepts, not test-taking skills or out-of-school experiences. These tests should also offer insight into aspects beyond student knowledge, like teaching and learning practices, and student meta-cognition.</p> <p>Last, assessments should be valid, reliable and fair. Implementing these assessments should improve the quality of instruction, and increase the educational opportunities available.</p> <p>These criteria would likely be achieved through multiple steps, rather than one giant leap.</p>			
<p>Define “deeper learning” and “21st-century skills”, elucidate their relationship with educational and economic outcomes, determine how to teach them, and examine potential issues (39)</p>	<p>Deeper learning is defined as the process through which a person becomes capable of transferring knowledge and skills learned in one situation, and applying it to new contexts and settings. Through deeper learning, students develop 21st-century competencies.</p> <p>These competencies can be divided into three domains: cognitive competencies (thinking and reasoning-related skills), intrapersonal competencies (self-regulation of behaviours and emotions), and interpersonal competencies (expressing ideas, and interpreting other messages).</p> <p>Research examining the relationship between 21st-century competencies and various outcomes is largely limited and correlational. Cognitive competencies have demonstrated consistent, positive, modest-sized correlations with desirable outcomes in education, workplace and health. Among intrapersonal and interpersonal competencies, conscientiousness is best correlated with desirable work and educational outcomes, while in contrast, antisocial behaviour is negatively correlated with these outcomes. Educational attainment strongly predicts adult earnings, health and civic engagement. There is little evidence that teaching can develop cognitive competencies that can be generalized and transferred to any new context.</p> <p>To support the development of 21st-century competencies, teachers should not only teach content, but also how, when, and why to apply the learned knowledge. Research-based teaching methods include using multiple and varied representations of concepts and tasks, encouraging questions and explanations, engaging learners in challenging tasks, introducing examples and cases, priming student motivation (e.g., connecting topics to personal lives), and using formative assessments to continuously monitor progress.</p> <p>More research is needed to establish common definitions of and common measurement tools for 21st-century competencies. More research is also needed to further elucidate causal relationships between competencies and outcomes, and to determine whether teaching can be used to facilitate the transfer of competencies across disciplines.</p> <p>At the systemic level, new approaches to teacher preparation and professional development are needed to support instructional understanding 21st-century competencies, and the acquisition of transferable knowledge and skills.</p>	n/a	No rating tool available for this type of document	n/a
<p>Determine how to lift the “floor” and “ceiling” of student</p>	<p>Math educators are currently attempting to achieve two seemingly mutually-exclusive goals: to help all students reach desired levels of math achievement (“raising the floor”), and to increase the expected level of mathematical achievement (“raising the ceiling”). Meeting these two goals can help enhance career prospects for students. This paper examines the steps that can be taken to ensure that whole groups of students are not excluded from higher math learning while striving for these goals.</p>	n/a	No rating tool available for this	n/a

Fostering K-12 students' global competencies

Focus of systematic review	Key findings	Year of last search/ publication date	AMSTAR (quality) rating	Proportion of studies that were conducted in Canada
math achievement (40)	<p>Large-scale assessments have found that math achievement is predicted by the number of math courses taken, and the amount of time spent studying advanced math. Given that students are often stratified into tracks of math classes by ability (college preparation, vocational, general education), students are given different opportunities to learn demanding math. The most positive effects in math achievement are often associated with those in high status tracks. Therefore, decision-makers should broaden the math courses available for traditionally underserved students, and avoid policies that limit math course opportunities, like tracking systems.</p> <p>Performance on achievement tests is positively associated with the cognitive demand required in math classes. Classes in the U.S. tend to require a lower cognitive demand in math classes, by focusing on routine memorization skills. The curriculum in the U.S. has often been called “a mile wide and an inch deep.” By comparison, higher performing countries place greater cognitive demands on their students by focusing on fewer concepts in greater depth, and emphasizing skills required for solving problems and forming connections among concepts. Thus, the paper recommends that math is taught at a higher level of cognitive demand. Task rigour can be increased by having teachers press for justifications and explanations of answers. Achieving this will require that teachers undergo training that prioritizes high curriculum standards.</p>		type of document	

Appendix 2: Summary of findings from primary studies about the effects of strategies to support the development of global competencies

Focus of study	Study characteristics	Sample description	Key features of the intervention(s)	Key findings
Evaluating educational computer-game design by middle school students (14)	<p><i>Publication date:</i> 2016</p> <p><i>Jurisdiction studied:</i> United States</p> <p><i>Methods used:</i> Qualitative case study</p>	21 students (16 boys and five girls) in a <i>Gamifying Social Studies</i> class were recruited for the study. All participants were computer-game players and two had prior experience in game design.	Students in a seventh-grade <i>Gamifying Social Studies</i> class were asked to create a computer game using <i>Gamestar Mechanic</i> , telling the story of a historical event they learned in class. Over the course of the project, field notes were taken by researchers for observational purposes. Researchers were also given access to students' accounts and passwords following the completion of the class project. Student feedback forms and reflection sheets were filled out by students and semi-structured interviews were conducted after class. All qualitative data were analyzed using the constant comparative method.	Researchers found that while most students were highly engaged with the computer-game design process, only half were able to integrate their social studies content into their video game. Through the project, students gained greater insight to the game design profession and learned to appreciate diverse and alternate perspectives. Overall, the class project left most students eager to create more computer games, with one student citing a desire to pursue the profession in the future.
Methods of teaching children digital literacy through design-based learning with digital toolkits in schools (15)	<p><i>Publication date:</i> 2015</p> <p><i>Jurisdiction studied:</i> The Netherlands</p> <p><i>Methods used:</i> Research through design approach</p>	107 primary school students and six secondary school students were recruited over the various stages of the study design.	A research-through-design approach was used to develop a way to create a reflective design-based learning approach to teach digital literacy and design thinking using digital toolkits in schools. Design explorations were conducted with input from diverse stakeholders, such as teachers, children, publishers, and educational scientists.	Researchers found that the key to teaching children to become “proficient in creating solutions for societal problems” is to practise digital fabrication skills with appropriate materials in an appealing design-based learning process. However, in order to do so, one must possess a good understanding of its complex context of use.
Student evaluation of integrated Environmental Studies Programs in Ontario (16)	<p><i>Publication date:</i> 2015</p> <p><i>Jurisdiction studied:</i> Ontario</p> <p><i>Methods used:</i> Case studies</p>	64 subjects (three cohorts of Grade 10 and Grade 11 students and their respective primary teachers) across three schools were included in the study.	Environmental Studies Programs (ESPs) are interdisciplinary secondary-school programs designed to help link environmental studies with core subjects and encourage student responsibility. Researchers conducted three case studies, collecting program feedback through student focus groups and teacher interviews.	It was found that program participation has real-world applications and can create a safe space for student dialogue and critical reflection. Students reported experiencing changes in environmental attitudes and behaviours as a result of program participation. Overall, this method of experiential learning was deemed a memorable opportunity for the development of social and interpersonal skills.
Assessing Collaborative Problem Solving in Education Environments (17)	<p><i>Publication date:</i> 2016</p> <p><i>Jurisdiction studied:</i> Australia, Singapore, Finland, United States, Costa Rica, the Netherlands</p>	Full classes of students (minimum 60 students at age 11, 300 students at age 13, and 300 students at age 15) in participating countries were recruited in the pilot study to assess the assessment system.	21st-century skills were explored and “collaborative problem solving” was targeted for development of assessment and teaching approaches.	<p>A framework was developed for problem solving that conceptualized a social and cognitive domain. The social domain is made up on three strands: participation, perspective taking, and social regulation. The cognitive domain refers to the ways in which students manage the problem and apply their reasoning skills.</p> <p>This frame is applied to assessment tasks that adhere to four characteristics: 1) they are aligned with the construct; 2) there is a</p>

Focus of study	Study characteristics	Sample description	Key features of the intervention(s)	Key findings
	<i>Methods used:</i> Not reported in detail			likelihood that students could engage with the tasks; 3) the logistics of online delivery; and 4) the psychometric characteristics of the task. The task used to test dynamic problem solving was called the Olive Oil Task which requires the students to virtually work out a sequence of movements that results in four litres of olive oil in one jug. The students each have different resources and different knowledge of how to use these resources and so must work together to determine what actions are necessary to accomplish the goal. The test was created to assess audience awareness skills such that each partner can adapt their own behaviour to suit the needs of the task. The underpinning cognitive skills that are tested include planning and executing, requiring that students demonstrate their ability to use cause and effect relationships to develop a plan. After piloting the Olive Oil Test, it was found to have high face validity as well as construct validity in testing students' dynamic problem-solving abilities.
Measuring critical thinking in primary school (18)	<i>Publication date:</i> 2016 <i>Jurisdiction studied:</i> Chile <i>Methods used:</i> Prospective cohort study	301 students from the third and fourth grades from three different types of schools falling into different SES brackets (state; low, state-subsidized; middle, and private; high) in Chile	Researchers administered a validated instrument to assess critical thinking in students of different SES-status schools.	The administered test used to identify critical thinking skills was found to be a reliable instrument. There were significant differences between the third and fourth grade students in all SES environments. Furthermore, significant differences were found between schools with different SES statuses, suggesting a possible relationship between SES and the development of critical-thinking skills. Standard deviation among students in the high SES school was found to decrease over time.
Using online data warehouses to assess quality and equity in online learning (19)	<i>Publication date:</i> 2012 <i>Jurisdiction studied:</i> United States <i>Methods used:</i> Mixed-methods cross-sectional analysis	255 online wikis were extracted according to those being used by PBworks. A Wiki Quality Instrument (WQI) was developed through 68 interviews with wiki-using teachers, 40 student focus groups and observations in 19 classrooms.	WQI was developed to measure opportunities for 21st-century skill development in students throughout the United States.	40% of wikis were found to be used exclusively by educators or were abandoned without being used by students. 34% of wikis were created through teacher-centred content delivery services within the classroom. 25% of wikis were found to be individually created for student projects and 1% of wikis were found to be collaboratively made for group projects and multimedia presentations. Wikis provided for higher-SES students in more affluent school environments were found to create more opportunities for 21st-century skill development than those used for lower-SES students. A considerable proportion of wikis provided students with opportunities to publish their materials, however, only a small number of wikis facilitated group collaboration. The study suggests that the use of wikis should be coupled with tools to track student learning and better evaluate critical thinking and other 21st-century global competencies.
Assessing the qualities required	<i>Publication date:</i> 2015	9,447 Australian students, 3,047	Data about openness and perseverance obtained from the 2012 PISA study results,	Openness in students' approaches to problem solving was found to be different than perseverance. PISA 2012 data found that students'

Focus of study	Study characteristics	Sample description	Key features of the intervention(s)	Key findings
for creative problem solving (20)	<p><i>Jurisdiction studied:</i> Australia, Norway, Singapore</p> <p><i>Methods used:</i> Retrospective cross-sectional study</p>	<p>Norwegian students and 3,692 Singaporean students from a total of 1,239 schools (mean age 15.8 years)</p>	<p>in which students worked on computer-based assessments in math, reading and creative problem solving for at least 40 minutes.</p>	<p>openness is a part of self-belief and personality. By contrast, perseverance was found to be more oriented toward the persistence and goal orientations in problem solving in the presence of obstacles. Norwegian students found high levels of openness and low levels of perseverance in the PISA 2012 data metrics; this was not replicated in other countries due to methodological factors that absorbed variance in questionnaire responses. However, it was the opposite for Singaporean students, suggesting a positive trend in higher values of openness and perseverance in this group of students. Overall, there were positive correlations between students' willingness to engage in problem solving and their performance on the PISA 2012 tasks. Performing well in creative problem solving may be linked to increases in students' self-beliefs and may positively impact future problem-solving tasks.</p>
Using virtual environments to teach elementary science (21)	<p><i>Publication date:</i> 2014</p> <p><i>Jurisdiction studied:</i> Australia, England, United States</p> <p><i>Methods used:</i> Mixed-methods prospective study (using tests and surveys)</p>	<p>15 fourth grade students in a Midwestern school and 30 elementary teachers from Australia, England and the United States</p>	<p>Students were given a virtual science computer game; data were collected using pre- and post-content tests and a survey of engaged learning. Teachers were surveyed on classroom observations of their students in the virtual landscape.</p>	<p>Students were found to have learned science content through the virtual environment, which was assessed in a traditional testing format. Virtual-world learning was found to increase student engagement, as it allowed opportunities for choice, socialization, exploration and individual curriculum pathways. Peer teaching and collaboration were found to emerge naturally, as they typically do in traditional learning spaces. 21st-century global competencies were demonstrated by students through learning by doing, situated cognition, collaborative learning in communities and deliberate practice measures during content learning exercises.</p>
Using a cosmopolitan approach to assess learning for global competencies in socio-economically deprived communities (22)	<p><i>Publication date:</i> 2014</p> <p><i>Jurisdiction studied:</i> United States</p> <p><i>Methods used:</i> Mixed methods qualitative analysis</p>	<p>35 students in underserved Chicago public schools, seven school volunteers and seven chaperones (six of whom were teachers)</p>	<p>Participants were observed for a total time of 400 hours and data was collected from in-depth, semi-structured interviews.</p>	<p>Cosmopolitan pedagogical processes (such as the fostering of hope, memory and dialogue) were engaged in many occasions amongst curriculum program staff, teachers and students in underserved schools. Artworks were made by students in which students integrated neighborhood development and systemic themes of poverty, violence and urban pressure. Interactions between students of different geographic regions helped students develop an understanding of the reduced distance between global and local social issues. Exchange Neighborhoods programs allowed students to develop presentations about tacit experiences from living in underdeveloped backgrounds, foster creative and open dialogue between students, and encouraged reflection. Educational practices that were more process-based than outcome-based (such as experiential learning opportunities) were found to be highly valued by students and teachers in developing global competencies. Reflection was revealed to be a hallmark of a successful cosmopolitan learning experience, helping students develop critical evaluative skills, and learn about and become empathetic of other students' cultural and social backgrounds.</p>
Equity in the use of digital	<p><i>Publication date:</i> 2015</p>	<p>1,349 principals of Ontario public schools</p>	<p>Survey data were collected to examine the use of digital tools in Ontario public schools.</p>	<p>99% of surveyed schools provided students with computer technology access. The adoption of mobile technologies in Ontario classrooms has</p>

Focus of study	Study characteristics	Sample description	Key features of the intervention(s)	Key findings
technologies in Ontario (23)	<p><i>Jurisdiction studied:</i> Ontario, Canada</p> <p><i>Methods used:</i> Survey data and retrospective database reviews</p>	(1,311 elementary and 297 secondary) representing all 72 school boards in the province	These results were combined with data from the Ontario Education Quality and Accountability Office (EQAO) to determine links between the digital divides and SES variables.	been instrumental in promoting class motivation, sustaining conversations and supporting seamless learning experiences. Schools in Northern Ontario were found to suffer from lack of network infrastructure and slow or unstable wireless internet access. Demographic data from EQAO suggest that families with lower incomes or students in smaller schools are more likely to lack technology access in the home. Based on principal survey data, digital literacy was found to be an important component of modern education; in Ontario, it has allowed schools to move away from textbook dependence and increase accessibility to alternative learning aids. Recent pedagogical innovations, like game-based learning and social networks, were less commonly used by surveyed schools. With regards to data trends on student performance, students with better competencies and confidence in reading, writing and mathematics were found to spend less time on the internet; however, not accessing the internet entirely proved disadvantageous for student performance as well. The study advocates for directing resources to schools that do not have adequate infrastructure for internet access. It also suggests a continual need for high-quality professional training and development to ensure teachers are competent in their use of technology. Further, it suggests ensuring that school boards dedicate special attention to ensuring that online materials support given curricula, reflect Canadian perspectives and are responsive to Ontario's student context.
'Teaching sustainability using a bio-regional literacy curriculum (24)	<p><i>Publication date:</i> 2013</p> <p><i>Jurisdiction studied:</i> Newfoundland, Canada</p> <p><i>Methods used:</i> Qualitative, mixed-methods prospective case study</p>	Twenty-six Grade 10 students using the Land, Sea and Time, Book 1 curriculum series	This article sought to identify the curriculum resources and practices that address education for sustainable development (ESD) through observations of students and analysis of themes. Students read, wrote about and discussed in creative, critical, exploratory participatory language education events.	Themes in students' activities were analyzed; students were able to explore relationships in ESD language education of intergenerational relationality, personal relationality and place-based relationality. It was found that interactive, participatory exercises in creative bio-regional art and literature developed by the province of Newfoundland and Labrador fostered values of sustainability by deepening students' awareness of the social and cultural landscapes in which they lived, thereby advancing the goals of fostering sustainable global competencies in education. The study advocates for the use of imaginative, creative bio-regional texts to be adopted by school boards, as they can develop community and culture-based understandings of local contextual issues.
Teaching 21st-century skills using information technology (25)	<p><i>Publication date:</i> 2010</p> <p><i>Jurisdiction studied:</i> Ohio, United States of America</p>	310 experimental classrooms in total comprising 153 students undergoing the experimental condition. and 237 classrooms of the control group	EnvisionIT, a 10-unit web-based curriculum designed to teach secondary students information-technology (IT) skills, was evaluated. Pre and post-test data were obtained from students to understand gains in 21st-century skills, including goal setting, knowledge on how to find jobs, and information about college.	The EnvisionIT curriculum was found to demonstrate improvements in students' acquisition of 21st-century skills. Experimental students made greater gains in IT literacy compared to the control students. Students with disabilities in the experimental group outperformed students in the control group as well. The gaps in performance and skills acquisition were more pronounced in upper classmen compared to lower classmen. Students with greater reading skills were found to benefit more from the experimental curriculum. Students who

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	<i>Methods used:</i> Pre- and post-test control group design	consisting of 130 students; a total of 119 students had disabilities		completed EnvisionIT increased their knowledge of how to set and achieve transition goals compared to the control group, and were better able to find opportunities for employment and information about post-secondary educational opportunities.
Students' perceptions of personal development education (26)	<i>Publication date:</i> 2016 <i>Jurisdiction studied:</i> United States <i>Methods used:</i> Mixed-methods qualitative analysis, including interviews, demographical analysis and observation	24 informal interviews and focus groups consisting of sophomore, junior and senior grade students in California	Interviews of student groups, data on student demographics, observations and written response journals were used to gather students' perspectives on a personal developmental education (PDE) program.	PDE was found to promote self-empowerment as a route to achieving 21st-century skills such as communicative and collaborative skills. It was determined that students appreciated the art of collaboration, were able to recognize the challenges and successes in professional interpersonal relationships, and were able to understand that credibility is increased as an outcome of learning effective communication techniques. Students in the sample placed heavy emphasis on building credibility through interpersonal relationships. Providing PDE opportunities to students was concluded to be a critical dimension of achieving equitable education and building 21st-century global competencies. Methods used to teach these competencies included direct instruction, interactive lectures, demonstrations, discussions, simulations, journal writing, reflections and project-based learning (collectively referred to as the C+C=S Curriculum). The study recommends strengthening teacher programs to help with classroom management and student preparation, as well as workshops in PDE to better train educators to meet the contextual and local needs of students of various SES backgrounds and competencies.
Investigate how conversations help children reason and form connections between theories and evidence (27)	<i>Publication date:</i> 2016 <i>Jurisdiction studied:</i> Western Canada <i>Methods used:</i> Case studies; interactive video analysis of classroom interactions during earth science classes	8 students in second grade and 8 students in third grade of Grade 2/3 science class	The teacher provided the students with a scientific question to investigate, and facilitated follow-up activities and group conversations that helped the children solve the given question.	Two episodes of classroom conversations were analyzed. The study found that reasoning among children occurs as a collective, logical and participative activity. Conversations between students and the teacher are used to actively evaluate theories and evidence, make connections with past experiences and knowledge, and problem solve. These processes help develop cognitive and social-reasoning processes. When children observe a phenomenon or a hypothesis that opposes prior beliefs or knowledge, they tend to selectively ignore discrepant evidence. Thus, when children build consensus around popular but inaccurate beliefs, the teacher is challenged by the need to reorient the conversation and scaffold their reasoning without infringing heavily upon their autonomy. In these examples, the teacher acted as a participant in the classroom conversation. Instead of giving out answers, she developed their reasoning and problem-solving skills by raising questions, inviting ideas, and encouraging them to interact with each other. The study did not look at how the social relationships between students may have affected conversations. Additionally, the study did not differentiate between intuitive and reflective thinking types.

Fostering K-12 students' global competencies

Focus of study	Study characteristics	Sample description	Key features of the intervention(s)	Key findings
<p>Examine perceptions of a survey used to evaluate the math and science college preparedness of post-reform CEGEP students (34)</p>	<p><i>Publication date:</i> 2017</p> <p><i>Jurisdiction studied:</i> Quebec, Canada</p> <p><i>Methods used:</i> Interviews with coordinators of the integration program</p>	<p>The first cohort of college students to have experienced the reformed curriculum</p> <p>Two original coordinators of the integration program, which ran the Math Science Diagnostic Test (MSDT) to measure the skills and knowledge of the first cohorts of post-reform students</p>	<p>In 2000, Quebec reformed its K-12 science curriculum in accordance with the Quebec Education Plan. The new curriculum placed a greater emphasis on competency development (mobilization of resources in a specific context, availability of diversified repertoire of resources, ability to reflect upon the process of mobilizing, reorganizing and integrating the resources) rather than the transmission of knowledge. The new curriculum also sought to emphasize scientific inquiry and technological processes. While the content did not change much, the reform resulted in significant changes in teaching practices. Many CEGEP faculty members voiced concerns that the reform's shift to problem-based learning would result in less time spent on foundational science content knowledge, and thus, lower college preparedness.</p>	<p>CEGEP faculty administered the MSDT to compare college preparedness in math and science between pre-reform and post-reform cohorts. The diagnostic test found no difference in preparedness between the two groups. In fact, the post-reform cohort also exhibited better problem-solving skills. Interviews with study coordinators examined the reaction to the test findings.</p> <p>The CEGEP community generally felt that the diagnostic test was too short and broad, and was administered to too few students to adequately evaluate student performance. Overall, since the reform, little has changed in terms of CEGEP syllabi and instructional practices, while high school pedagogies have changed significantly to include more problem- and inquiry-based lessons. The study authors also found that while there is good dialogue between CEGEPs and universities, there is a lack of collaboration between CEGEPs and high schools. Increasing communication between the two groups could ease academic transitions and reduce student anxiety.</p>
<p>Determine the perceptions of ESL families on the cultural competence of Albertan schools (28)</p>	<p><i>Publication date:</i> 2012</p> <p><i>Jurisdiction studied:</i> Alberta, Canada</p> <p><i>Methods used:</i> Survey evaluating student and parent perceptions of how effectively the schools respond to cultural diversity</p>	<p>242 ESL students and parents from Calgary and Edmonton, with ethnic backgrounds including Asian, South Asian, Middle Eastern, and African</p>	<p>The survey examined multiple facets of the cultural competence, including cultural representation in school practices, competence of school staff, school and student/family interactions, family-school communications, school-community collaborations, and the involvement of families in school activities.</p>	<p>Assessments were mediocre in most facets. Respondents assigned the least favourable ratings to the encouragement of heritage languages in schools, the availability of culturally focused services, and the involvement of ethnocultural families in promoting culture.</p> <p>The study authors concluded that the K-12 education system is still in the pre-cultural competence phase. So far, the response to diversity has been fragmented, and largely consists of ad-hoc, piecemeal strategies. The study authors made several recommendations to implementing a more integrated and coordinated strategy to achieving cultural competence and addressing inequities. Such an approach should emphasize the integration of content, the process of knowledge construction, the reduction of prejudice, and promoting an empowering school culture. To achieve this, schools would need to restructure professional preparation programs to enhance understanding of cultural diversity, and increase parental involvement in informing school activities and decision-making. Other tangible strategies to achieving diversity include conducting system-wide audits of policies, curricula and requirements; offering professional development opportunities for school personnel; and allocating adequate resources to promoting diversity and competence.</p>

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<p>Develop a measurement tool that assesses 21st-century learning and innovation skills of primary school students (29)</p>	<p><i>Publication date:</i> 2016</p> <p><i>Jurisdiction studied:</i> Adiyaman province, Turkey</p> <p><i>Methods used:</i> Scale development study</p>	<p>632 students attending fourth grade in five primary schools from different socio-economic areas</p>	<p>As existing scales measuring 21st-century skills are intended for adolescents and adults only, the authors developed a measurement tool that could assess 21st-century learning and innovation skills of primary-school students.</p>	<p>The scale was developed through six stages. First, the study authors established the scale items based on a literature review of existing scale items. Second, five experts evaluated each potential scale item based on their suitability for the age group and comprehensibility. A total of 56 potential scale items were then administered in a pre-test stage to 30 fourth graders, and various analyses were used to determine the validity and reliability of the items. The final scale had 39 items in total: 20 of the items evaluated creativity and innovation; 12 evaluated critical thinking and problem solving; and seven evaluated cooperation and communication skills. The scale had acceptable validity and reliability, with a Cronbach reliability coefficient of $\alpha = 0.955$.</p>
<p>Determine the characteristics of a media literacy program for middle school students (30)</p>	<p><i>Publication date:</i> 2015</p> <p><i>Jurisdiction studied:</i> U.S.</p> <p><i>Methods used:</i> Classroom field observations, interviews with teachers, discussions with students</p>	<p>40 seventh grade students attending a public Pre K to grade 8 school in an urban area</p>	<p>While adolescents are heavy users of information and communication technologies, they do not necessarily have the skills to evaluate and judge media texts, or create media products. This can affect academic and economic success, and civic engagement.</p> <p>The Media Literacy Workshop consisted of 10 media literacy analysis and evaluation classes, and 15 media production classes. The workshop sought to develop the ability to access, analyze, evaluate, and create texts in all forms (e.g., pictures, TV, songs).</p>	<p>There were three key findings. First, teachers used a range of texts (e.g. ads, popular fiction, TV shows) to encourage active participation. Second, teachers actively sought to include popular and current examples in the curriculum in order to capture student interest quickly and effectively. Through co-learning, teachers created a highly responsive curriculum that felt relevant to adolescent learners. Lastly, the teachers acted as media literacy leaders by holding community events and sharing curricula with other teachers to encourage the development of such skills outside of the classroom. These program features fulfil Common Core State Standards by providing middle-school students with 21st-century skills.</p>
<p>Create a shorter version of the Human Behaviour Rating Scale to measure 21st-century skills in students (31)</p>	<p><i>Publication date:</i> 2015</p> <p><i>Jurisdiction studied:</i> U.S.</p> <p><i>Methods used:</i> Scale development study</p>	<p>3,577 students aged 5 to 20 attending one of 10 public schools of a southeastern American school district</p>	<p>This study seeks to develop a brief version of the Human Behaviour Rating Scale (HBRS). The HBRS is a 91-item Likert scale completed by teachers that measures a student's 21st-century skills of persistence, curiosity, externalizing and internalizing affect, and cognition.</p>	<p>This study seeks to develop a brief version of the Human Behaviour Rating Scale (HBRS). The HBRS is a 91-item Likert scale completed by teachers that measures a student's 21st-century skills of persistence, curiosity, externalizing and internalizing affect, and cognition.</p> <p>The study authors produced a shorter 30-item tool called the HBRS-Brief based on their professional judgment and an exploratory factor analysis. The results from the tool were compared to student measures like standardized test results, student absences, and office discipline referrals. From these comparisons, it was found that the HBRS-Brief was a moderate to strong predictor of student academic and behavioural performance. Specifically, HBRS ratings of persistence, curiosity and cognition correlated with academic performance. Persistence, curiosity, externalizing affect, and cognition had medium to large relationships with office disciplines. All attributes except for internalizing affect had significant moderate relationships with</p>

Focus of study	Study characteristics	Sample description	Key features of the intervention(s)	Key findings
				<p>absences. The scale had high internal consistency coefficients and inter-item correlations.</p> <p>The results of this study are in line with previous empirical observations that persistence and curiosity can affect affective (e.g., student absence) and cognitive (e.g., academic achievement) behaviours.</p>
<p>Introduce the Community Index of Child Development, a tool that links two child population data sets to identify trajectories in childhood development at an aggregate level (32)</p>	<p><i>Publication date:</i> 2008</p> <p><i>Jurisdiction studied:</i> British Columbia, Canada</p> <p><i>Methods used:</i> Longitudinal analysis of linked population data</p>	<p>Students of the first two cohorts of the administration of the Early Development Instrument (EDI) (1999/2000, 2000/2001)</p>	<p>The Community Index of Child Development (CICD) links data from the EDI and the Foundation Skills Assessment (FSA).</p>	<p>The EDI is administered in kindergarten, and measures a child's readiness for school, while the FSA is administered in Grade 4, and measures numeracy, reading comprehension, and writing skills. The CICD examines the overall trajectory of childhood development based on EDI and FSA test results. Children can have a positive trajectory, in which they were found not vulnerable on the EDI and passed the FSA, or a negative trajectory, in which they were found vulnerable on the EDI, and did not pass the FSA. Children can also have a negative deflection, in which they were not vulnerable on the EDI but did not pass the FSA, or a positive deflection, in which they were vulnerable on the EDI, but passed the FSA. The CICD score is a ratio of positive-to-negative pathways and deflections in a given aggregate unit, like a neighbourhood. A higher ratio denotes better trajectories in the district.</p> <p>The CICD summarizes longitudinal development, which is advantageous to comparing cross-sectional data with potentially different sets of children. It can illuminate not only which neighbourhoods are performing well or poorly, but also in which school districts children tend to catch up or fall further behind. Additionally, the tool avoids the problems of relying on small samples, focusing only on high-risk populations, and examining only select developmental domains.</p> <p>Given its convenience and simplicity, the results are understandable to a variety of different audiences, including policymakers and parents. The tool can potentially be used in the future to explore various community influences on childhood development (e.g., long-term versus short-term poverty, social capital). Results of the tool are limited by the limitations of the FSA and the EDI. For instance, the FSA only examines language and communication.</p>



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