THE NATURE OF LEARNING, OECD, 2010

Chapter 9: Prospects and challenges for inquiry-based approaches to learning

Brigid Barron and Linda Darling-Hammond

Brigid Barron and Linda Darling-Hammond summarise the research on inquiry-based learning. A first key conclusion of their review of research evidence is that students learn more deeply when they can apply classroom-gathered knowledge to real-world problems; inquiry-based approaches are important ways to nurture communication, collaboration, creativity and deep thinking. Second, inquiry-based learning depends on the application of well-designed assessments, both to define the learning tasks and to evaluate what has been learned. Third, however, the success of inquiry approaches tends to be highly dependent on the knowledge and skills of those implementing them. If these approaches are poorly understood and mistaken for being unstructured, their benefits are substantially reduced compared with when they are implemented by those appreciating the need for extensive scaffolding and constant assessment to inform their direction.

The need for inquiry-based learning to support 21st century skills

Enthusiasm for educational approaches that connect knowledge to its applications has been on the upswing since the 1980s. Recommendations from a wide array of organisations have emphasised the need to support 21st century skills through learning that supports inquiry, application, production and problem- solving. These arguments have been promoted in scholarly research, national commission reports, and policy proposals, urging instructional reforms to help students gain vital media literacies, critical thinking skills, systems thinking, and interpersonal and self-directional skills that allow them to manage projects and competently find resources and use tools.

In order for these capacities to be nurtured, the reports argue, students must be given opportunities to develop them in the context of meaningful projects that require sustained engagement, collaboration, research, management of resources, and development of an ambitious performance or product. The rationale for these recommendations has come in part from research demonstrating that students do not routinely develop the ability to analyse, think critically, write and speak effectively, or solve complex problems from working on more constrained tasks that emphasise memorisation or call only for responses that demonstrate recall. In addition, there is a growing body of research indicating that students learn more deeply when they have had the opportunity to engage in more "authentic" learning.

A set of studies has found positive effects on student learning of instruction, curriculum and assessment practices that requires students to construct and organise knowledge, consider alternatives, apply disciplinary processes to content central to the discipline (*e.g.* use of scientific inquiry, historical research, literary analysis, or the writing process) and communicate effectively to audiences beyond the classroom and school. For example, a study of more than 2100 students in 23 restructured schools found significantly higher achievement on intellectually challenging performance tasks for students who experienced this kind of "authentic pedagogy" (Newmann, Marks and Gamoran, 1996). The use of these practices predicted student performance more strongly than any other variable, including student background factors and prior achievement.

While this kind of research is promising, the chequered history of efforts to implement "learning by doing" makes clear the need for greater knowledge about how successfully to manage problem- and project-based approaches in the classroom (Barron, *et al.*, 1998). The teaching suggested by these descriptions is not straightforward and requires knowledge of the characteristics of successful strategies and highly skilled teachers to implement them.

In this chapter, we focus on both the design and implementation of inquiry-based curriculum that engages children in extended constructive work, often in collaborative groups, and subsequently demands a good deal of self-regulated inquiry. The research we review spans the K-12 years, college and graduate education and can be found across core disciplines and in interdisciplinary programmes of study.

Research on the implementation and efficacy of these approaches for learning is yielding two major conclusions:

1. Small group inquiry approaches can be extremely powerful for learning. *To be effective, they need to be guided by thoughtful curriculum with clearly defined learning goals, well-designed scaffolds, ongoing*

*assessment and rich informational resources. O*pportunities for professional development that include a focus on assessing student work increase the likelihood that teachers will develop expertise in implementing these approaches.

2. Assessment design is a critical issue for revealing the benefits of inquiry approaches for group efforts and individual learning as well as for promoting the success of learning. Specifically, if one only looks at traditional learning outcomes, inquiry-based and traditional methods of instruction appear to yield similar results. *Benefits for inquiry learning are found when the assessments require application of knowledge and measure quality of reasoning.* Consequently, we also take up a discussion of "performance assessment" and its role in both supporting and evaluating meaningful learning.

An historical perspective on inquiry-based learning

The family of approaches that can be described as "inquiry-based" includes project-based learning, design-based learning and problem-based learning. Projects, proposed as a means for making schooling more useful and readily applied to the world, first became popular in the early part of the twentieth century in the United States. The term "project" represented a broad class of learning experiences. For example, in early works one sees activities as diverse as making a dress, watching a spider spin a web, or writing a letter. The key idea behind such projects was that learning was strengthened when "whole heartedness of purpose was present" (Kilpatrick, 1918).

Enthusiasm for such approaches for school-aged children has waxed and waned, as project-based learning has been rejected as too unstructured during several eras of "back to the basics" backlash. Critics of the progressive movement argued that discovery learning approaches led to "doing for the sake of doing" rather than doing for the sake of learning. There is a growing consensus that authentic problems and projects afford unique opportunities for learning but that authenticity in and of itself does not guarantee learning.

It is critical how these complex approaches are implemented. For example, initiatives using inquiry-based approaches (typically called "discovery learning" or project learning) were found in a number of studies to produce comparable achievement on basic skills tests while contributing more to students' problem-solving abilities, curiosity, creativity, independence and positive feelings about school. This kind of meaning-oriented teaching – once thought to be appropriate only for selected high-achieving students – proved to be more effective than rote teaching for students across a wide spectrum of initial achievement levels, family income, and cultural and linguistic backgrounds.

However, initiatives focused on inquiry were found more often to promote significant increases in learning gains among students taught by the early adopters – teachers who were extensively involved in design and piloting of the curriculum and who were given strong professional development. These effects were not always sustained as curriculum reforms were "scaled up" and used by teachers who did not have the same degree of understanding or skill in implementation.

At the present time, there is still controversy over whether open-ended approaches are effective and efficient for developing students' basic knowledge of a domain. And implementation issues continue to be a concern of both practitioners and researchers. Classroom research indicates that well-designed, carefully thought-out materials and connected classroom practices are needed to capitalise on inquiry-based approaches. Without careful planning, students may miss opportunities to connect their project work with key concepts underlying a discipline.

In recent years, the research base on inquiry approaches has grown. There is a growing consensus on the importance of a number of design principles that characterise successful inquiry-based learning environments and that can be used by teachers as they embark on developing them.

Inquiry-based learning

We summarise below the relevant research base on the different approaches to inquiry-based learning.

Project-based learning

Project-based learning (PBL) involves the completion of complex tasks that typically result in a realistic product, event, or presentation to an audience. Thomas (2000) defines productive project-based learning as 1) central to the curriculum, 2) organised around driving questions that lead students to encounters central concepts or principles of a discipline, 3) focused on a constructive investigation that involves inquiry and knowledge building, 4) student-driven, in that students are responsible for making choices and for designing and managing their work, and 5) authentic, by posing problems that occur in the real world and that people care

about.

Generally, research on the benefits of project-based learning concludes that students who engage in this approach experience gains in factual learning that are equivalent or superior to those who engage in traditional forms of instruction (Thomas, 2000). The goals of PBL are broader, however. The approach aims to enable students to transfer their learning more powerfully to new kinds of situations and problems and to use knowledge more proficiently in performance situations.

There is a number of studies demonstrating these kinds of outcomes in both short- and long-term learning situations. As noted, however, the goals of PBL are broader than simply the development of content knowledge. This approach aims to take learning one step further by enabling students to *transfer* their learning to new kinds of situations and problems and to use knowledge more proficiently in performance situations. Some examples help to illustrate this point.

Shepherd (1998) studied the results of a unit in which a group of fourth and fifth graders completed a nine-week project to define and find solutions related to housing shortages in several countries. In comparison to the control group, the students engaged in project-based learning demonstrated a significant increase in scores on a critical-thinking test, as well as increased confidence in their learning.

A more ambitious, longitudinal comparative study by Boaler (1997, 1998) followed students over three years in two British schools that were comparable with respect to students' prior achievement and socio-economic status, but that used either a traditional curriculum or a project-based curriculum. The traditional school featured teacher-directed whole class instruction organised around texts, workbooks and frequent tests in tracked classrooms. Unstruction in the other school used open-ended projects in heterogeneous classrooms.

Using a pre- and post-test design, the study found that although students had comparable learning gains when tested on basic mathematics procedures, those who had participated in the project-based curriculum did better on conceptual problems presented in the national examination. Significantly more students in the project-based school passed the exam in year three of the study than those in the traditional school. Boaler noted that, although students in the traditional school "thought that mathematical success rested on being able to remember and use rules," the PBL students had developed a more flexible, useful kind of mathematical knowledge that engaged them in "exploration and thought".

Many other studies have recorded student and teacher reports of positive changes in motivation, attitudes toward learning and skills as a result of participating in PBL, including work habits, critical thinking skills and problem-solving abilities. Some have found that some students who do less well in traditional instructional settings excel when they have the opportunity to work in a PBL context which better matches their learning style or preference for collaboration and activity type. One interesting study observed four PBL classrooms in the fall and spring of a school year, finding much larger increases in five critical thinking behaviours (synthesising, forecasting, producing, evaluating and reflecting) and five social participation behaviours (working together, initiating, managing, inter-group awareness and inter-group initiating) for initially low-achieving students over the course of the year than for initially high-achieving students.

Problem-based learning

Problem-based learning approaches represent a close cousin of project- based learning, and are often configured as a specific type of project that aims to teach problem definition and solution strategies. In problem-based learning, students work in small groups to investigate meaningful problems, identify what they need to learn in order to solve a problem, and generate strategies for solution. The problems are realistic and ill-structured, meaning that they are not perfectly formulated textbook problems but rather are like those in the real world with multiple solutions and methods for reaching them.

In addition, research that has sought to establish the characteristics of "good" problems suggests that they should resonate with students' experiences, promote argumentation, provide opportunities for feedback, and allow repeated exposure to concepts. In all problem-based approaches, students take an active role in knowledge construction. The teacher plays an active role in making thinking visible, guides group process and participation, and asks questions to solicit reflections. The goal is to model good reasoning strategies and support the students to take on these roles themselves. At the same time teachers also provide instruction in more traditional ways such as providing explanations which are crafted and timed to support inquiry.

Studies of the effectiveness of problem-based learning suggest that, like other project-based approaches, it is comparable, though not always superior, to more traditional instruction in facilitating factual learning, but it is better in supporting flexible problem-solving, application of knowledge and hypothesis generation. Additional

quasi-experimental studies have demonstrated more accurate hypothesis generation and more coherent explanations for students who participated in problem-based experiences, greater ability to support claims with well- reasoned arguments, and larger gains in conceptual understanding in science.

Learning through design

A third genre of instructional approaches has grown out of the idea that children learn deeply when they are asked to design and create an artefact that requires the understanding and application of knowledge. It is believed that design-based projects have several features that make them ideal for the development of technical and subject matter knowledge. For example, design activity supports revisions and iterative activity as projects require cycles of *defining→creating→assessing→redesigning*. The complexity of the work often dictates the need for collaboration and distributed expertise. Finally, a variety of valued cognitive tasks are employed such as setting constraints, generating ideas, prototyping, and planning through "storyboarding" or other representational practices. These are all critical skills for the 21st century.

Despite the wide range of applications of learning through design, much of the research-based curriculum development and assessment has taken place in the domain of science. For example, a group from university of Michigan has been developing an approach called *Design-based Science*, and a group from Terc (2000) developed a *Science by Design* series including units focused on constructing gloves, boats, greenhouses and catapults. A separate group from the Georgia Institute of Technology developed an approach they called *Learning by Design*.

Within the relatively small body of research that uses control group designs, the research on learning reported by Kolodner and colleagues (2003) shows large consistent differences between the *Learning by Design* classes and their comparisons. Their measures assess groups' abilities to complete performance tasks before and after instruction. Each task has three parts: first, students design an experiment that would provide a fair test; second, they run an experiment and collect data (the design is specified by the researchers); third, they analyse the data and use it to make recommendations. The researchers also score group interaction from videotaped records on seven dimensions: negotiation during collaboration; distribution of the work; attempted use of prior knowledge; adequacy of prior knowledge; science talk; science practice; and self-monitoring. They report that the Learning by Design students consistently outperform non-LBD students on collaborative interaction and aspects of meta-cognition (*e.g.* self monitoring).

The importance of assessment in inquiry-based approaches

As the discussion above suggests, collaborative and inquiry-approaches to learning require that we consider classroom activities, curriculum, and assessment as a system in which each interdependent aspect is important for providing an environment that will promote robust learning. Indeed, our ability to assess – both formatively and summatively – has enormous implications for what we teach, and how effectively. At least three elements of assessment are especially important for meaningful learning of the kind we have been describing:

- The design of **intellectually ambitious performance assessments** that define the tasks students will undertake in ways that allow them to learn and apply the desired concepts and skills in authentic and disciplined ways.
- The creation of guidance for students' efforts in the form of **evaluation tools** such as assignment guidelines and rubrics that define what constitutes good work (and effective collaboration).
- The frequent use of **formative assessments** to guide feedback to students and teachers' instructional decisions throughout the process. The nature of assessments defines the cognitive demands of the work students are asked to undertake. Research suggests that thoughtfully structured performance assessments can support improvements in the quality of teaching, and that inquiry-based learning demands such assessments both to define the task and to properly evaluate what has been learned. Some studies have also found that teachers who are involved in scoring performance assessments with other colleagues and discussing their students' work find the experience has helped them change their practice to become more problem-oriented and more diagnostic.

There are many ways in which authentic assessments contribute to learning. For example, exhibitions, projects and portfolios provide occasions for review and revision toward a polished performance. These opportunities help students examine how they learn and how they can perform better. Students are often expected to present their work to an audience – visitors, parents, other students – to ensure that their apparent mastery is genuine.

Presentations of work also signal to students that their work is important enough to be a source of public learning and celebration, and provide opportunities for others in the learning community to see, appreciate and learn from student work. Performances create living representations of school goals and standards so that they remain vital and energising, and develop important life skills. As Ann Brown (1994) observed:

> *audiences demand coherence, push for high levels of understanding, require satisfactory explanations, request clarification of obscure points... There are deadlines, discipline, and most important, reflection on performance. We have cycles of planning, preparing, practicing, and teaching others. Deadlines and performance demand the setting of priorities – what is important to know?*

Planning, setting priorities, organising individual and group efforts, exerting discipline, thinking through how to communicate effectively with an audience, understanding ideas well enough to answer the questions of others – all of these are tasks people engage in outside of school in their life and work. Good performance tasks are complex intellectual, physical and social challenges. They stretch students' thinking and planning abilities while also allowing student aptitudes and interests to serve as a springboard for developing competence.

In addition to designing tasks that are intellectually powerful, teachers need to provide guidance to students about the quality of work and interactions they are aiming for. The benefits of clear criteria given in advance have been documented by many studies. For example, Cohen and her colleagues tested the idea that clear evaluation criteria could improve student learning by improving the nature of the conversation. They found that the introduction of evaluation criteria led groups to spend more time discussing content, discussing the assignment and evaluating their products than groups who were not given criteria. They also found that individual learning scores were significantly correlated with the amount of evaluative and task-focused talk.

The criteria used to assess performances should be multidimensional, representing the various aspects of a task rather than a single grade, and openly expressed to students and others in the learning community, rather than kept secret in the tradition of content-based examinations. For example, a research report might be evaluated for its use of:

- ✓ evidence,
- ✓ accuracy of information,
- ✓ evaluation of competing viewpoints,
- ✓ development of a clear argument,
- ✓ and attention to conventions of writing.

When work is repeatedly assessed, the criteria guide teaching and learning and students become producers and self-evaluators while teachers become coaches. A major goal is to help students develop the capacity to assess their own work against standards, to revise, modify, and redirect their energies, taking initiative to promote their own progress. This is an aspect of self- directed work and self-motivated improvement required of competent people in many settings, including a growing number of workplaces.

Finally, formative assessment is a critical element in learning generally, and is especially important in the context of long-term collaborative work. Formative assessment is designed to provide feedback to students that they can then use to revise their understanding and their work. It is also used to inform teaching so it can be adapted to meet students' needs.

A theme in the literature on formative assessment is that feedback seems to be more productive to the extent that it is focused on student process rather than product, and keyed on the quality of the work (task-involving) rather than quality of the worker (ego-involving), for example providing comments rather than grades for students to consider. Shepard (2000) suggests that the focus on process and task allows students to see cognitive prowess not as a fixed individual trait, but as a dynamic state that is primarily a function of the level of effort in the task at hand. This can support their motivation as they sustain confidence in their own ability to learn.

There is a set of related practices of importance in the activities we have described, including the integration of assessment and instruction, the systematic use of iterative cycles of reflection and action, and ongoing opportunity for students to improve their work – which is grounded in a conception of learning as developmental and the belief that all students will learn from experience and feedback, rather than being constrained by innate ability.

Supporting collaboration within inquiry approaches

Much of the work involving inquiry-based learning involves students working in pairs or groups to solve a problem, complete a project, or design and build an artefact. Co-operative small-group learning, which Cohen (1994b) defines as "students working together in a group small enough that everyone can participate on a collective task that has been clearly assigned," has been the subject of hundreds of studies and several meta-analyses. Overall, these analyses come to the same conclusion: there are significant learning benefits for students who work together on learning activities.

Co-operative group work benefits students in social and behavioural areas as well, including improvement in student self-concept, social interaction, time on task and positive feelings toward peers. Ginsburg-Block and colleagues (2006) focused on the relationship between academic and non-academic measures. They found that both social and self-concept measures were related to academic outcomes. Larger effects were found for classroom interventions that used same-gender grouping, interdependent group rewards, structured student roles, and individualised evaluation procedures. They also found that low-income students benefited more than those from high-income backgrounds and that urban students benefited more than those from suburban areas. Racial and ethnic minority students benefited even more from co-operative group work than non-minority students, a finding repeated over several decades.

Nevertheless, effective co-operative learning can also be complex to implement. The classroom teacher plays a critical role in establishing and modelling practices of productive learning conversations. Aspects of the larger classroom learning environment shape small group interactions. Observing a group's interactions can provide a substantial amount of information about the degree to which the work is productive, as well as an opportunity for formative feedback and the provision of support for aligning understandings and goals among group members. Beyond any specific tool or technique, a particularly important role for the teacher is to establish, model and encourage norms of interaction that reflect good inquiry practices.

A great deal of work has been done to specify the kinds of tasks, accountability structures and roles that help students to collaborate well. In Johnson and Johnson's summary (1999) of 40 years of research on co-operative learning, they identify five "basic elements" of co-operation that have emerged as important across different models and approaches:

- ✓ positive interdependence,
- ✓ individual accountability,
- ✓ structures that promote face-to-face interaction,
- ✓ social skills and
- ✓ group processing.

A range of activity structures has been developed to support group work, from co-operative-learning approaches where students are simply asked to help each other complete individually-assigned traditional problem sets to approaches where students are expected to define projects collectively and generate a single product that reflects the continued work of the entire group. Many approaches fall between these two extremes. some approaches assign children in the group to management roles, conversational roles, or intellectual roles.

When designing co-operative group work, teachers should pay careful attention to various aspects of the work process and to the interaction among students. For example, Slavin (1991) argues: "it is not enough to simply tell students to work together. They must have a reason to take one another's achievement seriously." He developed a model that focuses on external motivators that reside outside the group, such as rewards and individual accountability established by the teacher. His meta-analysis found that group tasks with structures promoting individual accountability produce stronger learning outcomes.

Cohen's review of research (1994) on productive small groups focuses on internal group interaction around the task. She and her colleagues developed "complex instruction", one of the best-researched approaches to co-operative small-group learning. Complex instruction uses carefully designed activities that require diverse talents and interdependence among group members. Teachers are encouraged to pay attention to unequal participation among group members, which often results from status differences among peers, and are given strategies that allow them to bolster the status of infrequent contributors.

In addition, roles are assigned to support equal participation, such as recorder, reporter, materials manager, resource manager, communication facilitator and harmoniser. A major component of the approach is development of "group-worthy tasks" that are both sufficiently open-ended and multi-faceted that they require and benefit from the participation of every member of the group. Tasks that require a variety of skills – such as research, analysis, visual representation and writing – are well suited to this approach.

There is strong evidence supporting the success of complex instruction strategies in promoting student academic achievement. In recent studies, evidence of this success has been extended to the learning gains of new English language learners.

Challenges of inquiry approaches to learning

Many challenges have been identified with the management of the approaches just reviewed, as the pedagogies required to implement them are much more complex than the direct transmission of knowledge to students. In fact, inquiry approaches to learning have frequently been found to be highly dependent on the knowledge and skills of teachers involved. When these approaches are poorly understood, teachers often think of inquiry or other student-centred approaches as "unstructured," rather than appreciating that they require extensive scaffolding and constant assessment and redirection as they unfold.

Research on these approaches signals a number of specific challenges that emerge when students lack prior experiences or modelling regarding particular aspects of the learning process.

- Regarding disciplinary understanding, students can have difficulty generating meaningful questions or evaluating their questions to understand if they are warranted by the content of the investigation, and they may lack background knowedge needed to make sense of the inquiry.
- Regarding general academic skills, students may have difficulty developing logical arguments and evidence to support their claims.
- Regarding management of tasks, students often have difficulty figuring out how to work together, managing their time and the complexity of the work, and sustaining motivation in the face of difficulties or confusion.

Teachers may also encounter challenges as they try to juggle the time needed for extended inquiry. They need to:

- ✓ learn new approaches to classroom management,
- ✓ design and support inquiries that illuminate key subject matter concepts,
- ✓ balance students' needs for direct information with their opportunities to inquire,
- ✓ scaffold the learning of many individual students (providing enough, but not too much, modelling and feedback for each one),
- ✓ facilitate the learning of multiple groups, and develop and
- ✓ use assessments to guide the learning process.

Without supports to learn these complex skills, teachers may be unable to use inquiry approaches to best advantage, engaging students in "doing" but not necessarily in disciplined learning that has a high degree of transfer.

How can teachers support productive inquiry?

Successful inquiry-based approaches require planning and well thought out approaches to collaboration, classroom interaction and assessment. Classroom research has shown that simply providing students with rich resources and an interesting problem (*e.g.* design a household robot with arthropod features) are not enough. Students need help understanding the problem, applying science knowledge, evaluating their designs, explaining failures and engaging in revision. Students often neglect to use informational resources unless explicitly prompted.

Several research groups have offered design principles that can help guide curriculum efforts. Below we summarise the primary design principles from these groups.

Projects must be well designed with well-defined learning goals guiding the nature of activities.

Subject matter can be problematised by encouraging students to define problems and treat claims and explanatory accounts, even those offered by "experts," as needing evidence. The teacher should encourage students to question all sources. Rather than ignoring differences across sources, the teacher can draw attention to them and encourage them to look for converging sources.

Resources can scaffold both teachers and student learning

Resources such as models, tools, books, films or fieldtrips can support inquiry and discussion. Access to experts and a variety of informational resources are key in allowing students to find a broad range of topics,

contradictions and perspectives. Discrepancies across sources can be important for driving debates but also for developing students' reasoning and sophistication in using different types of evidence.

Another important resource is time. Students must be given plenty of time to investigate questions, carry out designs and share the group's current thinking and disagreements with one another and with the teacher.

Teachers must develop participation structures and classroom norms that encourage accountability, use of evidence and a collaborative stance

Students can be given authority to address disciplinary problems by personally identifying them with claims, explanations, or designs in ways that encourage them to be authors and producers of knowledge. The teacher can communicate an enthusiasm for debate and productive conflict. Public performances like presentations can encourage the ability to adopt a particular perspective as well as attention to quality. Students should be encouraged to address others' viewpoints even if they disagree. Disciplinary norms, such as paying attention to evidence and citing sources, should be modelled and nurtured. The teacher can encourage the students to incorporate a wide range of sources into their research. Students can also constantly be made aware of the requirement that they help their group members learn.

Well-designed formative assessment and opportunities for revision support learning and well designed summative assessments can be useful learning experiences

Formative opportunities for reflection on collaborative processes and work progress should be built in to help students self-assess and revise their course of action if needed. It is important to find a balance between having students work on design activities and reflecting on what they are learning, so that they can guide their progress. Incorporating reflective activities is important to encourage understanding.

The criteria used for summative assessment should be multidimensional, representing the various aspects of a task rather than a single grade, and openly expressed to students and others in the learning community.

Summary and conclusions

The current conversation about 21st century skills calls for classroom and other learning environments that, in addition to including the core subjects of schooling, encourage students to develop new media literacies, critical and systems thinking, interpersonal and self directional skills. This chapter has presented classroom approaches that support sustained inquiry and collaborative work. Such approaches are critical for preparing students for future learning. Three main conclusions may be drawn from our review.

1. Students learn more deeply when they can apply classroom knowledge to real-world problems. Inquiry and design-based approaches are an important way to nurture communication, collaboration, creativity and deep thinking. Attention to the processes, as well as the content, of learning is beneficial.
2. Inquiry approaches to learning are challenging to implement. They are highly dependent on the knowledge and skills of the teachers engaged in trying to implement them. When these approaches are poorly understood, teachers often think of them as "unstructured," rather than appreciating that they require extensive scaffolding and constant assessment and redirection as they unfold. Teachers need time and a community to support their capacity to organise sustained project work. It takes significant pedagogical sophistication to manage extended projects in classrooms so as to maintain a focus on "doing with understanding" rather than "doing for the sake of doing". Fortunately there is a wealth of examples and articulated design principles that can help teachers to do these things.
3. Assessment strategies must be designed to support both formative and summative evaluation. The nature of assessments defines the cognitive demands of the work students are asked to undertake. Research suggests that thoughtfully-structured performance assessments can support improvements in the quality of teaching, and that inquiry-based learning demands such assessments, both to define the task and to evaluate properly what has been learned.

As the international community explores strategies to prepare students for an increasingly complex and interconnected world, inquiry and design approaches to learning provide a well-researched approach that has the potential to transform important aspects of teaching and learning. Students develop critical collaborative and academic skills, and teachers are given opportunities to deepen their repertoire for nurturing skills for the 21st century. Collaboration among researchers and educators can only strengthen the possibilities for imagining and enacting transformative pedagogies that support deep engagement and learning for all.